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Eurowire

The International Magazine for the Wire & Cable Industries

ISSN 1463-2438

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INSULATES *Or* IDENTIFIES

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4 double twisting strander

5 wet drawing machine

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cellphone: 0086-13905264693

website: www.jsjintai.cn

The future is wired...

The developed world is being forced to re-think its attitude to energy. We can't claim we weren't warned, but the impact always had to be to our pockets before the question of sustainable energy became real, and the rapid rise in oil prices has provided the necessary catalyst.

I arrived in Pittsburgh, for the WAI Wire Expo, in time to witness the outcry that US fuel prices had achieved an all-time high average of 4 USD per gallon. I'd spent much of my flight over catching up with the previous weekend's Sunday papers and, unsurprisingly, both traditional and alternative fuels were high on the editorial agenda.

No news here, I know, but walking to the conference hall one morning I overheard a member of the centre staff comment, "Wire exhibition? Where's the future in that? Everything's going wireless!" It had a ring of truth about it and, still musing over a potential energy crisis, it made me stop and think about the future of wire.

Walking around the Wire Expo exhibition hall, it didn't take long to reach a reassuring conclusion.

In whichever way energy is produced in the future – and energy will continue to be produced, one way or another, on a domestic or global scale – something has to deliver that energy safely, reliably and efficiently; the wire and cable industry will continue to have an obvious and essential contribution to make.

Of course the industry's contribution needs to extend to energy saving, and developing environmentally safe processes; this is already happening (take a look through the editorial contributions in this issue) but we've an industry with a bright, confident future.

If this seems complacent or naïve then I apologise but, in a climate of change and uncertainty, isn't it nice to have some good news for a change?

And that was before I considered tele-communications, coat hangers, fencing, springs, suspension bridges …

Gill Watson

The International Magazine for the Wire and Cable Industries

***** US$33 purchase only**
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See page 100 for further details

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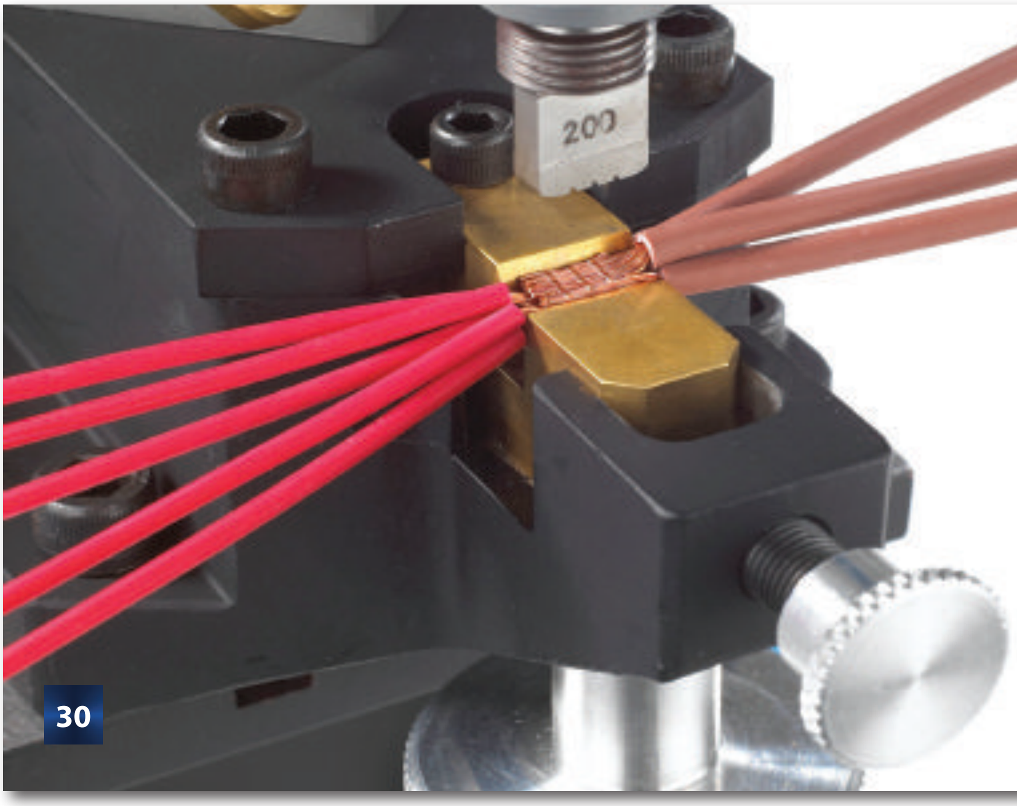

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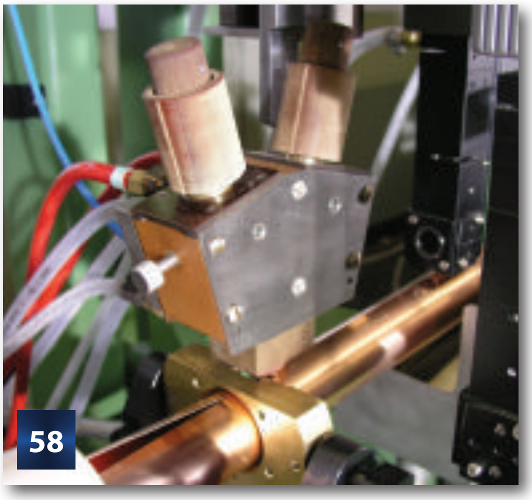

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In The Next Issue

Show issue
wire China 2008

Features On

- Rod & bar production
- Cables, compounds & extruding

Getting Technical

New wire & cable solutions for high heat environments

dates for your diary . . .

wire China 2008

September

23 – 26: **wire China 2008** – trade exhibition – Shanghai, China
Organisers: Messe Düsseldorf China
Fax: +86 21 5027 8138
Email: wire@mdc.com.cn
Website: www.wirechina.net

Photo copyright: BigStockPhoto.com Photographer: ctpaul

November

9-12: **IWCS** – technical conference – Rhode Island, USA
Organisers: IWCS Inc
Fax: +1 732 389 0991
Email: admin@iwcs.org
Website: www.iwcs.org

20-22: **Wire and Cable India** – trade exhibition – Mumbai, India
Organisers: CII
Fax: +91 22 2493 9463
Email: info@ciionline.org
Website: www.ciionline.org

April 2009

25-30: **Interwire** – trade exhibition – Cleveland, USA
Organisers: Wire Association Intl
Fax: +1 203 453 8384
Email: info@wirenet.org
Website: www.wirenet.org

May

12-15: **wire Russia 2009** – trade exhibition – Moscow, Russia
Organisers:
Messe Düsseldorf GmbH
Fax: +49 211 4560 7740
Email: info@wire-russia.com
Website: www.wire-russia.com

June

17-19: **Wire & Tube Kiev (TDS)** – trade exhibition – Kiev, Ukraine
Organisers: TDS – Expo
Email: olga@welding.kiev.ua
Website: www.weldexpo.com.ua

September

18-21: **Wire Turkey** – trade exhibition – Istanbul, Turkey
Organisers: Media Force
Fax: +90 212 465 7417
Email:
info@mediaforceonline.com
Website:
www.mediaforceonline.com

October

6 – 8: **Metaltech/Tubotech** – trade exhibition – Sao Paulo, Brazil
Organisers: Grupo Cipa
Email:
international@cipanet.com.br
Website: www.cipanet.com.br

13 – 15: **wire/Tube SE Asia** – trade exhibition – Bangkok, Thailand
Organisers: Messe Düsseldorf Asia Pte Ltd
Email: wire@mda.com.sg
Website:
www.wire-southeastasia.com

Drum twister bound for Saudi Cable

▲ *Gauder's latest drum twister, the largest of its type, will be supplied to Saudi Cable Company*

Gauder Group has announced an important contract for a drum twister line to be supplied to Saudi Cable.

This latest drum twister line is the 700^{th} supplied by Gauder to the cable industry and will be the largest of its type.

The line, for the production of high voltage power cable, will be designed for a 4 metre take-up reel and 30 tons weight.

Saudi Cable Company is a manufacturer of a complete range of cable in the Middle East and Pourtier - Gauder Group is a long-standing supplier.

Pourtier - Gauder Group – France
Fax: +33 1 64 26 61 10
Email: sales.pourtier@gaudergroup.com
Website: www.gaudergroup.com

Investment plans for reel producer

Madem already has production plants in Brazil, Spain, and USA and is to open a new plant in the Kingdom of Bahrain later this year. With production around 500 containers per month of knock down wood reels, Madem sells to over 40 countries and possibly all of the major wire and cable producers.

Madem Reels are stamped ISPM 15 heat-treated and made from renewable pine from North America, South America and Europe.

During 2008, Madem will be investing US$ 5,000,000 in a high tech plywood plant, capable of producing 70 containers of plywood flanges per month.

"Worldwide customers are looking to find new ideas, at Madem we offer new kit packaging, a new locking bushing system and on site assembling operations. Madem is working closely with customers suggesting spec changes that will provide cost savings to their customers," says Madem Group sales director, Leandro Mazzoccato.

Madem Reels– Brazil
Fax: + 55 54 3462 5900
Email: madem@madem.com.br
Website: www.mademreels.com

▲ *From left to right: Leandro Mazzoccato – Madem Group's sales director; Roger Santasusana – SL director of Euromadem Spain; and Gino F Mazzoccato – Madem Group president director*

Cables are high flyers at Frankfurt

For decades, Network and Safety system solutions from Dätwyler Cables have been used at Frankfurt Airport, and for much of the latest new building and expansion work, Dätwyler Cables will again be supplying the installation companies on site with cables, components and services from its nearby European distribution centre.

Frankfurt Airport is one of the largest hub airports in Europe, handling roughly 500,000 flights and 50 million passengers every year. Airport operator Fraport AG is constantly expanding capacity at Frankfurt Airport and there are many construction projects from other developers such as Lufthansa, Deutsche Bahn and several logistic companies and hotels.

▲ *Frankfurt Airport, where Dätwyler Cables are in demand for applications across the board*

Applications already using Dätwyler Cables range from office communications and connections for counter, display and card-reading devices to access control and the traffic management system.

Safety systems and fire prevention are essential. To ensure that all electrical equipment will function reliably in the event of a fire, many safety cable installations are provided by Dätwyler Cables. These include halogen-free ceramic cables with functional integrity, as well as tested connection, support, and mounting components.

After re-cabling the A380 maintenance hangar, Dätwyler is providing systems for Hall C in Terminal 1, the fire prevention enhancement projects in Terminal 2, the connection between these terminals, the expansion of various car parks and the new Gateway Gardens neighbourhood. Contracts include training and consulting services to the installation companies.

Dätwyler Cables solutions are tested beyond the standard technologies of DIN 4102-12, and are fully compliant with the demands of modern construction technology whilst also saving time and money.

Dätwyler Kabel+Systeme GmbH – Germany
Fax: +49 61 90 88 80 15
Email: heiko.knell@daetwyler-cables.com
Website: www.daetwyler-cables.com

Niehoff prefers Uhing

Rolling ring drives manufacturer, Joachim Uhing KG GmbH & Co, has received "Preferred Supplier" certification from machine manufacturer Niehoff, following a successful business connection of many years' standing.

Wolfgang Weber, commercial director of Joachim Uhing KG GmbH & Co, received the award from Martin Hannosy, procurement manager at Maschinenfabrik Niehoff, who explained that the award was in recognition of Uhing's "…product quality, service and delivery reliability," and continuing, "Uhing [has] proved to be a competent partner you can rely on in every respect."

Delighted with the recognition from Niehoff, Wolfgang Weber said he considers it "an incentive for continued dedicated commitment. It goes without saying that we will not rest on our laurels."

Joachim Uhing KG GmbH & Co – Germany
Fax: +49 4347 906 40
Email: info@uhing.com
Website: www.uhing.com

Maschinenfabrik Niehoff GmbH & Co KG – Germany
Fax: +49 9122 977 155
Email: info@niehoff.de
Website www.niehoff.de

Sikora opens its second office in Shanghai

Sikora Asia has established a second office in Suzhou/China, situated in a highly industrial area close to Shanghai.

Wanbin Chen, head of Sikora Asia, is confident about the business expansion: "We decided for the additional sales location to be more flexible and able to specifically address and attend customers on time. Our customers can expect a more convenient service with lower service costs, due to shorter travelling distances.

"As we also engaged new employees we can more profoundly react to individual customer needs and most of all we can improve the information flow with them.

"Simultaneously, our objective in establishing a second office here is to raise awareness about our products and to convey Sikora's company image of future-orientation," Chen explained.

Sikora Asia– China
Fax: +86 512 6777 2647
Email: sales@sikora-asia.net
Website: www.sikora.net

New measurement catalogue for 2008

Cropico has published a new, 48-page full colour brochure.

The brochure details the company's essential specifications of all products in its range of measurement instrumentation.

Cropico's range includes digital microhmmeters, resistance decade boxes, test standards and temperature measurement solutions used for high accuracy resistance, temperature measurement and calibration applications in the aerospace, manufacturing, engineering, electronics, pharmaceuticals, railway, automotive and utilities sectors.

Cropico – UK
Fax: +44 191 586 3511
Email: sales@cropico.com
Website: www.cropico.co.uk

EuroBLECH prepares to open its doors

The metalworking technology show EuroBLECH was first held in 1969 at London's Olympia Exhibition Centre.

Forty years and several location moves later, EuroBLECH is celebrating its 20th anniversary.

From October 21st to 25th, at the exhibition centre in Hanover, organisers expect to exceed the success of 2006 – when over 1,400 exhibitors from 40 countries welcomed 64,000 visitors from 73 countries to the 130,000m² hall space.

The event attracts industry professionals from across all metal working sectors. Specialists at all management levels, from SMEs as well as large and blue chip companies, will be making the trip to see the latest technologies, tools and systems on offer.

Potential exhibitors are advised to book their space as soon as possible, as floor allocation is almost complete.

Visitors to EuroBLECH can order a copy of the visitor leaflet. This will give all the important details of the exhibition, together with accommodation and travel information. It will be published in 12 languages and can be ordered online.

Mack Brooks Exhibitions – UK
Fax: +44 1727 814401
Email: info@euroblech.com
Website: www.euroblech.com

Solving a reel issue

Although some cable manufacturing companies provide limited schemes to recycle the large cable drums used for long length cables, the majority of cable reels are simply added to the waste disposal system.

Ventcroft is believed to be the first cable manufacturing company to offer a scheme to collect and reuse empty standard 100m cable reels.

Each year Ventcroft uses over 250,000 plastic reels to supply fire performance cable to users. Now both installers who use the cable, and wholesalers who distribute the cable, can take advantage of a scheme to help the environment and save money.

The plastic cable reels overcome the difficulty of disposing of cardboard and plywood reels, but it is the ability to recycle and reuse the reels which provides the greatest environmental benefit.

Plastic reels are more robust than cardboard or plywood, do not suffer from adverse weather and are moisture resistant.

Over 95% of plastic reels can be reused and the remainder can be recycled.

Ventcroft Ltd – UK
Fax: +44 1 928 581099
Website: www.protectingpeople.co.uk

Furnace safety 'first' for Norway

Elkem Solar has chosen Tenova Pyromet to supply a 3.5 MVA furnace in Kristiansand, Norway. The contract also covers the cooling system, tapholes, taphole drill and clay gun, pre-baked graphite electrode system, raw materials handling, secondary electrical system and all instrumentation and controls.

Pyromet will supply its MAXICOOL® system – an intensive cooling system for liquid bath operations, designed for heat loads of up to 500 kW/m^2.

For the first time in a Tenova Pyromet application, the furnace will use a mineral based oil as the cooling fluid. "The primary reason for using the oil is safety," says Tenova Pyromet Director Hugo Joubert. "While an oil leak may cause burning, it is slow enough to allow people to evacuate the site.

"Water, however, may cause an explosion and endanger lives."

Tenova Pyromet and Elkem Solar signed a confidentiality agreement to protect the intellectual property of both parties.

Tenova Pyromet Pty – South Africa
Fax: +27 11 482 1942
Email: pyromet@za.tenovagroup.com
Website: www.tenovagroup.com

New MD at Dätwyler UK

Dätwyler Cables has announced that Paul Cattell is the new managing director of Dätwyler (UK) Ltd. Mr Cattell will be responsible for the strategic direction of Dätwyler UK and will be in charge of financial and operational issues.

He will report to Markus Grueter, head of market region 1 at Dätwyler Cables in Switzerland.

Paul Cattell has held various sales and senior management positions in cabling, systems and blue chip companies. Before joining Dätwyler UK he had worked for Draka Comteq since 1999, where he became sales director UK & Ireland. His former positions at Draka include sales manager UK, market manager and business development manager for both copper cables and fibre optic solutions.

"Paul is an exceptional sales director with strong senior management experience and with a consistent track record of over achievement at all levels," said Markus Grueter.

"We believe that he is the right person to build upon our strong business relationships with our strategic customers and partners to ensure the ongoing growth. He will also support Dätwyler Cables in its new strategic positioning as a provider of high-quality systems solutions and services for electrical building infrastructure," he continued.

Dätwyler (UK) Limited – UK
Fax: +44 17 93 89 84 01
Email:
paul.cattell@daetwyler-cables.com
Website: www.daetwyler-cables.com

PA4T market development plant opens in Netherlands

Royal DSM NV has opened a market development plant for PA4T, the new polymer for use in electronics and other applications. The plant, located in Sittard-Geleen, the Netherlands is already operational.

PA4T, developed by DSM Engineering Plastics, is the first new polymer to be introduced in the new millennium. It is expected that PA4T will prove a replacement for metal in automotive construction, so offering opportunities for better fuel efficiency and lower emissions.

Nico Gerardu, member of DSM's managing board and responsible for the performance materials group, commented: "The opening of the market development plant is another significant step forward in the development of PA4T. This breakthrough polymer fits perfectly in DSM's accelerated Vision 2010 strategy and underlines again our commitment to innovation."

Roelof Westerbeek, global business director high performance polyamides at DSM Engineering Plastics said: "Our customers have told us they are very impressed by the excellent performance of PA4T in trials. The balance of dimensional stability, high mechanical and thermal performance and exceptionally low moisture uptake outpaces any existing polymer."

PA4T addresses in particular the market needs for lead free surface mount devices, such as circuit boards used in personal computers, as well as the current move towards halogen free electronics.

DSM – The Netherlands
Fax: +31 45 578 2234
Website: www.dsm.com

Emcore hits the top ten

Emcore announced an agreement to acquire the rest of Intel's Optical Platform division and its Connects Cable business. At approximately $7 per share, the deal is valued at slightly less than $28 million.

The acquisition puts Emcore in the top ten of the leading OC suppliers.

Daryl Inniss, vice president of industry analysts, Ovum commented: "The active optical cable business has good growth potential. Emcore has experience in parallel optics and indeed its captive supply of lasers and receivers puts it in good stead to make a high-margin product."

This acquisition follows Emcore's acquisition of Intel's telecom portion of Optical Platform division for $85 million earlier this year.

Emcore – USA
Email: info@emcore.com
Website: www.emcore.com

Fastener Fair for Budapest

There is a steady increase in economic activity in Eastern Europe. Romania attracted US$9 billion in foreign direct investment in 2006 alone, while Croatia is committed to achieving European Union entry standards by the end of this year. Later in 2008, Ukraine is expected to ratify World Trade Organisation membership, paving the way to more open trading relationships with the regions and the rest of the world.

Major producers, such as Peugeot Citroen and Daimler, are looking to open, or expand, production plants in Eastern Europe and Slovakia will soon have the highest per capita output of cars in the world. This, then, is the backdrop to a new regional trade show in Budapest, at the geographical and economic heart of developments in Eastern Europe.

The new Fastener Fair will take place on 22nd and 23rd September 2008, designed to be "both cost and time effective for exhibitors," show organiser, Jerry Ramsdale, explains: "It's a fly in, fly out exhibition, with a straightforward selection of stand options to provide exhibitors with hassle-free preparation, with no stand being larger than $20m^2$."

Set to showcase the fastener and fixing sector in Eastern Europe, Fastener Fair exhibitors are expected to include manufacturers, machine suppliers, distributors, importers, exporters and tool suppliers as well as trade associations and suppliers of services and related products.

Informal networking will be a key part of the show, beginning with an evening cruise on the Danube on the first night.

Fastener Fairs Group – UK
Fax: +44 1727 831 033
Email: jerry@fastfair.net
Website: www.fastenerfair.com

BUDAPEST

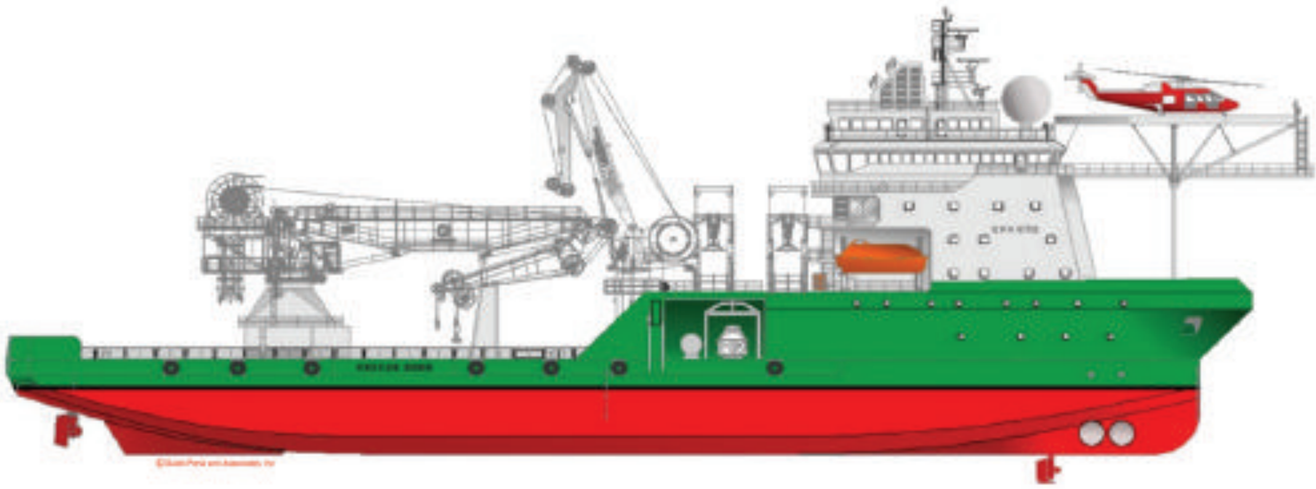
New moves in automation

Amaral Automation Associates has announced the appointment of Joe Snee as sales manager. Formerly with Huestis, Joe brings over 15 years of industry experience to his new position.

Joe Snee is a member of the Wire Association International and a member of the Exhibitions Planning Committee. He is also a member of the New England Chapter and is a member of the chapter's board of directors serving as Vice-President for 2008 and a member of the board of directors for the Wire and Cable Industry Suppliers Association (WICSA).

Amaral Automation Associates – USA
Fax: +1 774 203 3078
Email: joe@amaralautomation.com
Website: www.amaralautomation.com

Cables set to go to sea



▲ *Bourbon's latest offshore vessel - copyright Guido Perla (Bourbon)*

Nexans has signed a three-year contract to supply 3,146 km of halogen free, low-smoke marine power transmission (0.6/1KV and 250V power cables) and signal control cables for installation on Bourbon Offshore vessels.

Compliant with the most demanding of international standards, the cables will be installed in 54 new offshore supply vessels (less than 60 km per ship) being built for Bourbon at shipyards in China.

The cables will provide energy to equipment and conveniences, such as lighting.

The new ships will be used in a variety of roles to assist companies in developing deepwater and continental offshore oil and gas fields around the world.

They will be used as 'shuttle buses' between offshore platforms and ports, delivering people, materials and machinery. Some will also be capable of towing oil rigs into position.

"The shipbuilding industry is a priority market segment for Nexans as it's a booming industry, particularly in Asia, which requires a variety of high value-added products.

"Nexans provides reliable safety cables for all kinds of vessel: container ships, oil tankers, liquefied natural gas transporters and floating production, storage and offloading vessels," said Michel Lemaire, executive vice president for the Asia-Pacific area.

The cables will be manufactured in the Nexans plant in Shanghai, China.

Nexans Deutschland Industries GmbH & Co KG – Germany
Fax: +49 511 676 3777
Email: uniwema.tech@nexans.com
Website: www.nexans.de

Share your Dreams – the Ebner Trophy 2008

Ebner is encouraging a creative interest in metal by making 'Metal Dreams' the theme of this year's Ebner Trophy photography competition.

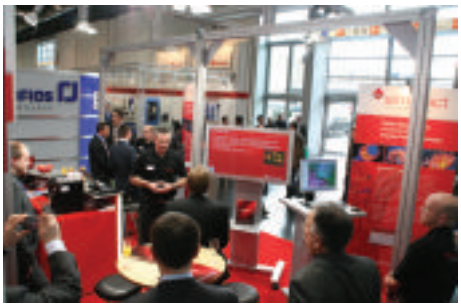
There are prizes for the three best photographs. See the website for more information and the entry form.

Ebner Industrieofenbau GmbH – Austria
Fax: +43 732 / 68 68 1000
Email: ebnertrophy@ebner.cc
Website: www.ebner.cc/ebnertrophy

Stand proves a draw at wire 2008

Simufact Engineering GmbH, provider of software and services to the bulk metal forming sector, announced that its booth at wire 2008 drew engineers from a range of industries.

At its first Düsseldorf show under the new name – changed from Femutec GmbH in February 2008 – the company is building up its brand recognition and focusing on its core business "Simulating Manufacturing".



▲ *The busy Simufact stand at wire 2008*

Simufact introduced the new version of Simufact.forming at the show, before its official release in May this year. Simufact.forming 8.1 offers significant improvements of the graphical user interface, a superior solver technology, a more efficient data exchange with CAD tools, plus the implementation of parallel computing methods, to guarantee short calculation times.

Simufact's latest activities include the foundation of Simufact-Americas LLC in the USA and a new office at the technology centre METAKUS in Baunatal.

Simufact Engineering GmbH – Germany
Fax: +40 790 16 222
Email: office@femutec.de
Website: www.simufact.de

FTTx shows 11% growth in 4Q07

Industry analysts, Ovum RHK, estimate that global FTTx deployments grew 11% in 4Q07 over 3Q07.

"According to our estimates, 1.6 million FTTx subscribers were added globally in 4Q07, up 11% from the previous quarter. We estimate the leading FTTx vendors for 4Q07 globally to be Mitsubishi and Sumitomo," says Lynn Hutcheson, vice president at Ovum RHK.

Verizon is said to lead North American FTTx deployments as it shifts to GPON. Asia-Pacific continues with 84% of all global installations, while North America had 14% of all global deployments. Europe continues to lag behind with only 2% of all installations.

Ovum RHK – USA
Email: skn@ovum.com
Website: www.ovum.com

第三届中国国际线缆及线材展览会
The 3rd all China – International Wire & Cable Industry Trade Fair

第三届中国国际管材展览会
The 3rd all China – International Tube & Pipe Industry Trade Fair

2008年9月23 – 26日
23 – 26 September 2008

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Shanghai Electric Cable Research Institute

中国国际贸易促进委员会冶金行业分会
Metallurgical Council of the China Council for the Promotion of International Trade

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Email: tube@neureuter.com.hk (for Tube China 2008 exhibitors)
Website: www.neureuter.com.hk

Celebrating a stand with a view

Harry Prunk, chairman of Sikora, was delighted with the success of the company's 192m² two-storey stand at wire 2008. Stand visitor numbers increased by 45% compared to wire 2006.

The ground floor formed the exhibition area, where all measuring and control systems were exhibited, while the modern lounge-styled second floor created a pleasant atmosphere for meeting and discussion.

"The second floor was enthusiastically received by our customers. From this outstanding position you could easily watch the fair in comfort," Mr Prunk explained.

▲ *The display level of Sikora's two-storey stand*

"Our customers immediately felt comfortable at our booth, which contributed to the further development of business connections and to make new contacts."

New developments in the spotlight at Düsseldorf included the Centerview 8000 for an 8-point-eccentricity-, 4-point-diameter and 8-point-ovality measurement, and the X-Ray 8000 NXT for the application in CV-lines.

The high achievers at the show were the diameter measuring devices of the Laser 2000 series, and the new display and control system, Ecocontrol 600 that clearly presents the measuring values of the connected measuring devices on an 8.4" TFT-colour monitor and controls the production process.

Sikora AG – Germany
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Shown and sold at wire

▲ *Left to right, Kevin Bennet of BWE, Mr Igor Myagkov and Mr Vitaly Kyyashko from SMETA*

BWE Ltd launched the new 'S' range of Conform™ continuous extrusion machines at wire 2008 in Düsseldorf, and found immediate success. BWE's Conform S315i model with Induction Heated Tooling System was sold to SMETA Donetski, Ukraine.

SMETA intends to extrude refrigeration tubes from 9.5mm diameter aluminium rod, but additional tooling has been ordered for other products.

The S315 is designed for small copper and aluminium applications such as rectangular wire (magnet wire) and sections, solid aluminium conductor (SAC) and aluminium round and multivoid tubes machines and will be manufactured and assembled in China.

BWE Ltd – UK
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Website: www.bwe.co.uk

Sales generated at wire 2008

Pressure Welding Machines, manufacturer of cold pressure welding equipment and dies, reported excellent sales leads from wire 2008 in Düsseldorf.

Managing director, Steve Mepsted, said: "Although the show seemed less busy this year, the quality of visitors to our stand was much higher than before, with far more decision-makers in attendance.

"Our portable trolley-mounted models proved the most popular with visitors, especially our new HP100 auto air/hydraulic welder designed for high cycle welding. The manual M101 model and pneumatic P101 machine also generated a lot of interest and sales leads which we have since converted into sales."

Pressure Welding Machines – UK
Fax: +44 1233 820847
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Website: www.pwmltd.co.uk

Middle East & African interest

Scapa Cable Solutions, part of the Scapa Group plc, reported a successful week at the wire 2008 Exhibition in Düsseldorf.

Visitors to the stand represented over fifty countries with particularly strong interest from the Middle East and Africa.

Scapa Cable Solutions manufactures an extensive range of cable wrapping tapes and cable components, which are supplied direct to market leading cable and cable kit manufacturers.

Scapa cable wrapping tapes are widely used in the manufacture of power, telecommunication, data transmission, fire survival and sub-sea cables, and have been used in many of the world's major cable projects.

Scapa Cable Solutions – UK
Fax: +44 161 301 7446
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Show voted "best ever"

This year's wire show was declared "the best one ever" for Nextrom and Rosendahl.

The booth was constantly crowded with attendees from the complete global wire, fibre and cable industry enjoying the group's traditional hosting, offering a variety of Austrian and Finnish specialities.

A highlight of the week was the Customer Evening, attended by 350 partners from 39 nations.

Many orders were signed, leading CEO of Nextrom and Rosendahl, Mr Siegfried Altmann to announce that, "this is without a doubt, the most successful fair in our history."

Rosendahl Maschinen GmbH – Austria
Nextrom Oy – Finland
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Website: www.rosendahlaustria.com

Niehoff success at wire 2008

Maschinenfabrik Niehoff reports its most successful participation ever at a wire trade show, welcoming visitors from all continents at its wire 2008 stand.

The completely new opto-electronic traversing system NBAT for double twist bunching machines as well as the MT200/RI170.2 line which features new annealing and preheating technology for the inline production of data and telephone wires attracted particular interest. Orders for several double twist bunching machines equipped with the NBAT were placed during the trade fair.

The exhibited data cable line consisted of an MT200 type wire drawing machine with an integrated RI170.2 continuous inductive annealer, developed and built by the Niehoff group joint venture company NBM. This line will be field-tested by a well known cable company manufacturing high performance LAN Cat 8 cables. Another cable manufacturer of the same capability is planning to order a similar line shortly.

During the five days of wire 2008 the other exhibited equipment – an MMH50/RM121 multiwire drawing line, the latest high speed rewinding machine DSA Niehoff System Hacoba with CS630 spool pay-offs for multiwire bundles, a double twist stranding machine DSI631 with back twist pay-off ARD630D and longitudinal tape pay-off ALB600, and a 24-carrier high speed braiding machine BMV24 with BAS 800 take-up and pay-off unit – were sold.

Maschinenfabrik Niehoff GmbH & Co KG – Germany
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Website: www.niehoff.de

RFS appoints vice president for global marketing

Radio Frequency Systems (RFS) has appointed Eric Mariette to the role of vice president of global marketing and strategy. On 1st May 2008, Mariette assumed responsibility for ensuring that RFS's portfolio of RF solutions is fully visible to the global wireless sector, and that the company's solution-set continues to meet the varied demands of the industry.

"By playing a role across the entire RF chain, RFS fulfils a unique position in our industry," said Mariette. "Very few companies offer the same breadth of technology. Our approach is to look at the 'big picture' solution, not just the immediate problem.

For example, the challenge of migrating from GSM 900MHz to UMTS 900MHz encompasses a deal more than a choice of antenna; it also introduces interesting co-location interference issues, requiring sophisticated filtering solutions.

"By having a total system approach, RFS is able to predict what other issues might arise and deal with them before they occur."

Mariette comes to RFS with twenty years of experience in sales, marketing and business operations across the telecommunication and IT sector, a great many of those years with communications solutions group, Alcatel-Lucent where he was Asia Pacific vice president of business support and operations for the mobile communications and convergence groups, based in Kuala Lumpur, Malaysia.

▲ *Eric Mariette, vice president of global marketing and strategy with Radio Frequency Systems*

Radio Frequency Systems – Germany
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UK wire market review indicates steady growth to 2012

Industry market research company, Market & Business Development (MBD) has released its UK Wire and Wire Products Market Development report, looking at the years 2003 to 2012.

MBD's assessment is of a steadily increasing market due to the relatively positive outlook of a number of key end-users, such as the construction industry.

The report includes the following conclusions:

- Between 2003 and 2007 the UK market for wire and wire products appears to have increased, in volume terms, by 3% reaching a five year peak in 2007 of 818,900 tons. This is equivalent to cumulative growth of 30% during the review period.
- The forecast for the UK market is for year-on-year increases, projected to reach 1,033,901 tons in 2012. This is equivalent to real term growth of 26% compared with 2007.
- The stranded wire, ropes and cables sector is projected to reach 284,119 tonnes in 2012.
- The fencing and mesh sector is anticipated to increase by 31% between 2007 and 2012, to 600,039 tons.
- UK production of wire and wire products is expected to increase by 14%, though annual levels are anticipated to slow from 5% in 2009 to 2% in 2012. Output volume is projected to reach 753,714 tons in 2012.

The complete UK Wire and Wire Products Market Report, is available from MBD.

Market & Business Development (MBD) – UK
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Amaral to distribute PWM

Pressure Welding Machines (PWM), manufacturer of cold pressure welding equipment and dies, has announced the appointment of Amaral Automation Associates of Cumberland, RI as distributor for the United States and Canada.

Joe Snee, sales manager of Amaral Automation Associates, said: "The addition of the PWM line provides Amaral Automation with the opportunity to represent the best in the cold weld field, and we look forward to working with the PWM team."

Pressure Welding Machines – UK
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Amaral Automation Associates – USA
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Website: www.amaralautomation.com

Handling upgrade for VALE

Companhia Vale do Rio Doce, recently rebranded as VALE, has selected Tenova for a new expansion step of its Brazilian Northern Iron Ore System.

VALE's development will expand the Northern system shipping Terminal, expected to reach an iron ore export capacity of 130 millions tons per year, as well as to improve the up-stream production capacity at its Carajas mine.

Within this framework, Tenova was awarded a first contract for a turn-key supply of two identical Stackers of 16,000 tph, 55m boom length each, at Carajas mine site, and for a Stacker and a Reclaimer at S Luis terminal.

This is not Tenova's first contract with VALE, and a further five machines with the same technical specifications are expected to be supplied in the future.

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Transatlantic Cable

Popped rivets challenge bow-gash as an explanation for the sinking of the Titanic

The general assumption has long been that an iceberg tore a huge gash in the starboard hull of the Titanic, which sank in under three hours in the early hours of 15th April 1912.

The discovery, in 1985, of Titanic's resting-place two miles down in the North Atlantic opened up new avenues of inquiry. An expedition of 1996 found not a large gash but, obscured by mud, six narrow slits where bow plates appeared to have parted from the hull. Naval experts speculated that rivets had popped along the seams, admitting seawater under high pressure.

Writing in the International Herald Tribune on the 96th anniversary of the catastrophe, William J Broad picked up the story with the involvement, as of 1997, of Timothy Foecke of the National Institute of Standards and Technology, a federal agency in Gaithersburg, Maryland. A specialist in metal fracture, Mr Foecke analysed two rivets salvaged from the Titanic and found about three times more slag than occurs in modern wrought iron. Slag, a glassy residue of smelting, could make rivets brittle and prone to fracture. ("Weak Rivets a Possible Key to Titanic's Doom," 15th April)

A team of scientists including Mr Foecke and Jennifer Hooper McCarty, whose doctoral thesis at Johns Hopkins University in Baltimore, Maryland, analysed Titanic's rivets, went on to study 48 rivets recovered over two decades from the ship's grave and found many riddled with high concentrations of slag. In early 1998, the marine forensic experts announced their tentative findings.

Mr Broad wrote: "The scientists found that the ship's builder, Harland and Wolff, of Belfast, struggled for years to obtain adequate supplies of rivets and riveters to build the world's three biggest ships at once: the Titanic and two sisters, Olympic and Britannic. Each required three million rivets, and shortages peaked during construction of the Titanic."

The account from that point, as pieced together from company and British government documents, has Harland and Wolff reaching beyond its customary suppliers of rivet iron to smaller forges employing workers of less experience and skill. Mr Broad wrote, "Adding to the threat, the company, in buying iron for Titanic's rivets, ordered No 3 bar, known as 'best,' not No 4, known as 'best-best,' the scientists found."

According to Mr Foecke, "Some material the company bought was not rivet quality." The damage to the hull, he said, "ends close to where the rivets transition from iron to steel."

Harland and Wolff also faced shortages of skilled riveters, according to archive papers cited by the scientists. Ms McCarty told the Herald Tribune that for a half-year, from late 1911 to April 1912, when Titanic set sail, the company's board addressed the shortfalls at every meeting.

❇ The conclusions of the marine scientists are vigorously rejected by Harland and Wolff, still very much in business in Belfast. A company spokesman pointed out that Olympic, sister ship to the Titanic, sailed without incident for 24 years until retirement. Another Harland and Wolff source, a former official of the company, said that big shipyards often had to scramble for parts and workers – and do, still, apparently. On one recent job, he said, Harland and Wolff had to look to Romania to supply welders.

The marine scientists argue the case for faulty rivets, and detail their archive findings, in "What Really Sank the Titanic," a new book from Citadel Press. James Alexander Carlisle, whose grandfather was a Titanic riveter, bluntly refutes the rivet theory on the website www.belfast-titanic.com

Mr Carlisle wrote, "On the Titanic's port side there is a three-metre dent, caused by the ship hitting the seabed. The dent has caused a 270-degree bend in the steel plates. This is most probably caused by the ship trying to bend after hitting the sea bottom. All rivets are in their original place."

Declares this voice of the opposition, "BAD RIVETS NO WAY!"

NAFTA and the neighbours

President Bush, contemplating a tattered legacy, tries to check erosion of his free-trade policies

"We talked a lot about [the North American Free Trade Agreement], and of course we agreed that this is not the time to even think about amending it or cancelling it," said President Felipe Calderón, of Mexico, in the presence of President George W Bush, of the United States, and Prime Minister Stephen Harper, of Canada. The Mexican president added, "This is the time to strengthen and reinvigorate this free trade agreement among our countries."

Perhaps. But the three counterparts have to know that their assertion of economic progress since 1994, when NAFTA was inaugurated, is not wholly embraced in any of their countries. Indeed, after two days of meetings with Mr Bush in New Orleans, in April, under the auspices of the United States Chamber of Commerce, the Mexican and Canadian leaders made a point of saying that, while they affirm their own faith in the pact that has eliminated tariffs and other restrictions on products traded among the US, Canada, and Mexico, they cannot bind their successors.

Nor, of course, can the American president speak for his successor, who will be elected on 4th November and take office on 1st January 2009. But, while Mr Bush seems comfortable with the idea of quitting the Oval Office with much other important business on the desk, viz the Iraq war, he is clearly intent on shoring up his free-trade policy, which had seemed set to become one of the less contentious holdovers of his presidency.

Over the months leading up to the election, Mr Bush has been increasingly critical of the two candidates for the Democratic nomination, Senators Hillary Rodham Clinton and Barack Obama, both of whom have repeatedly pledged themselves to seek renegotiation of the terms of NAFTA.

And he even roped Messrs Calderón and Harper into sharply criticising a decision by House Speaker Nancy Pelosi to scuttle a vote on a free trade agreement with Colombia. Senator John McCain, the presumptive presidential nominee of Mr Bush's own Republican party, is a supporter of NAFTA and in general a proponent of free trade.

Under NAFTA, the world's largest trade bloc, trade among America, Canada and Mexico will have risen to an estimated $1 trillion by the end of this year, from roughly $290 billion in 1994. But it has aroused various discontents in all three signatory countries, especially in the US where a downturn in the economy is exacerbating fears about job security. Opponents of expanded international trade say it helps businesses but threatens American jobs and keeps wages from growing. Mr Bush claims that Mrs Clinton and Mr Obama are employing anti-trade arguments to attract the votes of working-class Americans.

❈ Somewhat taken aback to find herself under fire from three heads of state, Speaker of the House Nancy Pelosi suggested that her chamber might yet hold a vote on a trade agreement with Colombia – if the Bush administration would consider an expansion of unemployment benefits, and an increase in training programmes to assist those US workers who lose their jobs as companies move operations overseas.

"The American people want solutions on the economy and less partisan rhetoric from the president," Ms Pelosi said in a statement. "Democrats have repeatedly told the president we are willing to work with him in good faith to create jobs and restore our economic strength."

Mr Bush was not soothed. "She's effectively killed [the deal with Colombia]," he fumed, and reiterated his warning that its failure would affect regional security by weakening the Colombian president, Álvaro Uribe, and strengthening Venezuela's president, Hugo Chávez. Mr Chávez has been openly contemptuous of the US, its president, and its policies in Latin America.

As those who would be president focus on Mexico, jobs lost to China go unremarked

Writing in the New York Times for 22nd April, Elizabeth Malkin points out that the Democratic candidates are replaying the arguments made against the North American Free Trade Agreement in the early 1990s, when opponents like the Texas data-processing tycoon Ross Perot argued that it would create a "giant sucking sound" of jobs moving to Mexico. But much has changed since then. "For a start," said Ms Malkin, "Perot Systems, which he helped found, has set up a Mexican subsidiary."

In the first years under NAFTA, jobs did leave the United States for Mexico. But Ms Malkin noted that, in this decade, American jobs lost to China have vastly outnumbered those going to Mexico.

And Mexican companies are moving their own factories to countries with an even lower wage scale – especially China, economist Enrique Dussel Peters told the *Times*. Dr Dussel heads the Center of China-Mexico Studies at the National Autonomous University of Mexico, the largest university in Latin America.

Transatlantic Cable

While the debate in the United States centres on Mexico as the cause of job losses in the US, Dr Dussel locates the source of the problem elsewhere. "There's a fourth uninvited guest at the NAFTA party," he said, alluding to China.

Goods entering Mexico from China and other Asian countries moreover have dissipated the surge in American exports to Mexico that was expected to flow from NAFTA. Ten years ago, almost 80% of Mexico's imports came from the United States. Last year, that dropped to below 50%.

Boeing's 'virtual fence' on the Mexican border falls short of expectations

Boeing Co makes airplanes, not virtual fences. Or, at least, it does not make good ones, according to the US government, which has scrapped Project 28, the $20 million Boeing prototype for the monitoring system being installed along a 28-mile stretch of the US-Mexico border. Officials cited the failure of the design to adequately alert Border Patrol agents to illegal crossings from Mexico into the United States. The decision against the design was announced on 23rd April, just two months after Homeland Security Secretary Michael Chertoff approved the Boeing system – a line of nine electronic surveillance towers installed along the border, southwest of Tucson, Arizona. But dissatisfaction had emerged much earlier.

On 22nd February, less than a week after Mr Chertoff accepted Project 28, the Government Accountability Office (GAO) told Congress that it "did not fully meet user needs." Accordingly, "the project's design will not be used as the basis for future developments." The major problem identified by the GAO was a time lag between the electronic detection of movement along the border and the transmission of a camera image to agents patrolling the area.

Officials said Chicago-based Boeing is to replace Project 28 with a series of towers equipped with communications systems, new cameras, and new radar capability. Meanwhile, the fence is still functioning. But according to the deputy director of the Secure Border Initiative programme, in Washington, it does not come close to meeting the goals of the border patrol. The virtual fence represents only a fraction of the technology and equipment for cross-border interception that Boeing is to provide under an $860 million government contract. The work under way in Arizona is the first phase of a federal undertaking to secure first the Mexican border to the south, then the border with Canada on the north. The US-Canadian interface is the longest undefended border in the world.

Of related interest . . .

- According to a study commissioned by the US Chamber of Commerce, a government plan to clamp down on illegal workers could cost American employers more than $1 billion a year. The Department of Homeland Security (DHS) would require employers to fire workers unable to resolve mismatches between their names and their Social Security numbers – those assigned to US citizens with their first jobs and retained by them for life. The Chamber of Commerce challenges the DHS contention that this method of ferreting out uncredentialled workers would not place a heavy burden on companies. The chamber also estimates the wages lost by legal workers in consequence of mistaken mismatches at up to $37 billion a year.

- Over the last two years, more than 3 million Latin American immigrants in the United States have stopped sending money home to their families in their home countries, according to a survey released 30th April by the Inter-American Development Bank. Only 50% of some 18.9 million Latino immigrants in the US now send money regularly to relatives, compared with 73% two years ago.

  The survey traced the drop in the number of people sending money home to pressures on the immigrants deriving from the slump in the low-wage job market and the Bush administration's crackdown on illegal immigration.

The survey, conducted in Spanish by the Washington-based bank from 9th to 23rd February, drew on information collected from 5,000 interviews. Of the immigrants responding, 47% said they did not have legal status; the others were US citizens and legal immigrants.

Automotive

- Volkswagen AG has said it will make an announcement this summer on whether or not to build a new US production facility. If it does decide to go ahead, the German auto maker will site the plant in either Alabama, Michigan, or Tennessee. Production would start within the next two years, with initial output of 100,000 to 150,000 annually and expansion to a maximum of 250,000 vehicles. Company officials have said the first car would likely be a replacement for the Passat passenger sedan designed for the US market. Volkswagen is the world's fourth-largest auto maker but commands only 2% of the US market. Earlier this year, Stefan Jacoby, the president and chief executive of Volkswagen Group of America, said the company hopes to more than triple its sales in the US to a million cars a year by 2018. Volkswagen recently moved its North American headquarters from suburban Detroit to Herndon, Virginia, outside Washington, to be closer to its East Coast customer base.

- Ford Motor Co plans to add 1,500 workers at a factory in Russia to increase its production in that country by almost 75%. A Ford spokeswoman in Moscow told Bloomberg News (22nd April) that the US company will increase capacity at the Vsevolozhsk plant near St Petersburg to 125,000 vehicles next year. The factory produces the Ford Focus hatchback, Russia's best-selling foreign-brand car in 2007, and will start making the midsize Mondeo this year, she said.

- General Motors Corp cited the slowdown in the US market for its 1% loss in first-quarter sales, a performance that placed the American auto giant behind its Japanese rival Toyota by about 160,000 vehicles. Toyota sold 2.41 million vehicles in the period – for a 2.7% increase over fourth-quarter 2007 – to GM's 2.25 million. Toyota outsold GM in the first quarter of 2007, too, but its full-year sales trailed GM's by about 3,100 vehicles. If, this year, GM retains its 76-year-old title as the world's largest auto maker, it will have foreign auto buyers to thank. In the first quarter, 64% of GM's total sales were made outside the US, the most ever. The company's sales grew 78% in Russia and 58% in India. North America was the only region in which GM did not set a sales record.

The economy

Exports stave off contraction – barely – in a first quarter of anaemic economic growth

The Commerce Department on 30th April reported that the US economy expanded at an annualised rate of only 0.6% over the first three months of the year, reflecting the increasingly pinchpenny ways of the average consumer in a period of sinking real estate values, tightening credit, and a deteriorating job market. Consumer spending grew at a miserable 1% annualised rate for the quarter, down from 2.9% the year before and 3.1% in 2006. The economy was kept from contraction only by growth in exports – helped by a weakening dollar – and a buildup of inventories by businesses.

Excluding these positive factors, domestic sales of goods and services dropped at an annualised rate of 0.4% in inflation-adjusted terms, the first quarterly decline since the end of 1991. Economic growth was also retarded by the continuing shrinkage in construction and business investment. Even the good news about higher inventories came with a cautionary note. Business must improve quickly, and stockpiled goods move out of factories, if companies are not to lay off more workers and take even more discretionary income out of an economy already short of free-spenders.

Transatlantic Cable

Moreover, if orders pick up, and jobs are saved, factories working down inventory are likely to cut back on production and, with it, working hours and purchases of raw materials. Paltry as it was, the first-quarter growth would appear to counter the view that the US economy is in recession – defined by the government as a "significant decline in economic activity spread across the economy, lasting more than a few months." Even so, many economists and other specialists consider the recession/no recession question a purely academic exercise at this point. They expect the economy to slip into negative around mid-year, given the spread of joblessness and the steady erosion of consumer spending power. Even those American workers with steady paychecks are losing ground. Also on 30th April, the Labor Department reported that wages and benefits dipped by 0.6% from the first three months of 2007 through March of this year in inflation-adjusted terms.

In brief . . .

- China claims to have tied the United States in the number of its citizens using the Internet: some 221 million people, according to the official Xinhua News Agency.

  This represents a 61% increase over the 137 million Chinese Internet users reported at the start of 2007. But a comparison based on the raw numbers may be misleading.

  The rating service Nielsen Online estimates the American online population at 221 million, as well; but it counts only the great majority of Internet users in the US with access at home or at work, while one-third of Chinese users gain access in cybercafes. The Xinhua report of 24th April drew upon data for February from the government's China Internet Network Information Center.

- The United States, with less than 5% of the world's people, has almost 25% of its prison population. According to data from the International Centre for Prison Studies at King's College (London), the US has 2.3 million convicts behind bars, more than any other nation. China, four times as populous as the US, places a distant second, with 1.6 million people in prison. The Chinese total excludes hundreds of thousands of non-criminals, such as political activists, held in so-called administrative detention.

  The United States also ranks first in rate of incarceration. It has 751 people in prison or jail for every 100,000 of the population (one of every 100 American adults is locked up)

  Russia places second among major industrialised nations, with 627 prisoners for every 100,000 people. The others have much lower rates. The incarceration rate in England is 151 per 100,000; in Germany, 88; in Japan, sixty-three.

- Hard times for Americans have opened up a new category of outsourcing, as Indian debt collection agencies in growing numbers are engaged by their US counterparts to follow up delinquent accounts. In the New York Times for 24th April, Heather Timmons reported that, while perhaps only 5% of American debt collection is now done outside the country, the sector is growing, with India set to become the largest operating area. One US debt collection agency, half of whose 300-strong workforce is in India, pays its collectors there an average monthly base salary of $425, plus bonuses for getting laggard clients and customers to pay up. While debt collectors in the United States earn about $6,500 a month, even so the job is attractive in India where the average income is $63 a month. And the agency's chief executive told Ms Timmons that the India-based collectors have an aptitude for persuasion. They are "very polite, very respectful, and they don't raise their voices," he said. "People respond to that."

Telecom

Motorola hopes to stem its losses by segregating its lagging cellphone unit

Motorola Inc posted a steep first-quarter loss as sales in the company's key handset unit fell 39%, extending a two-year slump. The Schaumburg, Illinois-based company – a once-strong rival to Finland's Nokia and Samsung, of South Korea – said 24th April that its cellphone division posted an operating loss of $418 million for the January-March quarter, compared with an operating loss of $233 million in the same period of 2007. The division shipped about 27 million handsets during first-quarter 2008, in the course of which its share of the global market fell to less than 10% – down from 22% last year. The mobile unit accounted for just 44% of total sales, compared with as much as two-thirds of Motorola's revenue just a few years ago. In contrast, the company's two other divisions presented a picture of health.

Writing in the technology section of USA Today, Leslie Cauley recalled the glory days of Motorola, which for decades set an example of inspired innovation. Founded in 1928, it greatly enhanced its status in 1973 when Motorola designers and engineers produced the world's first cellphone. The 28-ounce phone did not go on sale until 1984, but the company thereupon inaugurated "a global wireless revolution," said Ms Cauley ("Motorola Plots Its Comeback as Cellphone Icon," 24th April). In an effort to restore its position, Motorola has announced plans to split itself into two publicly traded companies: one devoted to the handset business, the other to the profitable units that provide software, hardware, and broadband gear. Currently, each of the two business categories contributes about equally to Motorola's $37 billion annual revenue.

In other telecom news . . .

- A large percentage of US residents cannot obtain the access speeds typically available to Internet users in Japan, South Korea, and some European countries. But, according to Glenn Fleishman, of PC World, broadband speeds and availability are finally starting to accelerate in America, promising relief from "the heartbreak of slow-broadband paralysis." He notes that AT&T, Verizon, Comcast, and other companies are rolling out 10 to 50 megabits-per-second service across the country, using fibre to the node (FTTX) and faster cable standards.

- Even as rates below 10 Mbps become more widely available, coverage areas for those services are expanding. Mr Fleishman's home city of Seattle, in the Pacific Northwest, is finally seeing digital subscriber line rates that match or exceed cable service. He wrote, "Qwest is now rolling out 12 Mbps and 20 Mbps DSL in 23 of its markets. They're the last major ILEC [incumbent local exchange carrier, formerly known as a Baby Bell] to create a real plan" for true high-speed broadband ("Faster Broadband! Thrill! Thrill!" 2nd May)

Dorothy Fabian – USA Editor

The splice is right with Sonobond

SpliceRite™ ultrasonic wire splicer from Sonobond Ultrasonics is designed to create perfect solid-state metallurgical bonds using the lowest possible voltage drop and minimum energy consumption.

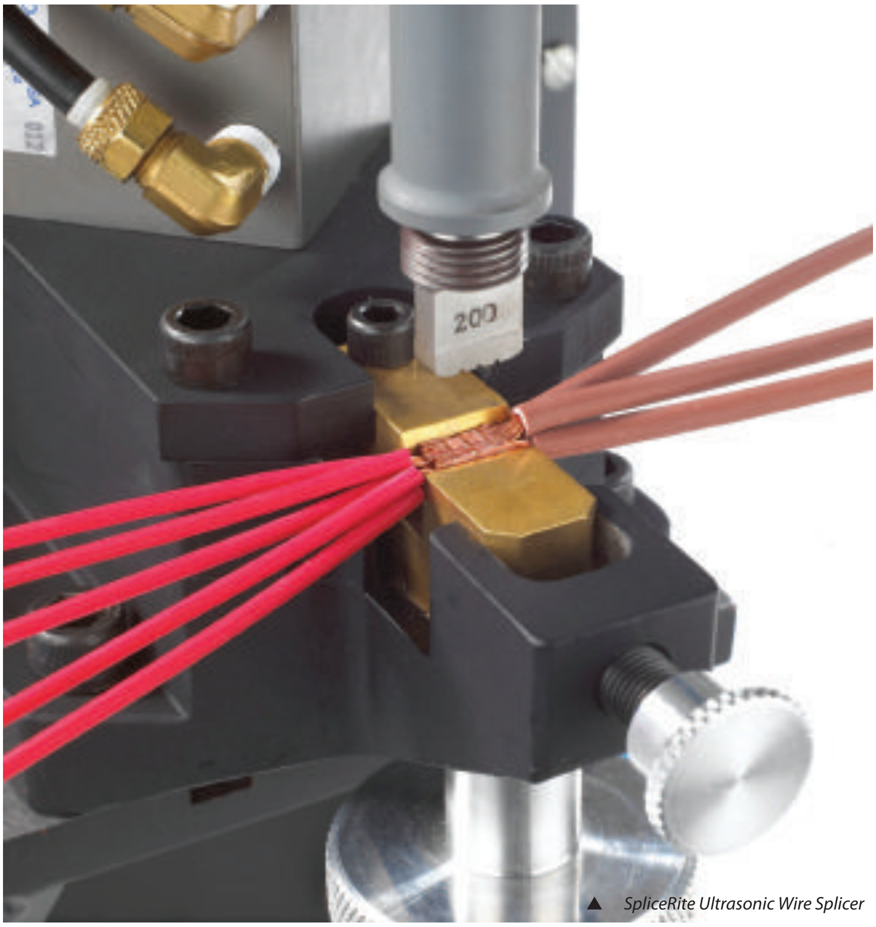
The unit eliminates the need for clipping, soldering, crimping, or dipping, quickly splicing wire bundles without producing arcs, sparks or fumes, or melting the wires. It will accommodate tinned or heavily oxidized wires and is available in 1,500 and 2,500 watts power capacities.

SpliceRite features Sonobond's patented Wedge-Reed system, combining high vibratory force with low amplitude coupling. It enables the unit to direct high frequency ultrasonic energy via a welding tip to the surface between the metals to be welded.

The vibratory energy disperses the oxides and surface films between the work pieces. A true metallurgical bond is then created without melting the materials.

All Sonobond metal welders, including the SpliceRite ultrasonic wire splicer, feature heat-treated, tool steel taper lock tips. These tips can last for up to 300,000 welds and permit quick tooling changes.

Sonobond ultrasonic welding units are environmentally friendly, economical and produce no waste, with the additional benefit of being easy to operate with only minimal training.



▲ *SpliceRite Ultrasonic Wire Splicer*

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technology at a glance

Nexans has been awarded a contract worth an estimated 24 million Euro to supply cables for the Sheringham Shoal offshore wind farm project.

The contract includes engineering, procurement and construction of two 22km 145 kV XLPE submarine export cables.

Full story inside

PWM has automated its HP100 air/hydraulic cold welder.

The new unit "can be used to recycle short lengths of wire that might otherwise be discarded, being too time consuming to weld."

Full story inside


EUROLLS
GROUP

100% tensile testing for specialist alloys

Alloy Wire International Ltd, a manufacturer of precision cold drawn round wire, flat wire and shaped wire, is using a PC-controlled universal materials testing machine from Lloyd Instruments as part of its quality assurance procedure. Every coil of wire is subject to tensile testing prior to dispatch.

Alloy Wire International specialises in the production of high performance nickel, cobalt and titanium alloys for use in any environment that requires resistance to very high temperatures and corrosion, but where the mechanical properties of the metal must be retained.

The materials are frequently used in the manufacture of springs, seals, fasteners and many other applications used in a variety of industries including aerospace, petrochemical, medical and nuclear.

Tensile tests are performed using a Lloyd Instruments EZ50 50 kN twin column universal materials testing machine equipped with NEXYGEN™ MT control and data analysis software. NEXYGEN™ MT features a comprehensive library of international standard tests for many different applications, including EN, BS and ASTM standards, however the system can also be configured to carry out user specified tests. Tests can be carried out on material both before and after heat treatment.

Alloy Wire International's quality manager, Peter Lambe, said: "Our focus is on the production of comparatively small quantities of material with fast turn-round, manufactured to customer specification, so testing and certification of every coil is a vital part of the quality process.

"Materials testing is an important part of this procedure and we have been using equipment from Lloyd Instruments for about 19 years.

"As well as tensile testing, we can also perform bend tests, elongation, torsion tests, wrap tests and proof stress tests as part of the certification, if required."

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Flat cable saves installation costs and complexity

With the Ecobus Power I 5 x 16mm² and the appropriate adapters, Dätwyler Cables introduces a complete energy flat cable system in the IP65 protection class.

The five-conductor Ecobus power flat cable (3L+ N + PE) is optionally available with a halogen-free low-smoke or with an oil-resistant PVC sheathing.

Available components include a Power I-adapter for the attachment of an input/output cable of up to 5 x 16mm and an output adapter for up to two cables of 5 x 6mm². Connections are furnished through contact point screws at suitable locations along the entire length of the cable, and also under voltage, thus avoiding stripping and cutting the flat cable.

The external measurements of the flat cable are 48.5 x 11.3mm, and the fire load is only 2.48 kWh/m. It can be protected with 3 x 63A, so a single cable can be operated at electrical capacities of up to 40kW.

Ecobus cables are approved by a Lloyds Register certificate for use in ship construction and on drilling platforms.

With Ecobus flat cable system the energy to be supplied can be tapped at any desired point using Ecobus puncture and connection adapters. Furthermore, these installations allow problem-free reconfiguration.

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▲ *Dätwyler flat cable system with IP65 protection*

Egyptian contract for Italian machinery

PS Costruzioni Meccaniche Srl has been awarded a large contract with Egyptian cables manufacturer, El–Sewedy, for nine coiling machines, both semi-automatic and fully automatic coil winding systems.

Some PS machines are to be installed at El-Sewedy Mother Company in Egypt, while others are destined for El-Sewedy branches. Cables to be processed by PS machines will range from 1mm to 25mm diameter.

PS will also supply an automatic coiling machine, mod. PS 600/25. This line can produce three coils, 100 metres long, per minute. These coils can reach an OD up to 600mm and have a maximum weight of 80 kilos.

PS Costruzioni Meccaniche Srl – Italy
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Wire lubrication control eliminates pre-coating chemicals

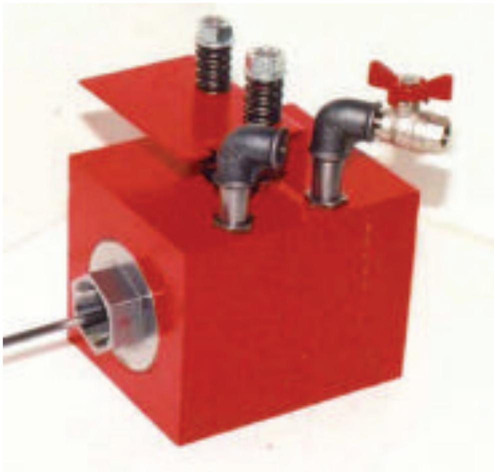
Advertorial on behalf of Decalub

New Lubricant Viscosity Control (LVC) system, used in conjunction with the PDH ultra high-pressure lubrication technology, can be used in the most demanding drawing applications, allowing mechanically descaled high- or low-carbon rod to be drawn directly at high speed, without pre-coating chemicals.

LVC/PDH rod dry coating/lubrication system uses three-way interaction between the pressure, temperature and lubricant viscosity to produce a fusion of standard lubrication compounds, liquefied to a viscosity to suit the application. This eliminates traditional pre-coating chemicals, including phosphate and borax pre-coating, and provides a consistent residual coat in the first draft.

The system permits frictionless drawing in remaining drafts with the full lubricant film at wire-die interface, giving physical separation of metal-to-metal contact, in the most demanding multi-draft applications from rod to wire in a one-step operation.

The new rod dry coating/lubrication system allows a wide range of residual coats, from strongly adherent – for high-tensile wire – to a light, water soluble coat for plating wire.



▲ *Wire lubrication by LVC / PDH system*

Typical applications of the LVC/PDH dry coating system include direct drawing from mechanically descaled H/C rod, without pre-coating chemicals, from 5.5mm down to 1.3mm at 18m/s, and to 3.25mm at 8.3m/s, with die life enabling production of 200-220 tonnes/die in the first draft.

The finishing die produces 40 to 60 tonnes of wire drawn without pre-coating chemicals and with improved ductility, cast and torsion.

LVC/PDH lubrication system features zero energy consumption, self-generating processing heat and pressure.

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Multiple measuring technologies

Zumbach Electronics' non-contact, on-line measuring and control instruments. products are used worldwide for dimensional parameters such as diameter, thickness, eccentricity, out-of-round and for physical or electrical parameters including expansion, capacitance and dielectric strength.

One or more parameters on a production line can be monitored simultaneously.

Ultrasonics

- for wall thickness, with UMAC®/ WALLMASTER systems
- up to 8 measuring points
- up to 15,000 measurements/s
- novel concentric transducer adjustment allows product diameter set in a few seconds.

Optical/Magnetic (combined)

- for eccentricity/concentricity and diameter, with ODEX® gauges
- insensitive to wire vibration due to high speed scanning
- extremely compact and fully static, no moving mechanisms
- automatic inductor control allows for installation in tight areas

X-Ray Tomography

- for wall thickness, eccentricity, diameter/ovality with RAYEX® Systems
- high simultaneous measuring rates, in x and y axis
- unique protection system for beryllium windows
- customised measuring tube segments

Laser

- for diameter/ovality with 1, 2 or 3 axis ODAC® gauges
- highest accuracy, repeatability up to 0.05 µm/0.0000001 in.
- ultra high scan rate, up to 2,000/s
- more than 60,000 gauges sold

Offering material savings, process optimisation and a fast return on investment, Zumbach equipment ensures the quality of wire and cable products of any size and form, using state-of-the-art technology throughout the range.

▲ *A typical gauge using each of Zumbach's technologies*

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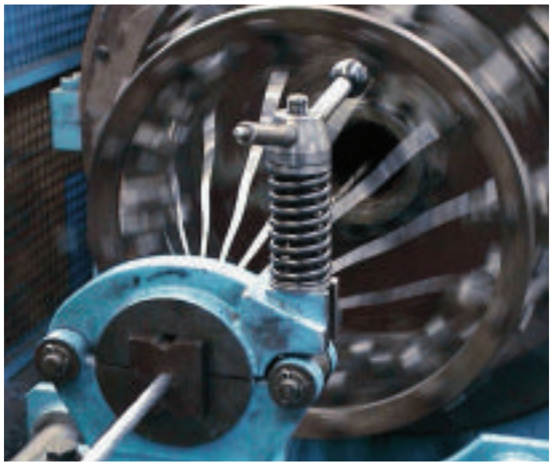
Emulsions for drawing

Bechem took the opportunity offered by wire 2008 to demonstrate its emulsions for aluminium multiwire drawing.



▲ *Emulsions offer environmental advantages over traditional oils*

Conventional oils have previously been used for the drawing of aluminium and aluminium alloy wires, and especially rod wire drawing. However, the partially highly viscous media are linked with known disadvantages, such as impossible filtration.

Bechem's Berudraw products have a lower viscosity, and are said to offer improved filterability, residue-free wires and more stable drawing processes. Using emulsion for multiwire drawing allows a cleaner and more pleasant working environment that cannot be achieved with conventional drawing oils.

Clean drawing machines and optimal filtration provide an almost residue-free finished product with a high quality surface finish.

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HVDC cable to link Finland and Sweden

Nexans has been awarded a contract by Fingrid Oyj, the electricity transmission system operator in Finland, and Svenska Kraftnät, a state utility which runs the national electrical grid in Sweden. The contract is for the manufacture and installation of a High Voltage Direct Current (HVDC) submarine power cable for Fenno-Skan 2, the new power interconnector between Finland and Sweden.

Nexans will supply around 200 km of specialised solid, oil-impregnated MIND (Mass Impregnated Non-Draining) cable for both the subsea and land based elements of the Fenno-Skan 2 interconnector. With a copper cross-section of 2,000mm^2, this will be the largest capacity HVDC cable manufactured by Nexans to date.

The Fenno-Skan 2 HVDC project will create a new 800 MW, 500 kV subsea electricity transmission connection between southern Finland and Sweden, following a 200 km route across the Gulf of Bothnia. It will form a bipolar arrangement with the existing 550 MW, 400 kV Fenno-Skan link, commissioned in 1989, to provide a 40 per cent increase in power transmission capacity between the two countries. Manufacture of the Fenno-Skan 2 cable will start in Autumn 2009.

▲ *Nexans' own cable laying ship – the CS Skagerrak*

The installation of the subsea cable, at a maximum sea depth of 100m, will be carried out by Nexans' own cable laying ship, the CS Skagerrak, and this is scheduled for spring 2011. The cable will be supplied in two continuous lengths of around 100 km, with just one offshore joint.

"This major contract for the Fenno-Skan 2 project reinforces Nexans' position as a key manufacturer and installer of high-technology cables for subsea power interconnectors," commented Patrick Barth, MD of Nexans' high voltage activity.

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Making sure the link's not missing!

Chain making machines are an important part of business for Vitari SpA.

The company manufactures machines for ornamental chains, welded and un-welded; welded chains for agricultural and industrial use; snow chains; alloy steel chains for the mining industry and lifting systems.

Various models of bending machines are produced, in one or three bending stages, and also two lines of welding machines for chains from ø2.0mm to 26mm.

▲ *Machines for making all types of chainss*

The alloy steel chain welding is completed in medium frequency (1,000 Hz) which enables the perfect control of all welding phases. All welding parameters for each specific diameter and material can be stored in the PLC of the machine

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Induction heating technology

ATE Applicazioni TermoElettroniche was founded in 1987. Combining in-depth experience in the fields of industrial electronics, static energy conversion and electric heating for various industrial applications, ATE has become well-known as a manufacturer of induction heating systems.

▲ *An ATE system installed for Buehler*

Specialisation, innovation and continuous investment in research and technology are applied to the entire process, from internal organisation to customer service, and are the underlying and guiding principles of ATE Applicazioni TermoElettroniche's business.

ATE's aim is to respond to new challenges, to develop new applications which satisfy the most demanding customers, accompanying them from the initial study right through to commissioning and during the entire useful life of the system.

ATE induction heating systems include heating plant and thermal treatment of wires, bars, tubes and steel strips; melting furnaces for ferrous and non ferrous metals and precious alloys and induction heating systems for hot assembling

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Non-contact measurement using Proton's InteliSENS

Proton has launched three models of non-contact laser doppler wire and cable speed/length measuring sensors. These sensors are a direct replacement for all cumbersome mechanical wheel or belt type cable length counters, and are wear-free.

In addition the sensors deliver a host of interfaces including incremental Pulse O/P's, profiBUS, RS232, CanBUS, Ethernet IP and deviceNET.

▲ *Proton's InteliSENS for cable measurement!*

In any cable factory there are material losses incurred of 1-2%, the result of shortages and over-lengths between intermediate processes, and the 'giveaway over-length' at final shipping. By offering three different sensors, Proton aims to supply a solution for "everything that moves in wire and cable," including applications that are difficult or impossible to measure using mechanical length counters.

By supplying every unit with a European wide recognised UKAS Certificate of Calibration, the Proton InteliSENS offers not only a system that is calibration-free but also has European Wide Traceability of Calibration.

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Website: www.protonproducts.com

Shot peening for valve and small pressure springs

Using the RDS shot peening system, shot peening of coil springs can be integrated into continuous production lines.

In RDS-Mini shot peening systems, single work pieces travel on horizontal rolls through the machine at a throughput rate of over 5,000 springs an hour. Springs are fed to the machine individually on a straight-line conveyor, or other loading system, and then moved through the blasting zone on continuously rotating horizontal rolls.

Cams attached to chains effect the necessary axial movements.

Inside the blasting zone, the springs are guided by adjustable baffle plates, which also serve to focus the shot stream on the work pieces for optimal exposure within the 'hot spot' of the blast pattern.

The parameters of the shot peening process, including shot quality, blast wheel speed/throwing velocity, the speed at which the work pieces rotate and dwell time, can be regulated to suit the specific type of work piece, and it is this definition of all parameters that ensures process-safety.

▲ *RDS-Mini shot peening system*

Process parameters can be recorded in the control system and retrieved when necessary.

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World's first...

At 600 metres long and a voltage of 138 kV, Nexans has claimed two world records for a superconductor cable incorporated in a power grid.

The world's longest and highest-voltage superconductor power transmission cable has been successfully energised in a test installation for the Long Island Power Authority (LIPA), one of the largest municipal electric utilities in the US. The 600-metre, 138 kV, 574 MVA power link, comprising three high temperature superconductor (HTS) cable phases running in parallel, is the world's first superconductor cable system installed in a live grid operating at transmission voltage.

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Harmonious future for OTA technology

OTA technology from Ernst Koch GmbH & Co KG is said to guarantee a particularly high quality product, and is especially suited for the production of spring steel and music wires.

Twenty-five of the machines have been supplied in the two years since the introduction of this new speed control technology. The OTA lines work without tuner and dancer rolls and thus ensure a linear wire passing from the first drawing block up to the spooler.

"We've noticed a continuously growing demand for the OTA machines since the introduction of the OTA technology," commented managing directors, Jochen Koch and Thomas Voss. "With the OTA speed control technology we've improved the productivity of our drawing machines by means of higher drawing speeds and longer operation times of the drawing dies on the one hand and achieving better quality results on the other hand."

The OTA lines are available in different sizes and models, and are suited for the processing of low and high carbon steel wires as well as of stainless materials.

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European growth for Xtra-Guard cables

Alpha Wire International has announced that sales of its Xtra-Guard® flexible cables range have doubled year on year in Europe for the last three years.

Growth has increased across the board in terms of industry sector but is most prevalent in the automation and control environments where robotics are increasingly utilised in manufacture. Xtra-Guard increases flex life cycles, refining cable profile and improving durability in single and multi-axis flexing applications.

Engineers are said to be increasingly aware of the difference between flexible and flexing. The ability of a cable to be bent and routed in order to create a 'dressed' installation is, of course, crucial. A flexible cable allows for easier installation and simplifies troubleshooting in the cabinet and/or equipment installation.

In many manufacturing applications cables have to withstand millions of flex cycles – something far more complex than simple flexibility.

Designers need to first consider the type of flexing that the cable will be required to withstand – such as single axis, torsional, multi axis or variable – as each requires a specific set of cable attributes. In applications where the cables will be subject to torsional or variable flexing, in robotics applications for example, it is essential to specify sophisticated cables that will be capable of twisting and random robotic flexing operation of ±360º per metre.

Harry Quinn, European director for Alpha Wire commented: "Our customers depend on us with their most critical applications, so just as systems become more demanding we continue to improve and refine all of our products.

"We understand that helping our customers to select the correct cable first time is essential to overall system reliability, system performance and safety. It's also crucial that this selection is made first time to avoid cable failure, which can be very costly in terms of production levels, profits and a company's reputation."

Alpha Wire has also made it easier to specify the right flex cable for the right application with www.xtraguard.com – an interactive web site and selection guide – that offers an intuitive and graphically-based product selector function. It allows engineers to quickly identify cable specifications for their system requirements.

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30 years of spring

This year marks the 30th year of trading in the UK for Lee Spring Ltd and sees the introduction of two new spring products: constant force springs and REDUX™ wave springs. Both spring types are offered from stock and can be custom designed to suit particular applications.

These products increase Lee Spring's portfolio to over 15,500 different types of stock spring.

Manufactured from high yield 301 stainless steel strip the constant force springs exert a near constant restraining force to resist uncoiling. This natural inbuilt stress resists load at an even rate and makes them suitable for use in retractor mechanisms.

Common applications include counterbalance springs, car seat belt and cable retractors.

Constant force springs are usually tightly coiled on a drum and either the free end or the drum can be attached to the load.

Four life cycle ranges are offered: 2500, 4000, 13000 and 25000 covering loads from 1.02 to 73.42N (0.23 to 16.50lb). Lengths vary from 356 to 1524mm (14" to 60"; thicknesses from 0.10 to 0.51mm (0.004 to 0.020") and widths span the range 6.35 to 31.75mm (0.250 to 1.250").

Wave springs perform a similar function to compression springs but use less height space due to a sine wave design.

Produced in stainless steel type 17-7 PH Lee Spring's REDUX™ wave springs can be used in static or slightly dynamic applications where space or radial and axial tolerances are tight.

They also offer greater control of axial movement and consistent load transfer.

Stock sizes range from rod sizes of 6.35 to 25.40mm (0.250 to 1.0") to suit hole diameters from 9.53 to 31.75mm (0.375 to 1.250") and in spring rates from 1.58 to 52.21N/mm (9.00 to 298lb/in).

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Wieland at wire

Among the products displayed on the Wieland-Werke AG stand at wire 2008 was its range of electronic wires, manufactured from high-performance copper alloys to combine the counteracting properties of high conductivity and high strength.

Special heat treatments and the addition of special alloying elements enable copper to resist alternating load, to transfer high currents and to withstand long-term high temperature operation without being subjected to high stress relaxation.

The materials K55, K65, K80 and K88 are used in connector pins, canted coil spring connectors, fatigue-resistant strands and high tension magnet wire.

Another new product on the stand was rectangular (flat) wire, tin coated by hot-dip tinning. This tinning method improves resistance to whisker formation in electrical contacts.

Wieland-Werke AG – Germany
Website: www.wieland.com

Analogue steps aside for new UFD40

Roland Electronic GmbH has introduced the newly designed digital UFD40 system as a successor to its proven analogue UFD detector.

The system has been designed to detect faults in butt welds and mechanical connections in wires, cables and small tubing made of metallic materials such as steel, stainless steel, copper, brass and aluminium.

▲ *Roland's digital UFD40 system succeeds the analogue UFDr*

UFD40 is based on the eddy current measurement principle; the material to be monitored passes through the orifice of an encircling coil sensor.

Roland Electronic offers sensors suited for materials ranging in diameter from 1mm to 90mm. The UFD40 has features typically available in classic eddy current fault detection systems designed for automated production processes, including adjustable frequencies, high and low pass filters as well as y-component and vector analysis.

This makes the system suitable to monitor many different discontinuities with one type of hardware.

UFD40 is of a modular design and offers several operating modes. The complete electronic circuitry for two independent measuring channels is housed in one IP65 module enclosure. Each channel automatically executes the measurement functions. The RS232 interface provides the connection to the host PC, which serves as the operating interface for the system and provides visualisation of all measurement values.

Both measuring channels function autonomously, allowing the disconnection of the host PC.

A parallel interface and fieldbus interface are available for communication with the production equipment PLC.

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Sheringham Shoal offshore wind farm secures its submarine cable

Nexans has been awarded a contract worth an estimated 24 million Euro to supply the submarine export cables for the Sheringham Shoal offshore wind farm project, located approximately 20km offshore from Sheringham, on England's north Norfolk coast.

The full execution of the cable contract, awarded by StatoilHydro, is subject to offshore development consent from the UK government and the project's final investment decision, expected during the second half of 2008.

The contract includes engineering, procurement and construction of two 22 km 145 kV XLPE (cross-linked polyethylene) submarine export cables, and a spare cable with associated equipment. An optical fibre cable manufactured at Nexans site in Rognan will also be included.

The power cables will be manufactured in Norway for delivery in mid April 2010.

The proposed wind farm will cover an area of 35 km^2 in water averaging 20m water depth. It is planned that 88 wind turbine generators, with a unit rating of 3.6 MW, will be connected via a network of infield cables to two offshore substations.

The total installed generation capacity will be 315 MW and, in an average year, approximately 1.1 TWh of power is expected to be available for export to the regional distribution network at Salle substation.

Completion and production start-up of the wind farm is planned for 3rd quarter 2011. The Sheringham Shoal Offshore Wind Farm will be developed by Scira Offshore Energy Ltd, a company established specifically for this development and owned 50% by StatoilHydro and 50% by Evelope Project.

▲ *An artist's impression of the proposed Sheringham Shoal offshore wind farm*

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Current issues at Cables 2008

The 8th AMI international conference, Cables, held from 15th to 17th April at the Maritim Hotel in Cologne, was applauded as "the most successful ever." AMI Consulting's Kerry Satterthwaite presented an overview of the European cable industry, concluding that restructuring in the European cables extrusion industry has paid off with a dramatic improvement in profits for 2007.

Primary focus of the conference was flame retardant performance under the new European Construction Products Directive (CPD). Wire and cable is now considered a building material under new EU legislation which classifies cables by their fire safety performance.

Testing protocols are still being established, explained Terry Journeaux of Prysmian Cables & Systems. The challenge is to develop repeatable and reproducible standards, and he detailed the European reaction to fire classification of cables under the CPD in 2008.

Many kilometres of cable are used in modern buildings and cars and, as electrical failure can be a common cause of ignition, cable fire performance and flame retardancy is critical. Dr Andreas Bacher of Wacker Chemie gave an overview of new silicones for wire and cable, including highlights of their superior heat resistance.

He commented on the synergistic effect of flame retardants, a topic also addressed by James Innes, president of Flame Retardants Associates of the USA.

Dr Rainer Sauerwein (Nabaltec) went on to examine trends in new metal hydrate flame retardants for high process temperatures. Materials differ in different global regions and include optimised metal hydrate blends. His paper examined potential future trends in flame retardants for cable applications.

New materials for cables were introduced at the conference including high performance polymers for the cables industry (Evonik Degussa), co-polyester resins for demanding cable applications (DSM Engineering Plastics), and recyclable polypropylene wire for automotive applications (Dr Lee, LS Cable Ltd of Korea).

Dow Wire & Cable is developing new polyolefin compounds to meet the needs of the international cables industry. Innovation challenges in the wire and cable market were discussed by Robert Tarimo, market manager from Dow Europe in Switzerland.

Dr Susanna Lieber of the Melos/Borealis team talked about the design of bedding compounds, which lie between the insulating compound and the cable sheath. Compatibility is important and factors that effect long-term performance, such as plasticiser migration, have been studied. She went on to describe how advanced bedding compound design can improve flame retardancy.

Dr Gunter Beyer of Kabelwerk Eupen has been working on nanocomposite flame retardants for the cable industry. In his 30 years of experience, layered double hydroxides have a major synergistic effect with halogen and non-halogen flame retardants. They appear to act by altering the degradation pathway and imparting barrier properties.

Daniel Calveras of General Cable, among the largest cable extrusion companies, followed up by describing General Cable's use of nanofillers in high performance medium voltage power cables.

Cables 2009 has been scheduled for 2nd to 4th March 2009 at the same venue.

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Cold welding went automatic at Düsseldorf

Pressure Welding Machines (PWM), manufacturers of high-performance cold welding equipment and dies, launched a new version of its best-selling HP100 air/hydraulic cold welder at wire 2008.

The new HP100 auto model can be used in either normal or automatic mode. In normal mode, the operator loads the material and then presses the foot pedal four to six times to activate the multiple upset process and complete the weld.

In automatic mode, the operator simply loads the material, presses a button and the machine does the rest.

In either mode, the HP100 auto guarantees consistent high quality welds on non-ferrous materials within a range of 1.00mm to 5.00mm (0.039" to 0.197").

The powerful solid steel welding head is mounted on an ergonomically designed trolley with a sloping platform that gives the operator a clear view of the weld area. Power consumption is minimal, and in operation the HP100 auto requires only a supply of compressed air and an electric power source.

▲ *The welding head of the new HP100 auto air/hydraulic cold welder*

Steve Mepsted, managing director of PWM, said: "The HP100 has been one of our best-selling models for the last five years. It's economical and can be wheeled to the weld area.

"In automatic mode, the machine provides wire and cable manufacturers with an effortless way of welding copper and aluminium wire and strip.

"Ideal for high cycle welding, the HP100 auto can be used to recycle short lengths of wire that might otherwise be discarded because they are too time consuming to weld, so helping manufacturers to reduce wastage and material costs."

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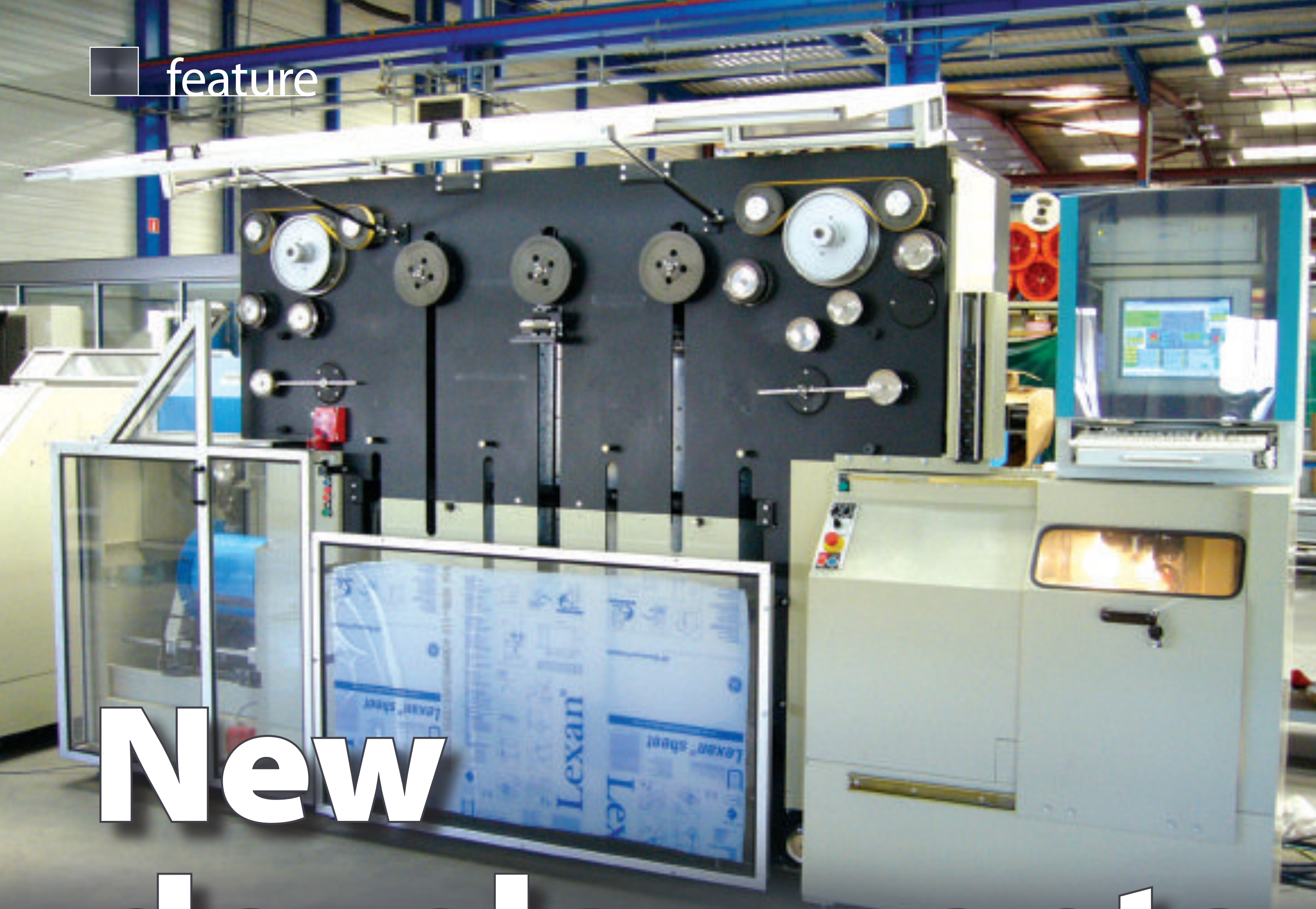


New developments in fibre optics

In the introduction to the expanded 2004 edition of Jeff Hecht's book City of Light: the Story of Fibre Optics [Oxford University Press, 1999] he enthuses, "I've covered the development of fibre optic communications for nearly a quarter of a century, and it's given me the rare thrill of watching a technology on a roll. I feel like a sports writer with the good luck to cover a truly great team on its way to a championship." However, the 1999 edition had ended on a wistful note. "The Last Mile: an Elusive Vision" cast an eye back over 20 years of efforts to bring fibre optics to the home, starting with a Japanese system called Hi-OVIS which began operation in 1978. "The idea retains its appeal," noted the historian of fibre optics. "But [it] has yet to be made practical."

Now, of course, fibre-to-the-home (FTTH) is altogether practical. The number of homes worldwide connected via end-to-end fibre steadily rises, as does the "take rate" — the percentage of those who, offered the service, choose to subscribe. FTTH connections posted another year of robust growth in 2007. The technology is leading the way into a high-bandwidth future.

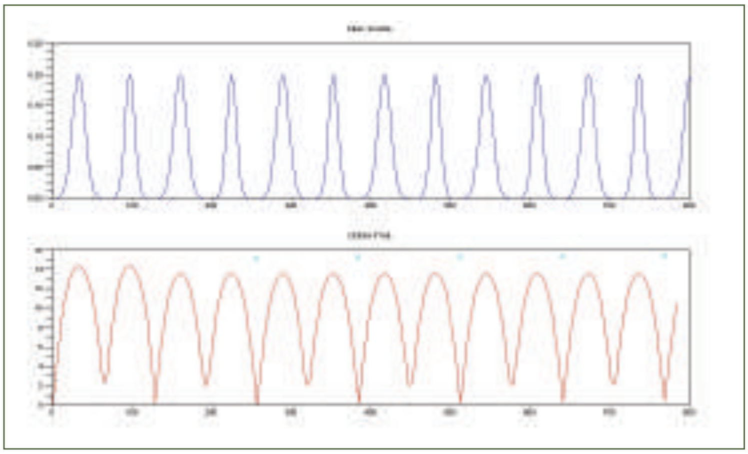
Measurement at the top of the draw tower

LIS-G instruments (Laser Interferometric Sensors for Glass) from Cersa-MCI are widely used in optical fibre manufacturing for bare diameter measurement and fine airline and glass defect detection.

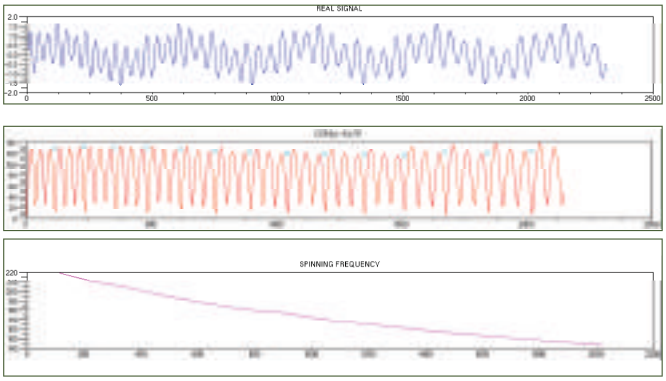
The metrology performance of the LIS-G makes spinning measurement at the top of the draw tower possible using the Non Circularity (NC) of the fibre, even down to 0.05µm of NC.

Cersa-MCI's LIS-G5 offers absolute in-line diameter measurement within ±0.15µm, highly stable, with no need for periodic calibration; repeatability and stability within ±0.004µm at 50kHz band pass, and independent fibre vibration measurement.

LIS-G instruments give an exact view in real time of the dimensional characteristics of the fibre, allowing users to perfect the drawing process, to maintain the fibre at high diameter stability, and to certify the whole production characteristics.



❍ **Graph 2**: *A modelling of a constant signal amplitude, constant period, constant frequency, showing a slight shape (width) difference between peaks, one and two*



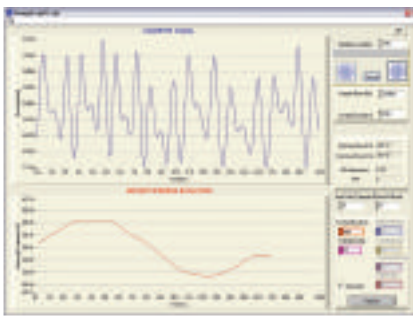
❍ **Graph 1**: *A modelling of a critical 'triangle' shape, with a large amplitude fluctuation and frequency change, with over diameter modulation to test signal computing*

At high drawing speed it is challenging to produce fibres of less than 0.05µm of NC. However, with a typical NC of 0.1µm at 125µm, the instrument shows clearly the spinning influence on the diameter fluctuation.

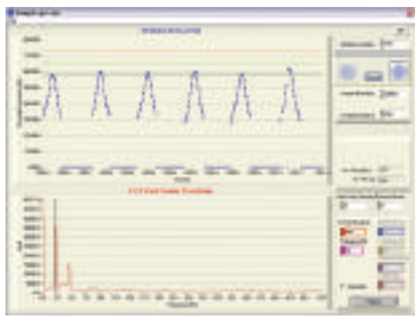
As the circumference of the fibre section is not perfectly round, the LIS-G diameter fluctuation shows a 'one turn signature'. The diameter is recorded at an appropriate time resolution over several spinning periods and then, using signal computing, the 'signature' can be recognised.

To do that, Cersa-MCI has developed its own correlation function (EATP) to show spinning frequency, peak-to-peak non-circularity amplitude and the spinning frequency profile, even though the spinning frequency changes continuously. The 'one turn signature' might be 2 peaks (oval), 3 peaks (triangle) or even 4 peaks (square) due to the NC shape.

❍ **Graph 3**: *The results on a typical* ***real signal*** *recorded by the* ***LIS-G on a draw tower*** *and its display on FiberWin PC software.* ***NC = 0.07µm****, 2 peaks per turn (Signature). This is close to the measurement limits*



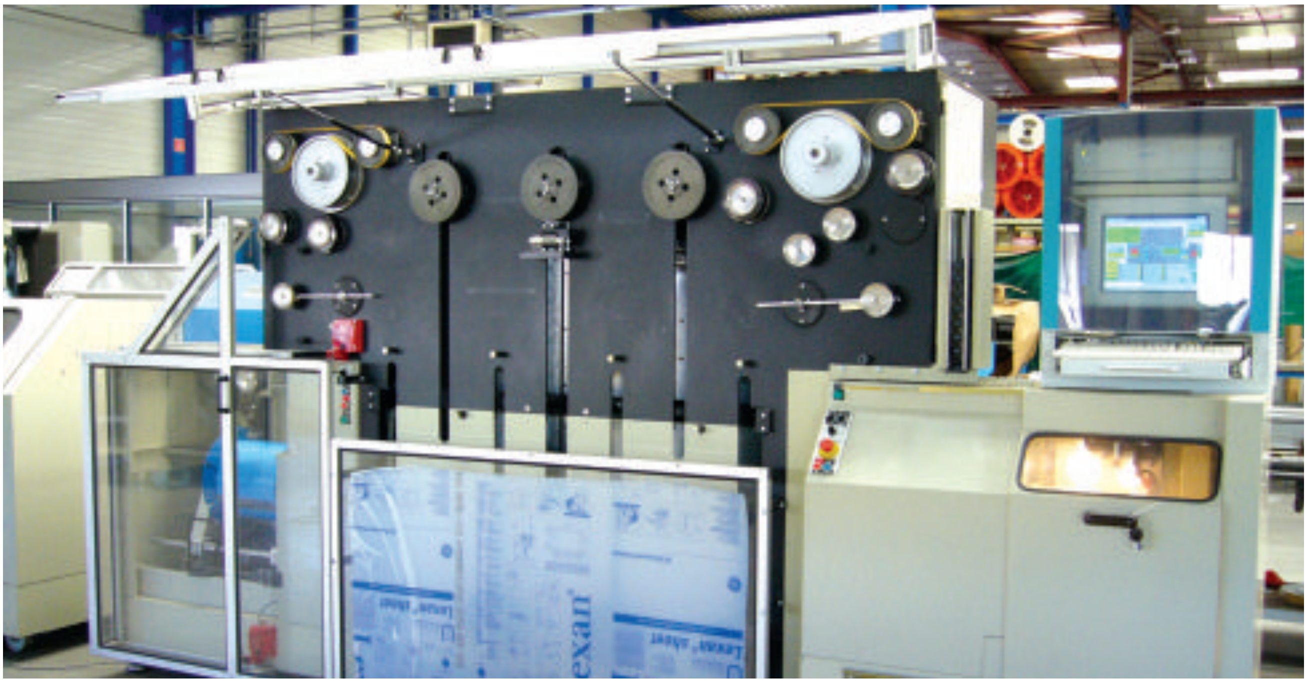
❍ **Graph 4**: *The results on a typical* ***real signal*** *recorded by the* ***LIS-G on a draw tower*** *and its display on FiberWin PC software.* ***NC = 0.24µm****, 2 peaks (almost 3) per turn*



❍ **Graph 5**: *Shows the spinning frequency profile (Spinning evolution) as well as its FFT. The FFT peak shows a 2 Hz frequency, which means one hertz of profile period. The peaks are alternatively directions*

To validate the signal computing, Cersa-MCI simulated specific limit signals in shapes and amplitudes. Then the in line experimentations gave excellent results. Today more than 20 draw towers benefit from this extended feature.

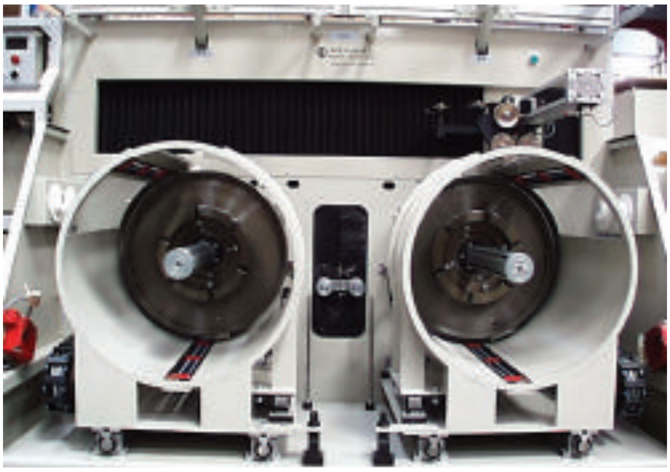
Cersa-MCI – France
Fax: +33 4 42 02 79 79
Email: sale@cersa-mci.com **Website**: www.cersa-mci.com



Prooftester for fibres

Conductix Wampfler, Delachaux Group, manufacturer of fibre optic machinery, has developed a new prooftester, type PT-2500. PT-2500 can reach a production speed up to 2,500 m/min, while maintaining a stopping time, in case of fibre break, of 5 seconds on the take-up. It is equipped with a fast threading system to reduce the labour costs and the traversing quality is believed to be better than the previous models (no more OTDR step). It can accommodate spool diameters of 500/310, 500, 100 kg. An upgrade is available of the former prooftester model PT-1800, to reach a production speed of 2,200 m/min (or 2,500 m/min, depending on the spool size) and to increase the quality of the traversing without any intervention of the operator after the starting adjustments.

In addition, Conductix Delachaux can propose complete new draw towers or upgrading of existing towers to draw bigger preforms to integrate its dual take-up, producing very few fibre breaks during spool change, and to use the company's own NCTM systems.



▲ *Dual take-up machine*

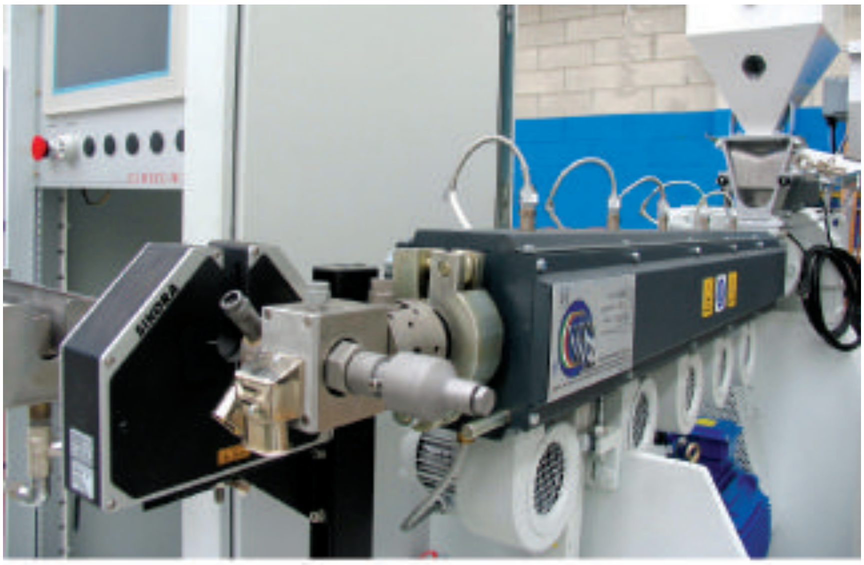
Conductix Delachaux fibre machinery is designed and manufactured in France, producing robust equipment for long life. All the PLC programs are flexible and can be made to suit individual customer requirements.

Conductix Wampfler - **Delachaux Group – France**
Fax: +33 479 42 5005
Website: www.conductix.com

Optic cable to meet the demands of data, voice and High Definition video

The WTS Wire Technology System company, Italy, manufacturers of machinery for the production of electrical and signalling cables, instrumentation, and telephone cables in copper and optic fibre has received an order from Global World System, specialists in cable and optical fibre networks for telecommunications.

The order is for the design, installation, implementation and technical operator training of a complete production line for fibre optic cables, including loose and tight optic fibre bundles of between 2 to12 fibres, loose and mini-bundles of cable from 2x12 OF, and tight optical fibres in mono and bi-fibre material.



▲ *The ELMECC-WTS b-line, a complete production line for fibre optic cables*

Optic cables produced on the WTS line will meet the demands of real-time data, voice and video transmission in HDTV (High Definition Television) or IPTV (Internet Protocol Television), mainly for video conferencing and video surveillance. In addition to manufacturing optic mono- and bi-fibre cables and loose optic fibre bundles the line can also produce sheathing with yarn reinforcement 'Ramidico' (Kevlar). The sheaths can be made in the following thermoplastic materials: PE: medium and high density PUR; normal polyurethane or anti-fire HLSZ; zero halogen compound PA; polyamide compounds (such as nylon) with glass yarn reinforcement for protection from rodents.

ELMECC-WTS – Italy
Fax: +39 0396 6366685
Email: elmecc-wts@elmecc-wts.com
Website: www.elmecc-wts.com

Optical networks – who's spending what?

Infonetics Research has analysed the optical network hardware market in Asia Pacific finding that China's spending has been more than double that of Japan, dwarfing the optical spending of India, the Republic of Korea, and all other countries in Asia Pacific. The report, Optical Network Hardware in Asia Pacific: China, Japan, India, and Republic of Korea, says China represents 43% of the $3.4 billion spent on optical hardware by Asia Pacific countries in 2007.

"China has over 1.3 billion people, yet only about 500 million mobile subscribers and 51 million broadband subscribers, so they have lots of room for mobile, broadband, and teledensity growth. The Chinese government considers telecom infrastructure an important part of their ability to compete, setting a goal of 75 million broadband users by 2008 to help present the new China to the rest of the world for the Beijing Olympics. Reports from China indicate a telecom restructuring may take place soon, quite possibly in 2008, which would slow capital spending for a year or so during the restructurings, mergers, and acquisitions, then spending will resume," said Michael Howard, principal analyst at Infonetics Research. Further findings include:

- Asia Pacific represents around a third of worldwide total telecom capital expenditure and about a quarter of worldwide optical equipment spending
- Asia Pacific countries are expected to significantly increase their spending on metro and long haul wavelength-division multiplexing equipment over the next 4 years

The full report, Optical Network Hardware in Asia Pacific: China, Japan, India, and Republic of Korea, is available from Infonetics.

Infonetics Research – USA
Fax: +1 408 583 0031
Email: larry@infonetics.com
Website: www.infonetics.com

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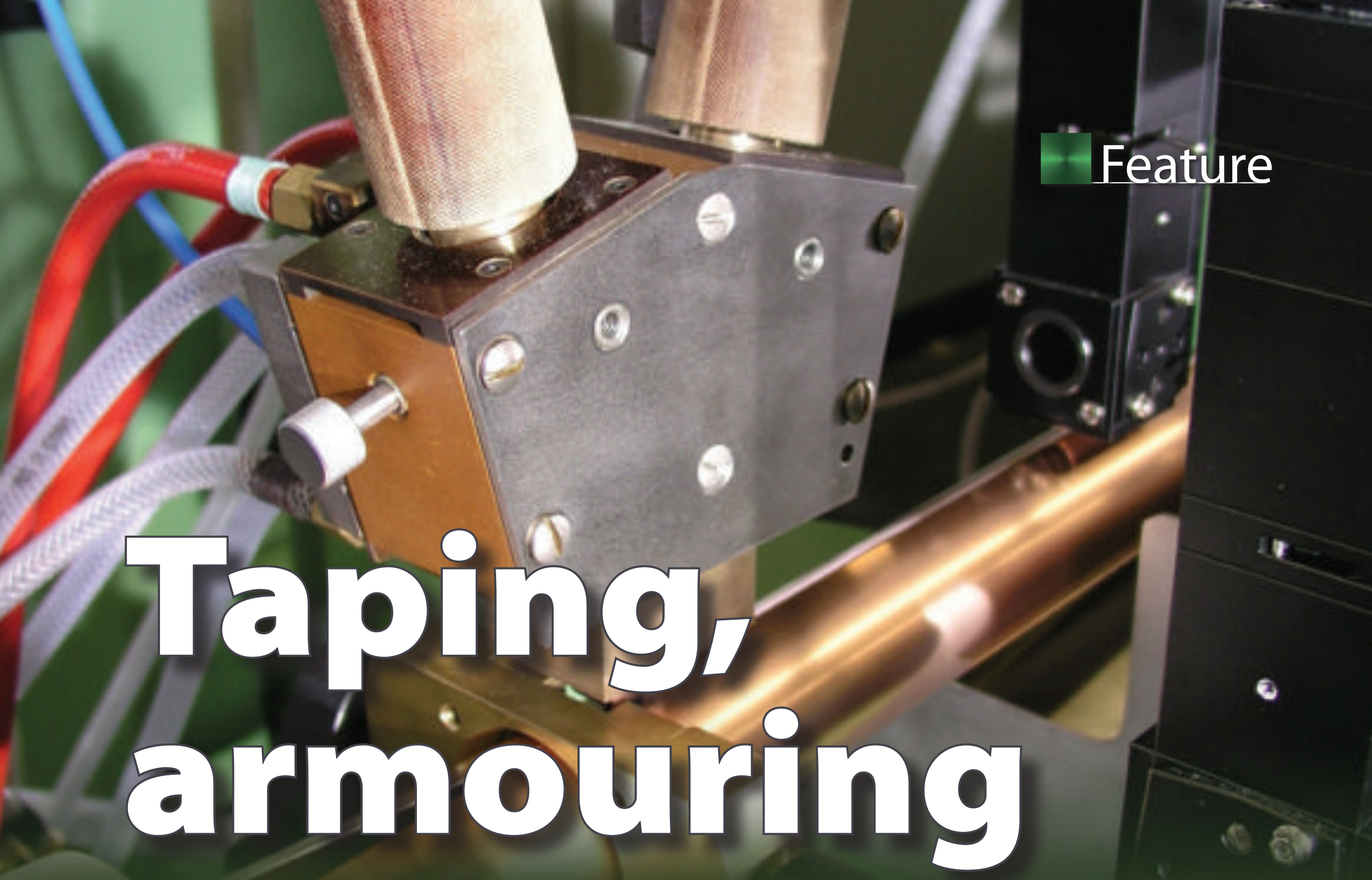


Taping, armouring & sheathing of cables

These are the defensive specialities, their very names suggestive of battle equipage. Without them, no cable would be diminished in its rated capacity or in any other specification, as tested in laboratory conditions but the prudent person would not wager on its lasting very long in the real world.

Taping, armouring, and sheathing – if protection and economy are both to receive their due – must be appreciated for the important and exacting industrial processes they are. Consider two runs of product being readied for shipment from a mill:

- a bundle of electrical cable is fitted with a sleeve to protect against contaminants;
- a cable made up of two dozen conductors twisted together receives an application of elastomeric material as it is drawn through the head of an extruder; the elastomer is cured by heating, then cooling; the cable is rotated about its axis preparatory to undergoing a half-dozen more procedures on its way to the shipping bay.

Both fall into the category of sheathing: like armouring and taping, a procedure with heavy responsibilities that must be met across a broad range of requirements. They are all in safe hands with the experienced professionals whose products and services are reviewed in this section of EuroWire.

Three times more production capacity

Pourtier - Gauder Group has developed three applications of its high-speed concentric armouring head to place one or two strips on power cable or communication conductors up to 50mm in diameter.

▲ *Pourtier CAH 670: double head version for 2 strips*

The head enables the application of a long length of strip without interruption and minimises loading and unloading operations. Thanks to the concentric process, which gives less centrifugal force than in a tangential process, the rotating speed ranges from 600 up to 1,500 rpm. The taping tension – controlled by dancer, motors and drives – is very accurate.

The first application, the CAH670, applies two tapes (steel or copper) onto the cable while the second, the CAHL720-60, is dedicated to apply pre-formed strip-type aluminium or steel (lapped cable). Both models can be equipped with an integrated spool-manufacturing unit for the rolling of the spool from standard pads, while the armouring head is taping. No handling of the spools is required as they are rolled directly on the machine. The loading operation is made without cutting the cable.

The third type, CAHi900-60, is specially designed to produce interlocking cable with aluminium or steel strip at high speed for a 36" spool (available for 2, 4 and 5" diameter).

The company has also designed a solution for steel wire armouring on small cables (diameter up to 20mm), the TEC 630-SWA multiwire concentric head achieving at least 2.5 times the productivity with conventional, single twist machines.

Pourtier Gauder Group – France **Fax**: +33 1 64 26 61 10
Email: sales.pourtier@gaudergroup.com **Website**: www.gaudergroup.com

RG's tapeformer

The RG Tapeformer is used by cable manufacturers to fold a variety of insulating materials around cable cores before entering the final jacketing stage.

They can be used with many insulating tapes including Mylar, paper and metalised foils, and can insulate a wide range of cables including LAN, power, telephone, communication, coaxial and automotive cable. The Tapeformer is positioned just before the extruder head and guarantees precision folds. With an extensive selection of models and folding profiles, the Tapeformer is manufactured to the user's exact requirements.

▲ *Staff from RG Attachments at wire 2008*

RG Attachments is looking to further extend the range of profiles offered by its Tapeformer series, based on feedback received from customers and visitors to its stand at wire 2008.

RG Attachments Ltd – UK
Fax: +44 116 2612403 **Email**: info@tapeformers.com **Website**: www.tapeformers.com

SAMP and DS&M started a new partnership

SAMP, manufacturer of extrusion cable lines, and DS&M, well-known in the field of dosage and control systems production, have together developed a new technology which enhances the performance of the whole extrusion process and is believed to be much cheaper than traditional production lines. After extensive experimentation, research and development, SAMP and DS&M have created a new extrusion module suitable for the vast majority of granulated material.

The group is called "Multiflex 25 Extrusion Module" and is made of a 25-diameter extruder integrated with a dosage and mixing unit of polymers and silane, conveniently developed to improve the homogenisation among solid and liquid components before plasticising.

▲ *The Multiflex 25 Extrusion Module*

Excellent results obtained for over a year on a pilot production line created the basis for a technical and commercial partnership between SAMP and DS&M, who recently signed a specific agreement.

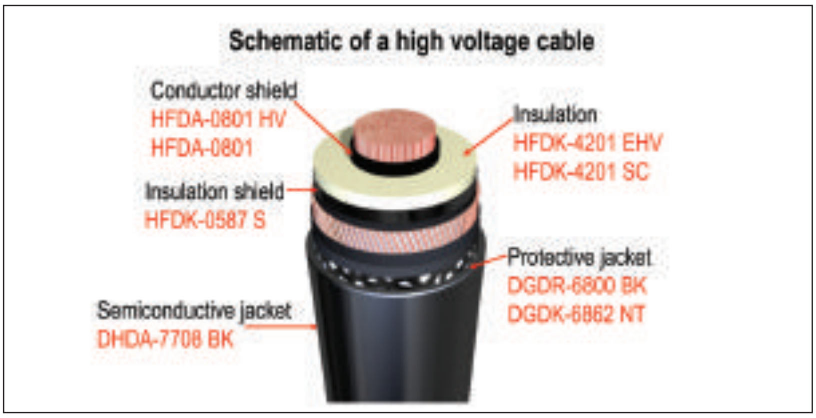
SAMP and DS&M presented their new project during the wire 2008 exhibition in Düsseldorf.

SAMP – Italy
Fax: +39 051 356 750
Email: info@sampsistemi.com
Website: www.sampsistemi.com

DS&M Srl – Italy
Fax: +39 059 281518
Email: info@dsem.it
Website: www.dsem.it

New flame retardant compound for use in high-heat environments

Dow Wire & Cable has introduced Unigard™ RE HFDA-1492, a reduced-emissions flame retardant compound for use in wires and cables needed in high-heat environments, such as those found in automotive engines and appliances. Capable of tolerating temperatures of up to 125°C, the new compound also offers important processing, environmental tolerance and ease of installation benefits while meeting industry and end-use market specifications.



Unigard RE HFDA-1492 is a colourable, peroxide-crosslinkable, polyethylene copolymer insulation compound. It is approximately 4% lighter than traditional materials used in automotive wire and cable applications and delivers more output per pound, offering system cost benefits as a result. Designed to enable the manufacture of cables that are more flexible with lighter weight and improved colour retention, HDFA-1492 also has a low specific gravity of 1.35 to help reduce the consumption of compound per cable length. Tests with HFDA-1492 have also shown a 20-50% improvement in line speeds on Dow customers' existing equipment, compared to a commercial automotive compound. A broad processing window, from 105°C to 135°C, also supports potentially higher line rates.

Unigard RE HDFA-1492 additionally addresses important environmental and North American legislative requirements by providing PVC-like performance with LS0H (low smoke zero-halogen) advantages at a competitive cost.

Dow Wire & Cable (Europe)
Tel: +800 3694 6367/+32 3450 2240 **Website**: www.dowwireandcable.com

Semi-conductive/non-conductive water blocking tape

Semi-conductive water blocking tapes are used for water blocking between power cable components. Its swelling characteristic is believed to be superior to traditional water blocking tape due to the lack of a covering fabric. It offers a replacement for traditional semi-conductive tape with no causticity.

▲ *Examples of water blocking tapes*

Non-conductive water blocking tapes are used for water blocking between the components of optical fibre cable, communication cable and power cable. Shenyang Jinggong Cable Material Co Ltd manufactures semi- and non-conductive water blocking tape and yarns and offers an efficient service, worldwide.

Shenyang Jinggong – China
Fax: +86 24 8931 2788
Email: office@jinggong-tapes.com **Website**: www.jinggong-tapes.com

Tapes and yarns

Smeets NV/SA, established in 1921, is a distributor of cable components such as woven semi-conductive tapes, waterblocking tapes and yarns, aramid yarns, FRP strength members, anti-fire fibreglass and mica tapes. Smeets' high quality products are widely used by most of the major cable manufacturers across America and Europe.

Africa and Middle East Smeets SA – Belgium
Fax: +32 2 377 24 07 **Email**: smeets@smeets1921.be **Website**: www.smeetstubes.com

Rigid cage screening

Rotating cages from Cortinovis have been developed for single and multi-wire screening of low, medium and high voltage cables with copper or aluminium. Special low fiction pneumatic pintles permit handling of fine wires, and each wire, from two to eight per bobbin, has individual break control.

A diving disc located at the closing point ensures accurate spacing of the wires. A full range of taping heads is available for semi-conductive, non-woven and plastic tapes.

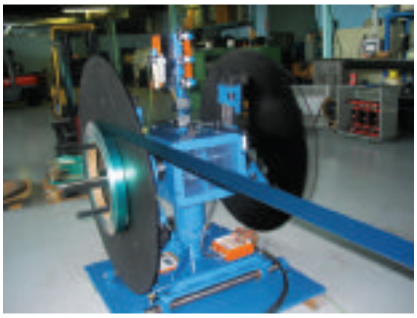
Using caterpillars for pulling, two belts with individual motors provide electronic balance of pull.

◄ *Rotating cages from Cortinovis*

Cortinovis – Italy
Fax: +39 035 313211 **Email**: cortinovis@cortinovis.it **Website**: www.cortinovis.it

Taping, armouring and sheathing of cables

Tensor Machinery provides a complete armouring system for steel, aluminium and copper tape applications from 15 to 100mm tape widths. The equipment includes tape pay-offs, accumulators, welders, corrugators and rollforming. For the tape pay-offs Tensor offers driven and non-driven designs, depending on the tape material and the type of tape accumulator used. Tensor also offers up to 600 feet of tape accumulation to ensure the line never slows down when performing a tape weld. The tape accumulator can be designed for either smooth tape or corrugated tape.



▲ *Tensor tape pay-off machine*

▲ *Tensor armouring equipment*

The tape welder can weld steel, aluminium and copper tape in seconds, with a small overlap weld. This is a resistance type welder where the tape maintains strength of 90 to 100% after it is welded. For the corrugator, Tensor provides an easily adjustable corrugation depth using a single crank lever, giving an even corrugation across the tape width. Both the upper and lower corrugator rollers can be driven to provide an accurate corrugation pitch; the corrugator can be provided with a variety of corrugation pitches. For tape forming the company suggests rollformers – a series of rollers that smoothly form a tape into a round tube shape with a slight overlap. Tape widths as small as 15mm can be formed into a round tube. There is virtually no friction in forming so high speeds can be obtained without heating the tape or damaging the tape coating.

All Tensor armouring equipment can be designed to operate as a complete system or individual components can be purchased for integration into any existing armouring line.

Tensor Machinery Ltd – Canada
Fax: +1 514 636 3288 **Email**: sales@tensorfiber.com **Website**: www.tensorfiber.com

Multitaping with controlled film tension

The product range of Maschinenfabrik Niehoff includes double twist stranding machines for the production of data and special cables. The product line includes tape pay offs, which are used to apply tapes of different material under precisely controlled film tension to the stranded conductor.

Films are important for the design of data and special cables consisting of insulated conductors. Films reinforce the wire insulation, protect the conductors against electromagnetic interferences or prevent the adhesion of extruded jacketing material to the stranded product. The first tape film is applied before the stranded product enters the stranding machine. During the stranding process high forces act on the foils, therefore, tension control of the film is critical and essential for high quality products. A pre-twister, placed between the tape payoffs and the stranding machine, helps achieve and maintain constant and accurate tension control.

Niehoff has developed manufacturing lines that address these tasks. These lines can be used to manufacture cables for industrial applications consisting of conductor pairs, three conductors or conductor quads. Over the last few years several of these lines have been successfully supplied to data cable producers in Europe.

▲ **Figure 1**: *ATP630 tangential payoff*

Depending on the cable construction, such lines consist of several payoffs type ATP630, three tape payoffs type ALB600 and a pre-twister type VVD180 or type VVD250.

▲ **Figure 2**: *ALB600 longitudinal tape payoff*

▲ **Figure 3**: *VVD pre-twister*

These components have the following tasks:

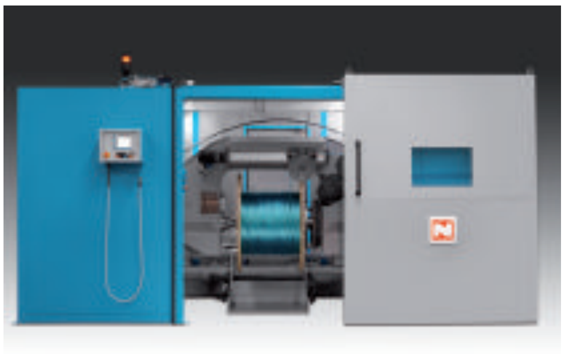
The ATP630 tangential payoffs with separate drive are designed for the uncoiling of high-quality cables, insulated single conductors, pairs and quads with a maximum diameter of 3mm. The payoffs are driven by a dancer-controlled spool drive with adjustable wire tension; the maximum haul-off speed is 300 m/min (*Figure 1*).

A dancer-controlled AC motor drives the ALB600 longitudinal tape payoffs with tape forming. They are designed to enable an easy and rapid film insertion and tensioning. The film tensile force is adjusted separately, and the forming tools for overlapping on the right or on the left can be quickly exchanged. The payoffs can be operated with payoff spool or film cassettes and are suitable for films with a maximum width of 40mm and a maximum thickness of 65mm. The maximum haul-off speed is 300 m/min (*Figure 2*).

The VVD pre-twisters (VVD180 and VVD 250) have been developed for the cost-effective production of insulated wires, pairs, quads and cable cores with 5- or 7-conductor design with three or more films applied in S or Z twist direction by double twist stranding machines.

The pre-twist devices enable the application of tapes under a reduced, controlled and constant tension. The devices can accommodate tapes made from all kinds of films used for the production of data and special cables. The speed can be infinitely adjusted and controlled.

The VVD pre-twisters are designed to handle stranded products with a maximum diameter of 10 or 15mm (*Figure 3*).



▲ **Figure 4**: *DSI1001 double twist stranding machine*

The double twist stranding machines of the DSI series (DSI631 and DSI1001) are designed for stranding of insulated cores to twins and quadders and for the stranding of four conductor pairs to form LAN cables and other special cables (*Figure 4*).

The DSI machines are built for a wide conductor cross section at a maximum stranding diameter of 8mm or 15mm and can be combined with numerous other production equipment to produce all types of data and special cables including LAN cables of all categories – current, under development and in the future – with the highest precision.

Maschinenfabrik Niehoff GmbH & Co KG – Germany
Fax: +49 9122 977 155 **Email**: info@niehoff.de **Website**: www.niehoff.de

Cable solutions for any environment

▲ *A typical application for fire retardant tape*

Scapa Cable Solutions offers a full range of non-woven semi conductive and insulative water swellable tapes. These tapes have been used in many of the world's major cable projects such as the Thunderhorse, NorNed, Ormen Lange and Estlink.

Scapa's woven range includes:

- semi conductive tapes – for core and conductor screening, offering the additional benefit of high strength for binding purposes. Various grades are available should bedding or extrudate penetration resistance properties be required
- fire retardant tapes – glass tapes, coated with a LSOH material for additional fire performance, and used increasingly to help cables pass various fire standards. Both insulative and semi conducting types are available
- Insulative tapes – these are used for binding and bedding purposes. Typically they are pinhole-free, however a version is available capable of venting volatiles that can build up during the production process
- Bituminised hessian and cotton tapes – generally used in PILC, these tapes are enjoying something of a renaissance as some of the newer cable designs recognise the value that they can give in armour bedding

Scapa also produces and distributes a comprehensive range of components for jointing and repairing the full range of cable types, which include tapes, putties and resins.

Scapa Cable Solutions – UK
Fax: +44 161 301 7446 **Email**: sales@scapacable.com **Website**: www.scapacable.com

LDPE unit for Abu Dhabi

Borealis and Borouge, a joint venture between Borealis and the Abu Dhabi National Oil Company, has announced the potential development of a LDPE (low density polyethylene) unit in Abu Dhabi to produce high performance material for cable and wire applications.

By the end of 2014, the project will add approximately 2.5 million tons per year of capacity to Borouge's polyolefin operations in Abu Dhabi.

This substantial capacity investment, in addition to Borealis' 350,000 t/y LDPE plant in Stenungsund, Sweden (due for completion in 2009) confirms a long-term commitment to the requirements of the global wire and cable industry.

Hans Christian Ambjerg, Borealis vice president, business unit wire and cable, commented: "…we continue to demonstrate our active commitment to delivering the advanced products and necessary supply levels to meet the sustainability needs of this very demanding market."

Borealis AG – Austria
Fax: +43 122 400 333
Email: info@borealisgroup.com
Website: www.borealisgroup.com

Wire & cable sheathing compounds

To meet the evolving fire performance and environmental compliance criteria in Europe, the Middle East, Asia and North/South America, AlphaGary has developed a portfolio of speciality compounds for a wide variety of cable designs and applications – both copper and fibre optic:

1. Smokeguard™ FP (with DuPont Teflon®) and Smokeguard™ HP fluoropolymer compounds that meet stringent cable fire performance for mission critical applications in extreme environments
2. Smokeguard™ low smoke vinyl alloys meeting RoHS environmental compliance for North American plenum and European CPD Class B1/B2
3. Megolon™ halogen-free materials for IEC 60332-1/60332-3C, European CPD Classes C thru E, power cable sheathing and crosslinkable insulations
4. Garaflex™ TPE styrenic, vinyl, olefinic/EPDM, and vulcanizate blends, and
5. Garathene™ thermoplastic urethane blends and alloys

AlphaGary offers colour concentrates to support all of its compound types, both custom-matched and to standards such as Munsell and RAL. AlphaGary is a specialist in advanced fire safety and environmental compliance, providing material compound solutions to meet cable performance requirements in different regions of the world.

AlphaGary Corporation – USA
Fax: +1 978 537 8385
Email: info@alphagary.com **Website**: www.alphagary.com

Splicing "on-the-fly"

Dynamex Series TPX tape payoff was developed specifically to enable uninterrupted tape supply for longitudinal taping in the extrusion process, but it can also be used in other continuous systems. This patented machine enables running a taping process continuously with unattended splicing, which until now has been considered unattainable.

Dynamex, an acknowledged developer of equipment for the wire & cable industry, is known for its high-speed single-twist cablers, driven payoffs, taping systems and ancillaries. The auto-splicing tape payoff accommodates two tape pads, one running and the other waiting to be spliced when the active one is depleted. The high-reliability splicing takes place automatically at full line speed, and at the right moment, regardless of the operator's presence.

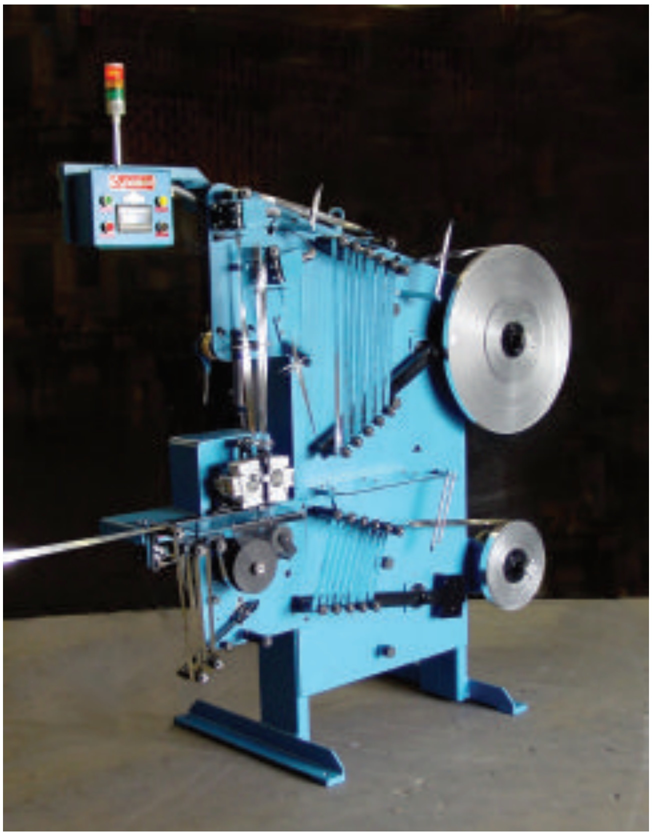
Both tape pads are driven, and the tape is delivered to the line from a driven capstan that fully controls the tape tension as it enters the process. A built-in alert reminds the operator to load a new pad and prepare the tape for the next splice.

The machine has a small footprint, and can be installed at any angle to the line for easy integration into an existing system.

Also provided with the payoff is a tape-redirector, which delivers the tape parallel to the line and into the tape former. An additional important advantage of this machine is that it minimises tape scrap. These systems run and splice automatically at speeds exceeding 400m/min, and can operate with tissue, kraft (brown) paper, water-swellable, Mylar, or tape aluminised on one or both sides.

Models are available for traditional flat pads, as well as wide spools with traversed tape. Dynamex also offers model TPX-TRFL that can run both flat pads and traversed pads.

Dynamex – USA
Fax: +1 310 329 0159
Email: sales@dynamexcorp.com
Website: www.dynamexcorp.com



▲ *The Dynamex Series TPX tape payoff*

High-heat aging performance and halogen-free

DSM Engineering Plastics has announced a new addition to its Arnitel® line of copolyester thermoplastic elastomers (TPEs) designed to meet the stringent performance and compliance needs of automotive designers. Arnitel® C, described as "a breakthrough technology for wire and cable coating", has been developed to provide superior high-heat aging performance, combined with halogen-free flame retardance and exceptional hydrolysis resistance. With excellent abrasion resistance, this new material offers designers the ability to reduce the weight and mass of wiring and cable through ultra-thin-wall coatings.

▲ *Arnitel® C, "a breakthrough technology for wire and cable coating"*

"As auto designers try to fit more and more components into a fixed space, it becomes critical to improve wire and cable coating flexibility and reduce mass and weight," said Francis Aussems, DSM innovation programme manager. "Additional under-the-hood content is also leading to rising temperatures that require improved heat resistance. We developed Arnitel® C specifically to meet these needs. In addition to exceptional performance, our new recyclable, halogen- and plasticiser-free TPE helps OEMs and Tiers meet environmental regulations."

Arnitel® needs no plasticiser to enhance flexibility, which translates into low outgassing and no environmental issues. The combination of this polymer with the halogen-free flame retardant system also gives low toxicity and smoke in case of a fire.

The new DSM material provides high-heat aging properties of all TPE-Es, with a continuous operating temperature rating of 3,000 hours at 175°C, so exceeding the requirements for temperature class D under ISO 6722. Arnitel® C also is hydrolysis-resistant (>150 days at 85°C in water), and on par with all other higher standard copolyester elastomers. The material has been tested and approved according to ISO6722 and LV112.

DSM Engineering Plastics – Netherlands **Fax**: +31 46 477 3959 **Website**: www.dsmep.com

Boosting competitiveness for low voltage cable producers

Borealis has launched a high productivity, low voltage cable insulation material designed to boost the competitiveness of cable manufacturers. Making its début at wire 2008, new Visico™ FX LE8823 is said to deliver all-round advances in productivity and cost efficiency, resulting in higher output and increased profitability at the manufacturing stage with knock-on benefits for grid owners and installers.

Visico FX is a new base material for low voltage moisture cured XLPE (cross linked polyethylene) cables, for faster production of consistently high quality cables. Its crosslinking speed is twice that of Borealis' traditional Visico material and typically more than five times that of grafted XLPE materials. This allows cost efficient curing under ambient conditions when used in combination with the Ambicat catalyst, resulting in a more efficient production flow by eliminating production steps and speeding up the overall production process.

By removing traditional bottlenecks from XLPE production, Visico FX shortens lead-times, reduces manufacturing complexity and lowers the potential for handling-related errors. At the same time, it delivers the environmental and cost-related benefits of reduced energy usage, and minimised handling and production space requirements.

In addition to advances in curing speed, Visico FX improves productivity by delivering a consistent product with less down time for cleaning. Suitable for running on standard extruder equipment, the new material shares the scorch retarder technology of standard Visico material, creating a smooth production process with minimum change, higher output and less waste. Visico FX also offers time and cost saving benefits to grid owners and cable installers. The material gives cables greater flexibility, thus improving ease of installation and so reducing time and cost.

Hans Christian Ambjerg, vice president of Borealis wire and cable, comments: "Borealis' Visico FX innovation demonstrates our commitment to developing products that respond to the business and sustainability challenges facing the wire and cable industry today. The low voltage cable market in particular faces increasing competition from low cost producers driving down sales margins. Visico FX gives companies a competitive edge by tackling the need for higher productivity and lower costs at the same time as addressing environmental concerns by reducing energy usage and waste generation."

Borealis AG – Austria **Fax**: +43 122 400 333 **Website**: www.borealisgroup.com

New 8-pad taping head for Queins

Queins & Co has recently designed a new high-speed 8-pad taping head, mainly used for flat conductors and CTC-strands. The manufacturing range further includes modern concentric and tangential taping heads for paper, plastics and Mica-tape.

▲ *The new high-speed 8-pad taping head*

Machines are also available for armouring with galvanised steel wires or steel tapes. Extrusion/sheathing lines are being built for all types of cables and equipped with state-of-the-art electrical controls and measuring instruments.

Queins & Co – Germany
Fax: +49 2472 3014
Email: info@queins.com **Website**: www.queins.com

Metallic cable sheathing

Nexans has developed the UNIversal WElding MAchine to sheath cables with a sealed metallic outer cover.

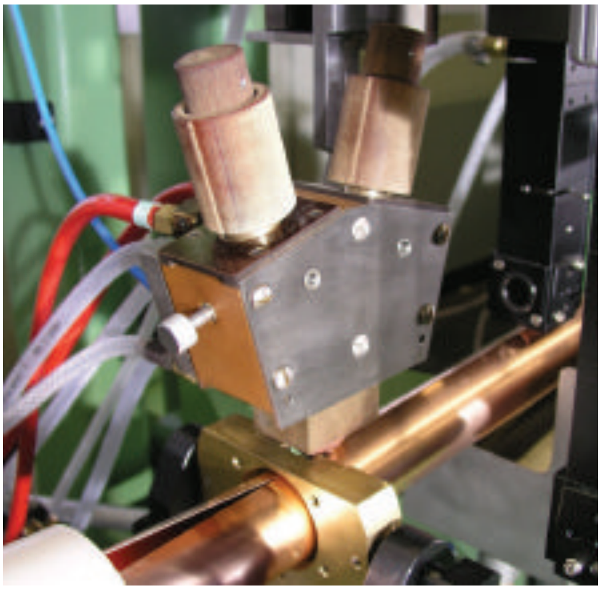
Special cables can require smooth or corrugated metallic outer conductors to assure crush resistance and high flexibility. A gas tight sheath with helical or annular corrugations protects the cable against moisture, liquid and gases, while the metallic sheath acts as a grounding conductor.

In the UNIWEMA process, a metal strip is introduced into the machine and, in a single operation, the strip edges are trimmed and formed around a cable core and the opposing strip edges are TIG (Tungsten Inert Gas) welded.

The standard UNIWEMA is equipped with a single electrode. In applications where the maximum allowable welding current with one electrode is insufficient (eg for thicker strips or if higher speeds are desired) the UNIWEMA can also be operated with a 3-electrode welding torch system, Polyarc welder.

For continuous TIG welding, Nexans has developed the TwinTorch® system. The TwinTorch system consists of two torches, control program and two welding rectifiers. When a used electrode has to be changed the PLC controlled process ignites the second torch; the used electrode can then be exchanged easily. TwinTorch technology achieves an uninterrupted welding seam without welding defects.

A split clamp caterpillar capstan, located downstream from the welding station, pulls the sheathed cable through the machine and, if desired, pushes it to the corrugation unit. The coordination of the forming and welding operations with the split clamp caterpillar capstan is a pre-condition for obtaining a uniform welded seam, thus ensuring optimum product quality.



▲ *Nexans TwinTorch® system*

One of the range of UNIWEMA units, UNIWEMA 60 is considered most suitable for the sheathing of special cables using tube diameters up to 60mm to produce a sheath with aluminium of 0.4mm to 1.8 mm wall thickness.

Nexans Deutschland Industries GmbH & Co KG – Germany
Fax: +49 511 6 76 37 77 **Email**: uniwema.tech@nexans.com **Website**: www.nexans.de

Films, foils and tapes for cables

Besel Group has been producer and converter of flexible materials for technical applications since 1975.

Besel processes 800 tons of films, foils and tapes every month. The company has recently moved to a new 42,000m² site, including 10,000m² site of stock space and production facilities, equipped with the latest in converting technology.

An ISO 9001 certified quality system is in place to ensure product quality and prompt delivery, and skilled staff and management are always on hand to assist customers with order and product advice.

Besel Basim San Tic Ltd – Turkey
Fax: +90 212 683 22 18
Email: info@beselfoil.com
Website: www.beselfoil.com

"Green" colour concentrates

Environmental building guidelines have been established by the US Green Building Council (USBG) to further the initiatives of RoHS and WEEE proposals, limiting the use of halogen-containing materials throughout the United States.

Ultralor EF, from Breen Colour Concentrates, has been developed in partnership with Delphi Packard Electric Systems to meet the performance demands of halogen free, high temperature, lightweight, thin wall insulation for wire and cable.

Tom Taylor, vice president of sales and business development for Breen Color Concentrates, believes that the guidelines of these regulations will impact on applications across numerous wire and cable markets including automotive, hospital, medical equipment, lighting equipment, fire alarm and security products.

Available in a range of colors, Ultralor EF products are compatible with flexible PPE compounds for wire and cable.

Ultralor EF is made using 100% virgin materials that do not contain halogens, lead, hexavalent chromium, cadmium, mercury, PBB, PBDE or other substances known to be hazardous to humans or the environment. The products meet the requirements of Directives 2002/95/EU (RoHS) and 2002/96/EU (WEEE).

Ultralor EF has already been approved by a leading automotive manufacturer for use in 2009 platform vehicles.

Breen Color Concentrates – USA
Email: ttaylor@breencolor.com **Website**: www.breencolor.com

Plastics for high and extra high voltage underground cables

Dow Wire & Cable has announced a complete portfolio of insulation, semi-conductive and jacketing compounds for high and extra high voltage underground cables in Europe, India, the Middle East and Africa. Dow Wire & Cable is building on the success of its super-smooth, extra-clean semi-conductive compounds, HFDA-0801 BK EC for high voltage and HFDA-0801 BK HV for extra high voltage. Both have already been proven in many high and extra high voltage underground transmission systems across Europe. "Demand for reliable underground power cable systems is growing rapidly in many parts of the world. Drivers for growth include the increased power demand globally, difficulty for utilities to obtain new rights of way for overhead lines, as well as the need to interconnect national/regional power grids for greater supply security," said Robert Tarimo, market manager for Europe, India, the Middle East & Africa.

Dow Wire & Cable's range for the manufacture of high and extra high voltage underground cables (from 66 kV to 500 kV) in the Europe, India, Middle East and Africa regions includes:

- insulation: HFDK-4201 SC and HFDK-4201-EHV, extra-clean crosslinked insulation compounds for HV and EHV respectively
- inner and outer semi-conductive layers: HFDA-0801 BK EC and HFDA-0801 BK HV, super-smooth, extra-clean semi-conductive compound for HV and EHV respectively
- jacketing: A choice of DGDR-6800 BK (a black high density polyethylene compound) or DGDK-6862 NT (a self-colouring polyethylene compound, where an alternative colour to black is required); also DHDA-7708 BK (a semi-conductive black polyethylene compound that can be added into the jacketing mix to enhance cable integrity testing after production, installation and during usage)

Dow Wire & Cable – Europe **Tel:** +32 3450 2240 **Website**: www.dowwireandcable.com

Specially developed cable products from Polifibra

Polifibra (Milan) invests each year more than 4% of its turnover in R&D activities. A recent development has been a range of shielding tapes that are produced with a lubricant applied to the aluminium face. The purpose of this additional layer is to help to reduce the adverse effects of friction created during the forming process. The friction can cause stretching and even breaking of the tape, which in turn creates problems with machine down time and costly repairs. Polifibra worked closely with one of its customers to develop a coating that was both indistinguishable to the naked eye and indeed inert. The application of the slippery coating enabled considerably fewer breakages; improved performance of the tape itself when forming around the wires and of course increased productivity for the customer.

Polifibra's dedicated R&D resource has also developed a shielding tape, destined for the high-speed (10gbps) LAN cable market. This product, described as "revolutionary", is working well and has enabled the development of a previously untapped market; the product and design have now been patented, protecting both the customer and Polifibra.

Polifibra SpA – Italy
Fax: +39 039 60 61 300
Email: info@pf-polifibra.com
Website: www.pf-polifibra.com

Mixer compounds

Mixer has been manufacturing cable compounds since 1996. The company now produces insulation, sheathing, filling and masterbatch cable compounds with both rubber and thermoplastic. The trademark Ekopren® products are based on halogen free polymers and additives with low toxicity and clear smoke emission. The Mixer range includes heavy metal free, high LOI and fire/oil/ozone resistant compounds. Fully automated production lines and advanced testing facilities maintain consistent quality of an annual production of 20,000 metric tons of cable compounds. Banbury internal mixers and strainer extruders are used to manufacture compounds in granule (pellet) form.

Mixer offers technical and engineering services to assist cable manufactures to adapt their equipment to extrude compounds in pellet form. Mixer's on-site laboratory is at customers' disposal for testing material properties and behaviours. Clients can request tests of their products in order to verify the correct cross-linking of materials, the correct extrusion behaviour and if product complies with standards. Engineering assistance is available to maximise the results of extruder machinery. Mixer expertise includes designing and constructing modifications to existing equipment as well as optimising operational parameters during extrusion.

Mixer SpA – Italy
Fax: +39 0545 47038 **Email**: staff@mixer.ws **Website**: www.mixer.ws

Geca-Tapes offering better protection for less

The newly developed GT609 from Geca-Tapes is a semi-conductive, nonwoven, strong, light, impermeable tape that can be used as a wrapping, bedding and separating layer. GT609 was developed at PGI Geca-Tapes' R&D facility in Bailleul, France.

The thin (0.15mm), strong construction (90N/cm) of GT609 allows it to be applied longitudinally as well as helically, protecting the conductor or the insulation sheath during extrusion, wire armouring, handling or temporary storage, and makes it a lighter alternative to existing wrapping and bedding tapes.

More importantly, the high quality of the GT609's base web and carbon black finish provides Geca-Tapes' users with a pinhole-free, impermeable, peripheral wrapping tape, preventing the extruded compound from migrating towards the conductor during the extrusion process.

A variety of tapes are already used for similar purposes but, in order to be fully effective, they need to be applied in two layers.

GT609 can be applied longitudinally in a single layer, hence providing materials usage savings as high as 30%.

PGI Geca-Tapes – France
Fax: +33 3 28 43 74 63
Email: info@geca-tapes.com
Website: www.geca-tapes.com

High cavitation strength primary coatings for optical fibres

By Huimin Cao[1], DSM Desotech Inc, Elgin, Illinois, USA;
and Markus Bulters[2] and Paul Steeman[2], of DSM Research, Geleen, Netherlands

Abstract

It is well known that the design of soft primary coatings in combination with hard secondary coatings provide good micro-bending protection for dual-coated optical fibres. However, this dual layer design also introduces thermal stress in the coating system due to the mismatch of the thermal expansion/contraction of the two coating layers. Under the tri-axial tensile stress, the soft primary coating may form internal ruptures. The cavitation of the primary coating is a possible defect mode that can be detrimental to fibre attenuation performance. In this paper, the mechanism for coating cavitation in terms of different types of driving forces is discussed. Cavitation strength of the primary coating is introduced as a key property for achieving a robust, high-performance coating system with the desired low micro-bending sensitivity in combination with high cavitation resistance.

1. Introduction

One of the major advantages of the dual-layer coating design for optical fibres is to provide better micro-bending protection than that afforded by a single layer coating. Soft primary coating, acting as a buffer layer, combined with hard secondary coating, acting as a shielding layer, provides ideal bending resistance for the fibres to withstand external stresses in a cable environment.

[1]Thermal stress in the dual-layer coating system is inevitable due to the different thermal expansions and contractions of the glass, primary coating, and secondary coating. Standard single mode or multi-mode fibres with high quality dual-layer coatings do not exhibit out-of-spec attenuation increase during temperature cycling, because the thermal stress is distributed uniformly around the fibre. However, for fibres having a certain amount of defects in the coating system, especially in the primary coating, a high level of attenuation from micro-bending loss can be present at room temperature, and the attenuation can increase dramatically as temperature drops due to the non-uniform thermal stress imparted by the defects. Potential defects in the primary coating include particles and gels, crystal formation, geometry irregularities, de-lamination, and cavities.

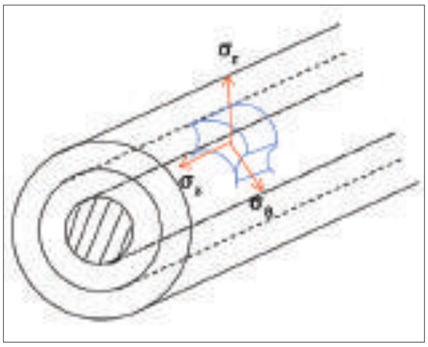
De-lamination and cavities are both associated with tensile stresses in the primary coating introduced thermally or mechanically. While the de-lamination of primary coating from glass has been well studied,[3, 4] the possibility of cavity formation from internal rupture of the primary coating has not been adequately addressed. Although primary coatings usually have very high elongation under uni-axial tensile stress, the coating material may develop internal ruptures under a tri-axial tensile stress. In-depth research work has been conducted at DSM Desotech in recent years to study this possible failure mode. The mechanism of cavity formation in the primary coating has been investigated and the development of primary coatings with high cavitation resistance has been achieved through proper molecular design of the cross-linking network structure of the coatings.

2. Mechanism of cavity formation in the primary coating layer

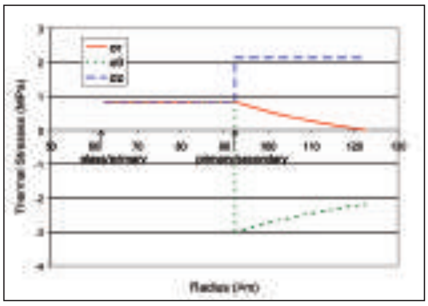
The driving force for cavity formation in the primary coating is the tri-axial tensile stress, which at a high level may exceed the cavitation strength of the coating and cause cohesive failure of the coating structure. Two types of tri-axial stresses can be present in the coating depending on different origins. The stress can be thermally induced from temperature variation or induced from external mechanical forces.

2.1 Cavities Induced by the thermal stress

2.1.1 Thermal stresses in a dual-layer coating system. It has been well understood that thermal stresses are present in the coated fibre system.[2-5] The tri-axial stress in the primary coating, as illustrated in *Figure 1*, is caused by the mis-match between the thermal expansion coefficients of the glass, primary coating and secondary coating.



▲ **Figure 1**: *Tri-axial thermal stresses in a dual-layer coating system*



▲ **Figure 2**: *Calculated thermal stresses in a dual-layer coating system*

Based on the theory of material mechanics, the tri-axial stress, consisting of radial stress σr, tangential stress σ_θ and axial stress σ_z components can be calculated. *Figure 2* shows the calculated stress distribution in a typical dual-layer coating system where coating layer thickness is 30 μm each, Young's modulus E1=1MPa, E2=1GPa, linear thermal expansion coefficients α1=3x10-4/K, α2=1x10-4/K and Poisson ratios ν1=0.5, ν2 =0.4.

The system is exposed to a temperature change of -30°C, to simulate the stress in the coating system when the coated fibre is cooled down from the drawing process to room temperature. Although the temperature in the coating during UV-curing could be as high as 100°C, the thermal stress only starts to build up when the temperature drops below the secondary coating T_g (~50°C). The three stress components in the primary coating are tensile and all at the same level as shown in *Figure 2*.

This means the stress in the primary coating at room temperature is a hydrostatic tensile stress. It increases as temperature decreases further until reaching the primary coating T_g (typically ~-20ºC), when the primary coating also turns into the glassy state. The calculated tensile stress in the primary coating is ~0.8 MPa at room temperature as shown in *Figure 2*. Due to the visco-elastic property of the secondary coating, the actual stress level should be lower than the calculated stress and decrease with time as the secondary coating undergoes stress relaxation at sub-T_g temperatures.[5]

While the risk of coating cavitation by thermal stress is low for typical dual-coated fibres, precautions must be taken to evaluate certain types of coating systems discussed below. The new developmental trend for primary coatings is to further reduce their modulus and T_g to provide improved micro-bending buffering protection over a wide temperature range. In this type of coating system, the tensile stress keeps building up as temperature begins to drop, yet the primary coating remains in its rubbery state. As shown in *Figure 3*, the calculated tensile stress increases linearly with temperature decrease. The stress relaxation of the secondary coating is also much slower at low temperatures. In addition to the risk of high thermal stress, a lower modulus primary coating may also be more prone to cavitation, due to its lower crosslink density.

It is therefore very important that primary coatings with low modulus and low T_g be carefully designed to have high cavitation strength through optimum structure of the crosslinking network.

In-depth knowledge of the cavitation resistance of UV curable coating materials at the molecular level allows the development of coating systems having improved micro-bending performance combined with high cavitation strength, to assure robust fibre performance over a wide temperature range. Another example of a high-risk situation with regard to cavity formation is fibre with thicker than standard coating layers.

The tensile stress in the primary layer of a fibre with the glass/coating OD structure of 125/350/500 µm is calculated and also plotted in *Figure 3*. The tensile stress in the primary coating of this fibre is 2.8 times the stress level of that in the primary coating of a standard 245 µm OD coated fibre. Therefore, fibres having thicker coating layers should be composed of a primary coating having high cavitation strength in combination with a secondary coating having faster stress relaxation.

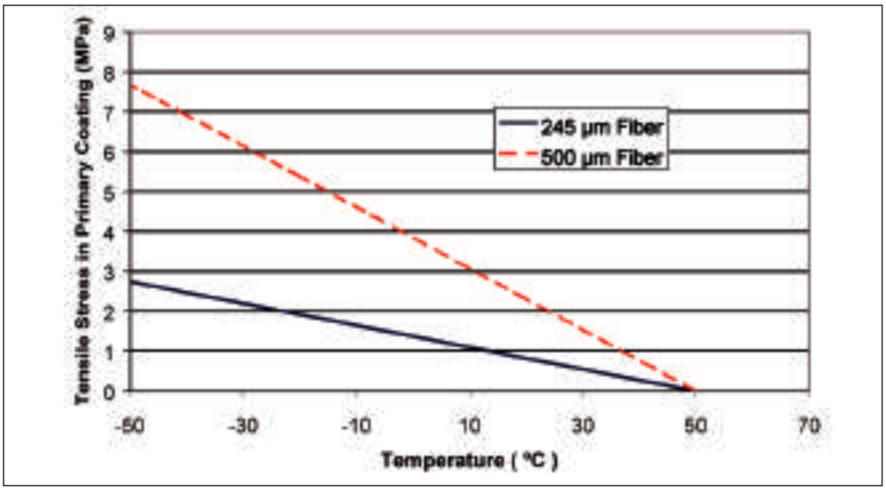
2.1.2 Cavity formation in the primary coating. Figure 4 shows microscope images of some cavities formed in a 500 µm OD coated fibre, after temperature cycling between 85ºC and -60ºC. Irregularly shaped coating ruptures of different sizes can be observed in the primary coating layer. The fact that the coating ruptures are wide open, shown as voids, indicates the presence of a tri-axial tensile stress in the primary layer at room temperature.

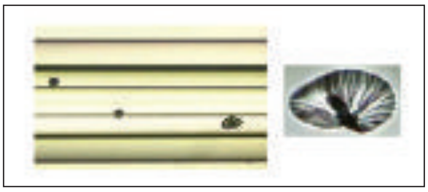
From fracture mechanics theory, the parameter representing the cavitation resistance of a material is called cavitation strength. When the tri-axial stress reaches this critical point, the material starts to rupture and form internal cavities. It has been calculated and proved experimentally that for an ideal rubber, the tri-axial stress for a very small spherical hole to be inflated unboundedly is (5/6)E, where E represents the Young's modulus.[6] Any microscopic network defect in the material may serve as the initial rupture site.

This means for a 1 MPa primary coating, a tri-axial tensile stress of 0.83 MPa can already cause cavity formation according to the un-bounded growth mechanism, if the coating material behaves like an ideal rubber. By proper molecular design of the coating's cross-linked network structure, the desired high cavitation resistance can be achieved, with the cavitation strength significantly exceeding the coating modulus.

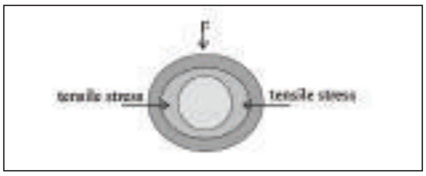
In this type of high cavitation strength primary coatings, small cavities will not grow

▼ **Figure 3**: *Calculated thermal stress vs temperature for a regular 250µm fibre (assuming the stress starts to develop below secondary Tg ~50°C)*

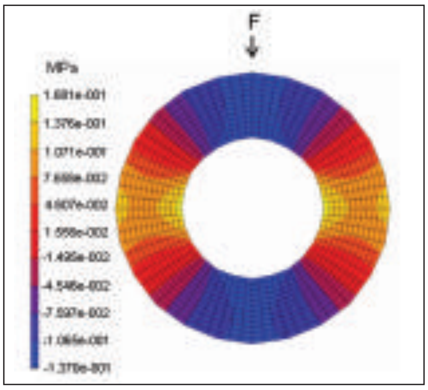




▲ **Figure 4**: *Cavities in the primary coating layer induced by temperature cycling in a 500µm fibre (left) 40x (right) 200x*



▲ **Figure 5**: *A schematic diagram of the localised tensile stresses in the primary coating by a mechanical lateral force*



▲ **Figure 6**: *Mean normal stress in the primary coating layer induced by a mechanical lateral force calculated by Finite Element Analysis*

un-boundedly and the material will not rupture even under a relatively high tensile stress level that could be present in the primary coating.

2.2 Cavities induced by the mechanical stress

In addition to the hydrostatic thermal tensile stress, cavity formation in primary coatings can also be driven by anisotropic tri-axial stress resulting from a mechanical impact on the coated fibre. It has been previously reported that coating tears were observed under high tension, when pulling fibre through a re-winder assembly to test the coating's resistance to de-lamination.[4]

When an external mechanical force is exerted on a coated fibre, the coating layers will de-form and result in a non-uniform stress field in the coating material.

Figure 5 schematically illustrates the deformation of the coating layers under a lateral force F. Since the secondary coating is a much harder material than the primary coating, the secondary layer behaves like a hollow tube being pressed under the lateral pressure with the shape of the tube changing to oval, but with no deformation on coating thickness. The primary coating is bonded on both sides with glass and secondary and is forced to deform internally. The areas of primary coating along the force direction are compressed and the areas perpendicular to the force direction are stretched. The tensile stress in these stretched areas has a significant tri-axial component that may cause primary coating cavitation if the stress exceeds the cavitation strength of the coating.

Figure 6 demonstrates a mean normal stress field calculated by Finite Element Analysis in the primary coating layer of a fibre with OD geometry of 125/240/410 µm under a simulated lateral force condition.

The result quantitatively shows different stress fields varying from compressive (-) to tensile (+). As shown in *Figure 6*, the areas under the highest tensile stress are the spots perpendicular to the direction of the applied force and close to either side of the interfaces between glass and primary coating and between primary coating and secondary coating. These areas are where the cavitation would most likely start under applied mechanical lateral force.

Figure 7 shows some examples of intentionally induced cavities in the primary coating formed by mechanical lateral impacts. The lateral force has to be dynamic with the speed, either along the fibre (sliding) or perpendicular to the fibre (hitting). A static lateral force can only result in de-lamination.

In *Figure 7*, the mechanical impact was created by sliding a 1mm diameter metal rod along the fibre direction. A fixture was made attaching the metal rod to an automatic rub tester with controlled speeds and controlled forces by adding different weights on the fixture. Both force level and impact speed influence the stress state in the coating.

At very slow speeds, de-lamination occurs rather than coating cavitation. This may be because the small de-lamination area formed at the initial contact of the force propagates along the fibre and releases the tensile stress in the coating. At medium to high speeds, cavities and/or de-lamination can be formed as shown in *Figure 7*. The cavities are localised on the two side areas, which is in agreement with the theory.

Cavities and de-lamination are two competing failure modes. They may appear individually or simultaneously, depending on the properties of adhesion level and cavitation strength of a particular coating.

The adhesion level of primary coating on glass should be balanced with the strip force requirement. A high cavitation strength is always desirable for a primary coating to improve the robustness of the coated fibre. One should be aware, however, any coated fibre will eventually fail in the form of de-lamination and/or cavitation when the mechanical impact is elevated to a certain level.

While thermal stress is intrinsic from the dual-layer design, mechanical stress comes from external sources. Any abnormal high-pressure impacts on fibres should be avoided during the fibre drawing, spooling, proof-testing and handling processes.

3. Cavitation strength of primary coatings

3.1 Cavitation strength test

The physical concept of cavitation strength as described in 2.1.2 is the critical tri-axial stress level at which a material starts to rupture. A test method has been developed to measure the cavitation strength of a coating material from a cured film.

3.1.1 Measurement setup. In principle the way to induce tri-axial tensile stress in a coating material is straightforward: increase the volume of the rubber-like coating material. The coating is cured and adhered between two flat surfaces, which are separated in a tensile testing machine. With the controlled increase of the distance between the two plates, a tri-axial tensile stress is generated in the coating.

The setup is designed so that the coating thickness is less than 5% of the diameter of the plates. Because this very thin layer of coating is bounded to the plates, the sideway contraction of the coating is restricted. Consequently, a tri-axial tensile stress is created uniformly in the coating material. In order to obtain reproducible values of the cavitation strength, the alignment of the setup is important, since this affects the stress distribution in the sample. Furthermore, to be able to study the development of the amount of cavities with the load in a reproducible way, the stiffness of the setup should be high (ie the compliance should be low) in order to minimise the storage of elastic energy in the measurement setup.

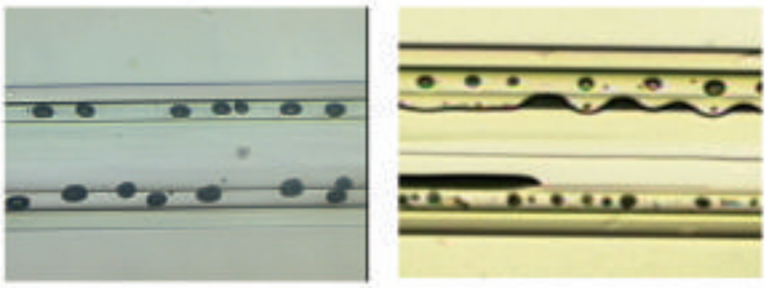
3.1.2 Sample preparation. The sample setup is illustrated in Figure 8. To avoid de-lamination during the course of the experiment, the surfaces of the glass plates and the quartz billets have to be properly prepared. First the surfaces were roughened by polishing using a carborundum powder. The glass and quartz pieces were then burned clean in an oven at 600ºC for one hour, and the surfaces were rinsed with acetone and allowed to dry. Subsequently, the surfaces were treated with a solution of a silane adhesion promoter – Methacryloxypropyltrimethoxysilane (A174 from Witco) was used. The silane layer was cured by placing the treated glass or quartz plates in an oven at 90ºC for 5-10 minutes. After this pre-treatment, a droplet of resin was disposed onto the glass plate and covered with the quartz billet. The film thickness is set to approximately 100 µm using a two-plate micrometer. The sample was cured with a 1 J/cm^2 dose, using a Fusion F600W UV-D lamp system.

3.1.3 Measurement of the cavitation strength. The sample was placed in the tensile testing apparatus (Zwick type 1484). The pulling speed was 20 µm/min. When an experiment was started, a video camera, attached to a microscope with 20x magnification, recorded the behaviour of the film, while also showing the stress level being exerted on the film.

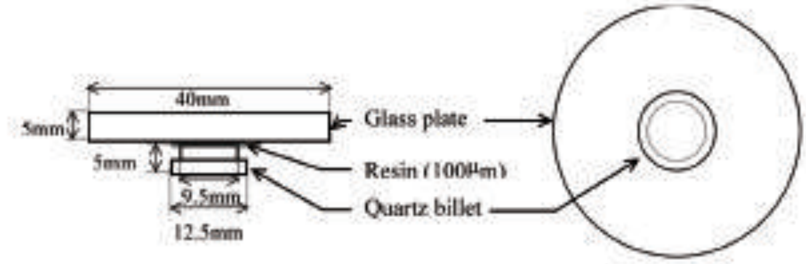
Figure 9 shows an image of the sample, captured by the video camera, with many cavities already formed. From the videotape, the number of cavities appearing as a function of the applied stress was plotted as illustrated in *Figure 10*.

It was found that the stresses at which the first cavity was observed were all at a similar level for different coating materials. However, the stress levels started to exhibit clear differences among different coatings, as more cavities were formed. In this test method, the stress value corresponding to the formation of 10 cavities was selected to represent the cavitation strength of the measured coating.

▼ **Figure 7**: *Examples of cavity/delamination formation in the primary coating layer by mechanical lateral impact*



▼ **Figure 8**: *Sample set up of the cavitation strength test*



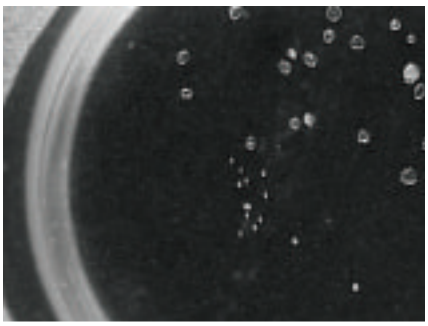
For example, the coatings shown in *Figure 10* were reported as having cavitation strength values of 0.96 MPa and 1.49 MPa, respectively.

3.2 High cavitation strength primary coatings

As discussed in 2.1.2, coating cavitation occurs when the tri-axial tensile stress exceeds the cavitation strength of the coating material. In order to reduce the risk of coating cavitation, the two effective approaches are to 1) reduce the level of thermal stress, and/or 2) increase the coating cavitation strength. The thermal stress level is affected by both coating layers where secondary coating plays a more important role than the primary coating. On the other hand, cavitation strength is an intrinsic property of the primary coating. A high cavitation strength primary coating is always desired to ensure the robustness of the coated fibre, under conditions of thermal stress and any possible mechanical stresses encountered during processing, handling and deployment in the field.

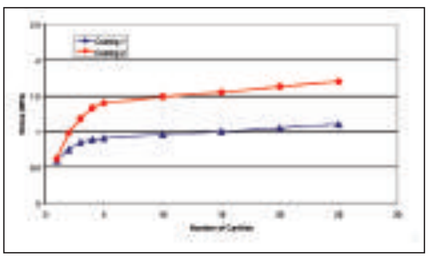
Table 1 gives several examples of primary coatings with different cavitation strength behaviour. The cavitation strength (σcav) was measured using the test method described in 3.1. The values of storage modulus E' at room temperature from DMA and the ratios of σcav /E' are also listed.

As discussed in 2.1.2, the cavitation strength of an ideal rubber should be (5/6)E. From *Table 1*, each of the coatings has a cavitation strength higher than its modulus, which indicates the coatings do not comply with perfect elasticity. The modulus, corresponding to the crosslink density of the coating, still plays an important role in determining the cavitation strength of a coating material. However, through proper molecular level design of the polymer network structure, high cavitation strength can be achieved independently of the coating modulus.



▲ **Figure 9**: *Example of cavities in a sample recorded by the camera (20x) at certain stress level*

▼ **Figure 10**: *Tensile stress in relation to the number of observed cavities in two coating materials*



In other words, ideal soft, but tough coatings having a high ratio of cavitation strength/ modulus can be realised. The low modulus is for the benefit of better micro-bending performance.

From *Table 1*, Coating A has the lowest modulus, however, its cavitation strength is also the lowest (<1 MPa). In fact, the fibre with this coating showed severe cavities from the cooling process after fibre drawing. Coating B, with cavitation strength equal to 1.21 MPa, is considered strong enough to withstand the thermal stress encountered during fibre cooling. No cavities were observed on the fibre with Coating B. Also from theoretical analysis, this cavitation strength level is sufficiently higher than the calculated ~0.8 MPa thermal stress in the primary coating. However, the ratio of σcav/E' of Coating B is only 1.2, the lowest among all the coatings. This type of coating is considered adequate to withstand the regular stress situations, but did not realise its full potential to become a highly robust coating material.

On the other hand, Coatings C, D, E and F exhibit the desired high cavitation strength properties. The modulus of Coating C or Coating D is at the typical level among commercial primary coatings. However, their cavitation strength is designed to be at an exceptionally high level through optimum molecular structure of the crosslinking network. Coating E has a medium-low modulus level (combined with low T_g), which was developed to be applied on both single mode and multi-mode fibres. The cavitation strength of this coating is still at very high level (2.1 MPa) and allows for a high ratio of σcav/E' (2.3). Coating F provides excellent micro-bending resistance attributed to the ultra-low modulus (and low T_g). In the mean time, a sufficiently high level of cavitation strength (1.51 MPa) has also been achieved with the ratio of σcav/E' being as high as 2.4. For ultra-soft coatings like this, special precautions must be taken to incorporate the property of good cavitation strength into the coating structure. Otherwise, the pitfall of developing coating cavitation and deteriorating fibre attenuation performance is a possible risk.

Situations such as Coating A where cavities were already present in the fibre after drawing can be easily identified. The hidden risk lies in situations where cavities in the coating can gradually form and cause attenuation increase in the field, when the fibre goes through environmental temperature cycles or stays at low temperatures for a long time period, ie in submarine cables. A carefully designed high quality coating system not only contributes to premium fibre performance but also provides better long-term reliability of the optical fibres.

4. Conclusions

Primary coating cavitation has been studied comprehensively as a possible failure mode in dual-layer coated optical fibres.

Coating	E'	σ_{cav}	Ratio
	(MPa)	(MPa)	σ_{cav}/E'
A	0.37	0.95	2.6
B	0.97	1.21	1.2
C	1.33	2.5	1.9
D	1.2	2.8	2.3
E	0.9	2.1	2.3
F	0.64	1.51	2.4

▲ **Table 1**: *The measured cavitation strength properties of the selected primary coatings*

The driving force for coating cavitation is a tri-axial tensile stress, which can be induced by internal thermal stress or external mechanical impact. The coating ruptures cohesively when the tri-axial tensile stress exceeds the coating cavitation strength. A test method was developed to quantitatively evaluate the cavitation strength of a coating material.

Through understanding of the coating cavitation mechanism and insights on coating cavitation resistance, it has been possible to design coating materials with high cavitation strength to provide robustness to coated fibre under potential thermal and mechanical stresses. High cavitation strength/modulus ratios have been obtained, to afford the desired low modulus/low T_g primary coatings, for improved micro-bending protection, in combination with the high cavitation strength. ■

5. References

[1] D Gloge, 'Optical-fiber Packaging and Its Influence on Fiber Straightness and Loss', The Bell System Technical J, 54(2), 245-262 (1975)

[2] W W King, 'Thermally Induced Stresses in an Optical - Fiber Coating', J of Lightwave Technology, 9(8), 952-953 (1991)

[3] W W King and C J Aloisio, 'Thermomechanical Mechanism for Delaminations of Polymer Coatings from Optical Fibers', J of Electronic Packaging, 119, 133-137 (1997)

[4] P L Tabaddor, C J Aloisio, C H Plagianis, C R Taylor, V Kuck and P G Simpkins, 'Mechanics of Delamination Resistance Testing', International Wire and Cable Symposium Proceedings, p 725 (1998)

[5] C J Aloisio, W W King and R C Moore, 'A Viscoelastic Analysis of Thermally Induced Residual Stresses in Dual Coated Optical Fibers', International Wire and Cable Symposium Proceedings, p 139 (1995)

[6] A N Gent and P B Lindley, 'Internal Rupture of Bonded Rubber Cylinders in Tension', Proc Roy Soc A, 249, 1958

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Ultraschallschweißen wird vorgestellt

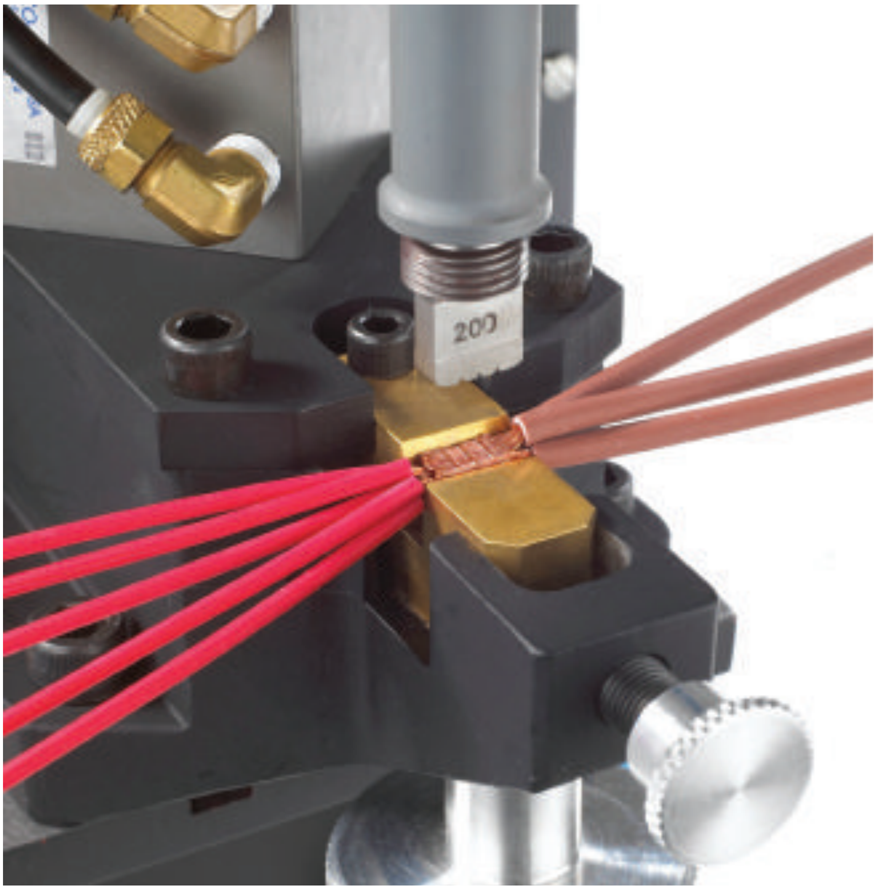
SpliceRite™ Ultraschall-Drahtspleißer stand im Mittelpunkt auf dem Sonobond Ultrasonics Stand während der im Mai stattgefundenen Ausstellung Electrical Wire Processing Technology Expo in Milwaukee, USA.

SpliceRite ist dazu bestimmt perfekte metallurgische Bindungen im festen Zustand, mit Einsatz niedrigstmöglichem Spannungsabfall und minimalem Energieverbrauch, herzustellen.

Die Einheit schließt den Bedarf an Klemmen, Löten, Crimpen oder Eintauchen, dank des schnellen Spleißens von Drahtbündeln ohne dabei Bögen, Funk oder Rauch zu erzeugen noch die Drähte zu schmelzen, aus. Außerdem können verzinnte oder stark oxydierte Drähte gespleißt werden.

Die Einheit ist mit einem Mikroprozessorregler ausgestattet, der bis zu 250 Arbeiten speichern und abrufen kann, während Schweißungen je nach Höhe, Energie oder Zeit hergestellt werden. Dieser Ultraschall-Metallschweißer steht in 1500 und 2500 Watt Stromkapazität zur Verfügung.

Alle Sonobond Metallschweißer, einschließlich der SpliceRite™ Ultraschall-Drahtspleißer, bieten kegelförmige Klemmspitzen aus Stahl für wärmebehandelte Werkzeuge. Diese Spitzen können bis zu 300.000 Schweißnähte überdauern und ermöglichen schnelle Werkzeugwechsel.



▲ *Mit SpliceRite™ Ultraschall-Drahtspleißer können Drahtbündel schnell und sicher gebunden werden, selbst wenn die Drähte verzinnt oder oxydiert sind*

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Anschließenfinnland und Schweden

Nexans wurde ein Vertrag in Höhe von rund 150 Millionen Euro von Fingrid Oyj erteilt, dem Stromübertragungssystembetreiber in Finnland, und von Svenska Kraftnät, einem staatlicher Stromversorger, der das nationale Stromnetz in Schweden betreibt.

Der Vertrag sieht die Herstellung und Installation eines HVDC-(Hochspannungs-Gleichstrom) Unterseekabels für Fenno-Skan 2 vor, der neue Interkonnektor zwischen Finnland und Schweden.

Nexans wird ein rund 200 km langes, festes, nicht abwanderndes massegetränktes (MIND - Mass Impregnated Non-Draining) Sonderkabel liefern, sowohl für die Unterseewie für die Festlandabschnitte des Fenno-Skan 2 Interkonnektors. Mit einem Kupferdurchmesser von 2.000 mm², wird es das HVDC-Kabel mit größter Kapazität sein, das bis heute von Nexans hergestellt wurde.

Die Herstellung des Fenno-Skan 2 Kabels wird in Nexans´ Anlage in Halden, Norwegen, ab Herbst 2009 laufen. Die Verlegung des Unterseekabels, die bei einer maximalen Meerestiefe von 100 m erfolgt, wird durch das unternehmenseigene Kabelverlegungsschiff – CS Skagerrak - durchgeführt und ist für Frühling 2011 geplant. Das Kabel wird in zwei durchlaufenden Längen von rund 100 km geliefert, so daß nur eine Offshore-Muffe benötigt wird.

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Schwergewicht

▲ *Die neuste Trommerverseilmaschine ist die größte ihrer Art*

Gauder Group freut sich einen wichtigen Vertrag für eine Trommelverseilanlage bekannt zu geben, die der Saudi Cable Company geliefert wird.

Diese neuste Trommelverseilanlage ist die 700ste, die von Gauder an die Kabelindustrie geliefert wird und wird die größte ihrer Art sein. Die Anlage, die zur Erzeugung von Hochspannungs-Stromkabeln dient, wird für eine 4 Meter große und 30 Tonnen schwere Aufwickelspule entworfen.

Pourtier - Gauder Group ist seit langem Lieferant von Saudi Cable, einem führender Hersteller mit einer kompletten Auswahl an Kabeln im Mittleren Osten.

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Neue Investition für Spulenhersteller

Madem hat bereits Produktionsanlagen in Brasilien, Spanien und den USA und ist jetzt dabei eine neue Anlage im Königreich Bahrain noch in diesem Jahr zu eröffnen. Mit einer monatlichen Produktion von rund 500 Containern zerlegbarer Holzspulen, verkauft Madem in über 40 Länder und wahrscheinlich an die wichtigsten Draht- und Kabelhersteller.

Im Laufe des Jahres 2008 wird Madem 5 Mio. USD in eine hochtechnische Sperrholzanlage investieren, die 70 Container Sperrholzflansche pro Monat erzeugen kann.

“Kunden aus der ganzen Welt suchen nach neuen Ideen, Madem bietet neue Kit-Verpackungen, ein neues System von Klemmhülsen und Montageverfahren vor Ort. Madem arbeit eng mit den Kunden zusammen, schlägt Spezifikationsänderungen vor, die seinen Kunden Kosteneinsparungen bieten werden,” sagt der Verkaufsleiter der Madem-Gruppe, Leandro Mazzoccato.

▲ *von links: Leandro Mazzoccato - Verkaufsleiter der Madem-Gruppe; in der Mitte: Roger Santasusana - Leiter, Euromadem Spanien SL.; rechts: Gino F Mazzoccato Präsident und Leiter der Madem-Gruppe*

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Primärbeschichtungen mit hoher Kavitationsfestigkeit für Lichtwellenleiter

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und [2]Markus Bulters und [2]Paul Steeman, DSM Research, Geleen, Niederlande

Übersicht

Es ist wohl bekannt daß die Ausführung von weichen Primärbeschichtungen in Kombination mit harten Sekundärbeschichtungen einen guten Mikrobiegeschutz für zweifach beschichtete Lichtwellenleiter bietet. Jedoch erzeugt dieser zweischichtige Aufbau auf Grund der Fehlanpassung zwischen der thermischen Ausdehnung und Schrumpfung der zwei Beschichtungsschichten auch thermische Spannung im Beschichtungssystem. Unter der dreiaxialen Zugbeanspruchung könnte die weiche Primärbeschichtung zu inneren Brüchen führen. Die Kavitation der Primärbeschichtung ist ein möglicher Fehlmodus, der für die Leistung der Faserdämpfung schädlich sein könnte. In dieser Arbeit wird der Mechanismus für die Beschichtungskavitation in Bezug auf die verschiedenen Typen von Triebkräften beschrieben. Die Kavitationsfestigkeit der Primärbeschichtung wird als eine Schlüsseleigenschaft vorgestellt, um ein robustes Beschichtungssystem mit hoher Leistung und der gewünschten niedrigen Mikrobiege-Empfindlichkeit in Kombination mit einem hohen Kavitationswiderstand zu erzielen.

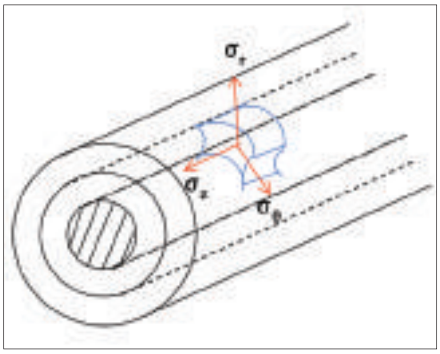
1. Einleitung

Einer der wichtigsten Vorteile des zweischichtigen Beschichtungsaufbaus für Lichtwellenleiter besteht darin einen höheren Mikrobiegeschutz im Vergleich zur einschichtigen Beschichtung zu bieten. Eine weiche Primärbeschichtung, die als Pufferschicht wirkt, kombiniert mit einer harten Sekundärbeschichtung, die als Abschirmungsschicht fungiert, bietet eine ideale Biegefestigkeit für die Fasern, die externen Beanspruchungen in einer Kabelumgebung widerstehen müssen.

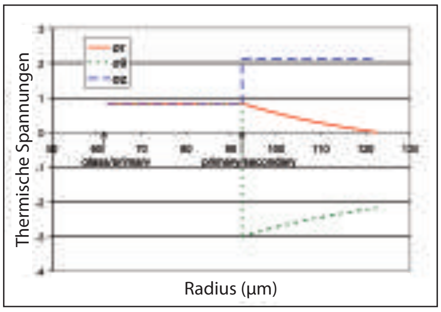
[1]Thermische Spannung ist im zweischichtigen Beschichtungssystem unvermeidlich wegen der unterschiedlichen thermischen Ausdehnungen und Schrumpfungen des Glases, der Primärbeschichtung und der Sekundärbeschichtung. Standard Monomode- oder Multimodefaser mit hochwertigen zweischichtigen Beschichtungen weisen keine „out-of-spec"- Dämpfungserhöhung während des Temperaturzyklus auf, weil die thermische Spannung gleichmäßig um die Faser verteilt wird. Dennoch kann für Fasern, die eine bestimmte Menge von Mängeln im Beschichtungssystem – insbesondere in der Primärbeschichtung – aufweisen, bei Raumtemperatur ein hohes Dämpfungsniveau wegen des Mikrobiegeverlusts vorhanden sein, und die Dämpfung kann erheblich zunehmen während die Temperatur wegen der uneinheitlichen, thermischen, von den Mängeln verliehenen Spannung, sinkt. Potentielle Mängel in der Primärbeschichtung schließen Teilchen und Gel sowie Kristallbildung, Unregelmäßigkeiten der Geometrie, Delaminierung und Kavitäten ein.

Die Delaminierung und die Kavitäten sind beide mit den Zugbeanspruchungen in der Primärbeschichtung verknüpft, die thermisch oder mechanisch eingeführt werden. Während die Delaminierung der Primärbeschichtung vom Glas ausführlich untersucht wurde, [3, 4]hat man sich mit der Möglichkeit der Kavitationsbildung aus inneren Brüchen der Primärbeschichtung nicht ausreichend beschäftigt.

Obwohl Primärbeschichtungen in der Regel sehr hohe Dehnungen unter der einaxialen Zugbeanspruchung aufweisen, könnte jedoch das Beschichtungsmaterial innere Brüche unter einer dreiaxialen Zugbeanspruchung entwickeln. Eine in die Tiefe gehende Forschungsarbeit wurde bei DSM Desotech in den letzten Jahren durchgeführt, um dieses potentielle Ausfallverhalten zu untersuchen. Der Mechanismus der Kavitätsbildung in der Primärbeschichtung wurde erforscht und durch ein geeignetes Molekulardesign der Vernetzungsstruktur der Beschichtungen wurde die Entwicklung von Primärbeschichtungen mit hohem Kavitationswiderstand erreicht.



▲ **Bild 1**: *Dreiaxiale thermische Spannungen in einem zweilagigen Beschichtungssystem*



▲ **Bild 2**: *Berechnete thermische Spannungen in einem zweilagigen Beschichtungssystem*

2. Mechanismus der Kavitätsbildung in der Primärbeschichtungslage

Die Triebkraft für die Kavitätsbildung in der Primärbeschichtung ist die dreiaxiale Zugbeanspruchung, die bei einem hohen Niveau die Kavitationsfestigkeit der Beschichtung überschreiten und zu einem Kohäsivbruch der Beschichtungsstruktur führen könnte. Zwei Typen dreiaxialer Beanspruchungen können in der Beschichtung vorhanden sein, je nach den unterschiedlichen Ursprüngen. Die Beanspruchung kann von der Temperaturschwankung thermisch verursacht werden bzw. von äußeren mechanischen Kräften.

2.1 Durch thermische Spannung verursachte Kavitäten

2.1.1 Thermische Spannungen in einem zweilagigen Beschichtungssystem. Es wurde sicher verstanden, daß die thermischen Spannungen im beschichteten Fasersystem vorhanden sind. [2-5]Wie in *Bild 1* dargestellt, wird die dreiaxiale Spannung in der Primärbeschichtung durch die Nichtübereinstimmung zwischen den thermischen Ausdehnungskoeffizienten des Glases, der Primärbeschichtung und der Sekundärbeschichtung verursacht.

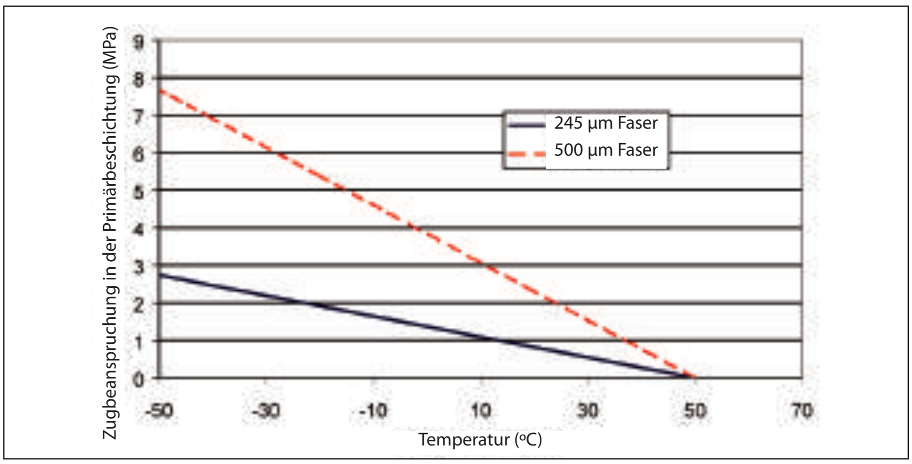
Basierend auf der Theorie der Materialmechanik, kann die dreiaxiale Beanspruchung berechnet werden, die aus Bestandteilen der Radial- σ_{rr}, der Tangential- σ_{θ} und der Axialspannung σ_z besteht. *Bild 2* zeigt die berechnete Spannungsverteilung in einem typischen zweilagigen Beschichtungssystem, wo die Schichtdicke der Beschichtung je 30µm entspricht, Youngs Modul E_1=1MPa, E_2=1GPa, lineare thermische Ausdehnungskoeffizienten $\alpha_1=3x10^{-4}$/K, $\alpha_2=1x10^{-4}$/K und Poisson Verhältnisse v_1=0,5, v_2 =0,4. Das System ist einer Temperaturänderung von -30ºC ausgesetzt, um die Spannung im Beschichtungssystem zu simulieren, wenn die beschichtete Faser vom Ziehverfahren auf die Raumtemperatur abgekühlt wird. Obwohl die Temperatur in der Beschichtung während des UV-Aushärtens einen Höchstwert von 100ºC haben könnte, beginnt die thermische Spannung sich erst dann aufzubauen, wenn die Temperatur unter die Glasübergangstemperatur (T_g – Glass transition temperature) der Sekundärbeschichtung (~50ºC) sinkt.

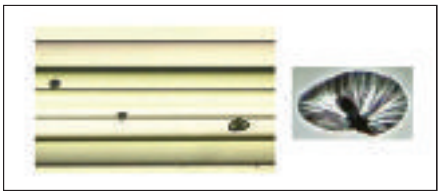
Die drei Beanspruchungsbestandteile in der Primärbeschichtung sind Zugbeanspruchungen und befinden sich alle auf demselben Niveau, wie in *Bild 2* dargestellt. Das bedeutet, daß die Beanspruchung in der Primärbeschichtung bei Raumtemperatur eine hydrostatische Zugbeanspruchung ist: sie steigt während die Temperatur abnimmt bis die Primarbeschichtung T_g (in der Regel ~-20ºC) erreicht wird, wenn sich die Primarbeschichtung ebenfalls in den Glaszustand umwandelt. Die berechnete Zugbeanspruchung in der Primärbeschichtung ist ~0.8 MPa bei Raumtemperatur, wie in Bild 2 dargestellt. Wegen der viskoelastischen Eigenschaft der Sekundärbeschichtung, sollte das Ist-Beanspruchungsniveau niedriger sein als die berechnete Beanspruchung und allmählich abnehmen, wenn die Sekundärbeschichtung der Beanspruchungsentspannung bei Temperaturen von Sub-Tg unterzogen wird.[5]

Während die Gefahr der Beschichtungskavitation durch thermische Spannung niedriger für typische zweifach beschichtete Fasern ist, sind Maßnahmen zu treffen, um bestimmte nachfolgend beschriebene Beschichtungssystemtypen auszuwerten. Die neue Entwicklungstendenz für Primärbeschichtungen besteht darin deren Modul und T_g weiter zu reduzieren, um einen verbesserten Mikrobiege-Pufferschutz über einen weiten Temperaturbereich zu bieten. Bei diesem Beschichtungssystemtyp baut sich die Zugbeanspruchung weiter auf wenn die Temperatur anfängt zu sinken, dennoch bleibt die Primärbeschichtung in ihrem Gummizustand. Wie in *Bild 3* dargestellt, steigt die berechnete Zugbeanspruchung linear mit der Temperaturabnahme. Die Beanspruchungsentspannung der Sekundärbeschichtung ist bei niedrigen Temperaturen außerdem viel langsamer. Neben der Gefahr der hohen thermischen Spannung, könnte auch eine niedrigere Modulprimärbeschichtung wegen ihrer niedrigen Vernetzungsdichte eher zur Kavitation neigen.

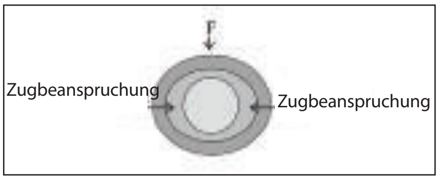
Um eine hohe Kavitationsfestigkeit durch eine optimale Vernetzungsstruktur zu erreichen ist es sehr wichtig, daß die Primärbeschichtungen mit niedrigem Modul und niedriger T_g sorgfältig entworfen werden. Dank der guten Kenntnis des Kavitationswiderstands von UV-härtenden Beschichtungsmaterialien im Molekularniveau, kann die Entwicklung der Beschichtungssysteme ein verbessertes Mikrobiegeverhalten aufweisen, kombiniert mit einer hohen Kavitationsfestigkeit, um eine robuste Faserleistung über einen weiten Temperaturbereich zu sichern.

▼ **Bild 3**: *Berechnete thermische Spannung gegen Temperatur für eine normale 250µm Faser (unter der Vorraussetzung, daß die Spannung anfängt sich bei einer Temperatur, die unter jener der Sekundärbeschichtung mit T_g ~50°C liegt, zu entwickeln)*

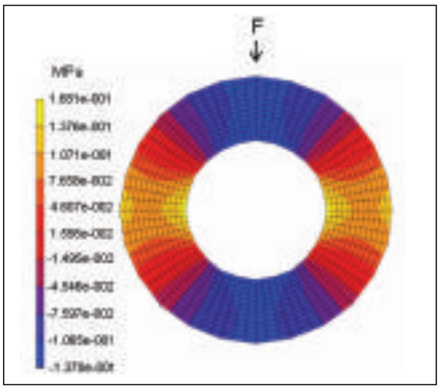




▲ **Bild 4**: *Kavitäten in der Primärbeschichtungslage durch Temperaturzyklen in einer 500µm Faser (links) 40x (rechts) 200x verursacht*



▲ **Bild 5**: *Ein schematisches Diagramm der örtlich begrenzten Zugbeanspruchungen in der Primärbeschichtung durch eine mechanische seitliche Kraft*



▲ **Bild 6**: *Durchschnittliche normale Spannung in der Primärbeschichtunglage, durch eine mechanische seitliche Kraft verursacht, die mit der Finite-Element-Analyse berechnet wird*

Ein weiteres Beispiel über eine hochriskante Situation in Hinblick auf die Kavitätsbildung besteht in einer Faser, die im Vergleich zu Standardschichten dickere Beschichtungslagen aufweist. Die Zugbeanspruchung in der Primärschicht einer Faser mit einer Außendurchmesserstruktur des Glases/der Beschichtung von 125/350/500µm wird berechnet und auch in *Bild 3* graphisch dargestellt.

Die Zugbeanspruchung in der Primärbeschichtung dieser Faser entspricht 2,8 Mal dem Beanspruchungsniveau in der Primärbeschichtung einer normal beschichteten Faser mit einem Außendurchmesser von 245µm. Daher sollten Fasern mit einer dickeren Beschichtungslage aus einer Primärbeschichtung mit einer höheren Kavitationsfestigkeit in Kombination mit einer Sekundärbeschichtung bestehen, die eine schnellere Beanspruchungsentspannung ermöglicht.

2.1.2 Kavitätsbildung in der Primärbeschichtung. *Bild 4* zeigt Mikroskopbilder einiger Kavitäten, die sich bei einer beschichteten Faser mit 500µm Außendurchmesser bilden, nach einem Temperaturzyklus zwischen 85ºC und -60ºC. Unregelmäßig geformte Beschichtungsbrüche unterschiedlicher Größe können in der Primärbeschichtungslage beobachtet werden. Die Tatsache, daß die Beschichtungsbrüche weit offen sind - was mit Leerstellen dargestellt wird - zeigt das Vorhandensein einer dreiaxialen Zugbeanspruchung in der Primärschicht bei Raumtemperatur.

Nach der Theorie der Bruchmechanik, wird der Parameter, der den Kavitationswiderstand eines Materials darstellt, Kavitationsfestigkeit genannt. Wenn die dreiaxiale Beanspruchung diesen kritischen Punkt erreicht, fängt das Material an zu brechen und formt innere Kavitäten. Es wurde berechnet und durch Experimente erwiesen, daß für einen idealen Gummi, die dreiaxiale Beanspruchung um ein sehr kleines kugelförmiges Loch uneingeschränkt auszubreiten, (5/6)E entspricht, wo E den Youngs Modul darstellt.[6] Jeder mikroskopische Vernetzungsmangel im Material könnte als anfängliche Bruchstelle dienen. Das bedeutet für eine 1MPa Primärbeschichtung, daß eine dreiaxiale Zugbeanspruchung von 0,83MPa bereits eine Kavitätsbildung entsprechend des unbegrenzten Zuwachsmechanismus verursachen könnte, wenn das Verhalten des Beschichtungsmaterials dem eines idealen Gummi entspricht. Anhand eines geeigneten Molekulardesigns der Vernetzungsstruktur der Beschichtung, kann der gewünschte hohe Kavitationswiderstand mit einer Kavitationsfestigkeit, die das Beschichtungsmodul wesentlich übertrifft. erreicht werden.

Bei dieser Art Primärbeschichtungen mit hoher Kavitationsfestigkeit werden kleine Kavitäten nicht unbegrenzt zunehmen und das Material wird nicht brechen, auch nicht unter einem relativ hohen Zugbeanspruchungsniveau, das in der Primärbeschichtung vorliegen könnte.

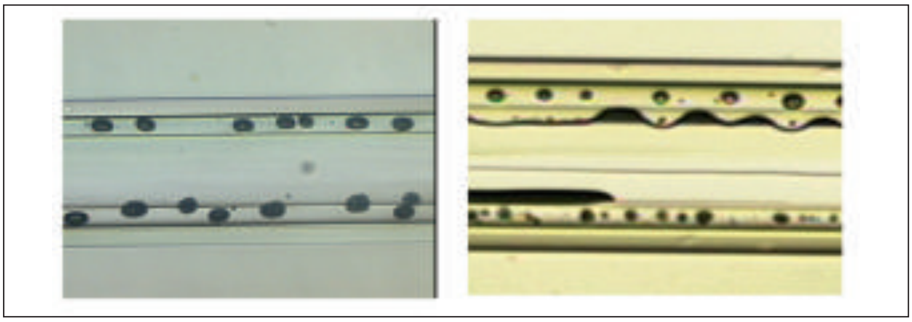
2.2 Durch mechanische Spannung verursachte Kavitäten

Neben der hydrostatischen thermischen Zugbeanspruchung, kann die Kavitätsbildung bei Primärbeschichtungen auch durch eine richtungsabhängige dreiaxiale Spannung angetrieben werden, die sich aus einer mechanischen Auswirkung an der beschichteten Faser ergibt. Es wurde zuvor berichtet, daß die Beschichtungsrisse unter hoher Spannung beobachtet wurden, wenn die Faser durch eine Vorrichtung zum Umwickeln gezogen wird, um den Beschichtungswiderstand zur Delaminierung zu testen.[4] Wenn eine äußere mechanische Kraft auf eine beschichtete Faser ausgeübt wird, verformen sich die Beschichtungsschichten und dies spiegelt sich in einem uneinheitlichen Spannungsfeld im Beschichtungsmaterial wider. *Bild 5* verdeutlicht schematisch die Verformung der Beschichtungsschichten unter einer seitlichen Kraft F. Da die Sekundärbeschichtung aus einem viel härteren Material als die Primärbeschichtung besteht, verhält sich die Sekundärschicht wie ein hohles Rohr, das seitlichen Druck unterzogen wird, wobei die Form des Rohrs sich in eine ovale Form verändert, jedoch ohne Deformationen bei der Beschichtungsdicke. Die Primärbeschichtung ist an beide Seiten am Glas und an der Sekundärbeschichtung gebunden und ist gezwungen innen zu verformen. Die Bereiche der Primärbeschichtung, die sich entlang der Kraftrichtung befinden, sind komprimiert und die Bereiche, die senkrecht zur Kraftrichtung liegen, sind ausgesteckt. Die Zugbeanspruchung in diesen ausgestreckten Bereichen weist einen wichtigen dreiaxialen Bestandteil auf, der die Kavitation der Primärbeschichtung verursachen könnte, wenn die Beanspruchung die Kavitationsfestigkeit der Beschichtung überschreitet.

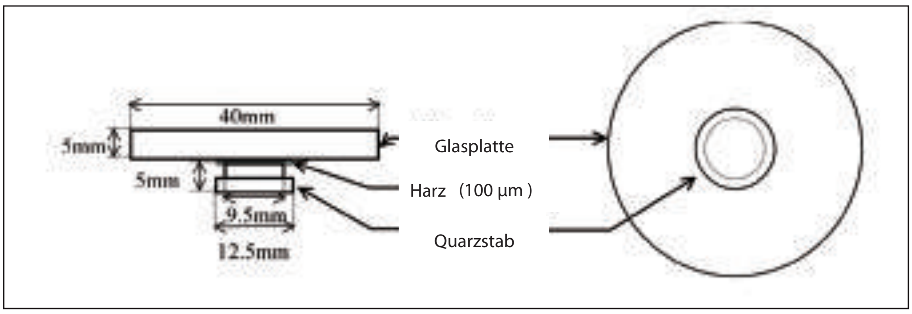
Bild 6 stellt ein durchschnittliches normales Spannungsfeld dar, das durch eine Finite-Element-Analyse in der Primärbeschichtungslage einer Faser mit einer Geometrie des Außendurchmessers von 125/240/410µm berechnet wird, unter simulierter seitlicher Kraftbedingung. Das Ergebnis zeigt quantitativ verschiedene Spannungsfelder, variierend von zusammengepreßten (-) bis zu entspannten (+). Wie in Bild 6 dargestellt, sind die Bereiche unter der höchsten Zugbeanspruchung jene Stellen, die senkrecht zur Richtung der angewandten Kraft und neben den beiden Seiten der Schnittstellen zwischen Glas und Primärbeschichtung und zwischen Primärbeschichtung und Sekundärbeschichtung befinden. Diese Bereiche befinden sich dort wo die Kavitation unter angewandter mechanischer seitlicher Kraft möglicherweise zu erscheinen beginnt.

Bild 7 zeigt einige Beispiele absichtlich verursachter Kavitäten in der Primärbeschichtung, die durch mechanische seitliche Auswirkungen geschaffen werden. Die seitliche Kraft muß mit der Geschwindigkeit dynamisch sein, entweder entlang der Faser (gleiten) oder senkrecht zur Faser (schlagen). Eine statische seitliche Kraft kann nur zur Delaminierung führen. In *Bild 7*, wurde die mechanische Auswirkung durch das Gleiten eines 1mm dicken Metallstabs entlang der Faserrichtung bewirkt. Ein Gerät wurde hergestellt durch das Anbringen eines Metallstabs an ein automatisches Reibungsprüfgerät mit gesteuerten Geschwindigkeiten sowie Kräften, indem verschiedene Gewichte dem Gerät hinzugefügt wurden. Das Kraftniveau sowie die Auswirkungsgeschwindigkeit beeinflussen den Spannungszustand in der Beschichtung. Bei sehr niedrigen Geschwindigkeiten, entsteht eher eine Delaminierung als eine Beschichtungskavitation. Dies könnte sich daraus ergeben, daß der geringe Delaminierungsbereich, der sich am anfänglichen Kontakt mit der Kraft bildet, sich entlang der Faser verbreitet und die Zugbeanspruchung in der Beschichtung freisetzt. Von Mittel- bis zu Hochgeschwindigkeiten, können Kavitäten und/oder Delaminierung entstehen, wie in *Bild 7* dargestellt.

▼ **Bild 7**: *Beispiele von Kavitäts-/Delaminierungsbildung in der Primärbeschichtungslage durch eine mechanische seitliche Auswirkung*



▼ **Bild 8**: *Vorbereitung der Probe des Kavitationsfestigkeitstests*



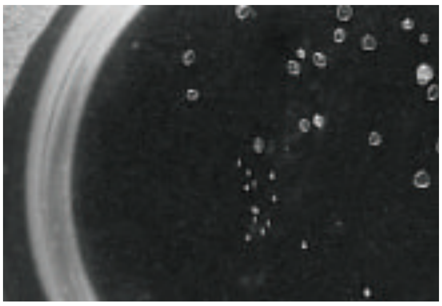
Die Kavitäten sind örtlich auf die zwei Seitenbereiche begrenzt, was mit der Theorie übereinstimmt.

Kavitäten und Delaminierung sind zwei konkurrierende Fehlerzustände. Sie könnten einzeln oder gleichzeitig erscheinen, je nach den Eigenschaften des Haftniveaus und der Kavitationsfestigkeit einer besonderen Beschichtung. Das Haftniveau der Primärbeschichtung am Glas sollte mit der Anforderung der Abisolierkraft ausgeglichen werden. Eine hohe Kavitationsfestigkeit ist für eine Primärbeschichtung immer wünschenswert, um die Robustheit der beschichteten Fasern zu verbessern. Dennoch sollte man sich bewußt sein, daß jede beschichtete Faser in der Form der Delaminierung und/oder Kavitation schließlich versagen wird, wenn die mechanische Auswirkung sich auf ein bestimmtes Niveau erhöht. Während die thermische Spannung dem zweilagigen Design innewohnt, ergibt sich die mechanische Spannung aus äußeren Ursprüngen. Alle ungewöhnlichen Hochdruckauswirkungen an den Fasern sollten während Zieh-, Spul-, Prüfungs- und Handhabungsverfahren vermieden werden.

3. Kavitationsfestigkeit der Primärbeschichtung

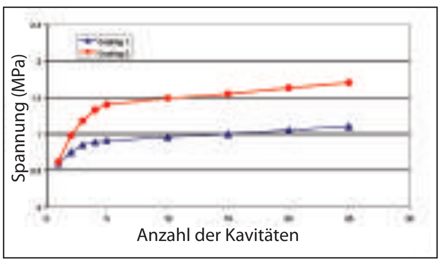
3.1 Kavitationsfestigkeitstest

Das physikalische Konzept der Kavitationsfestigkeit, wie im Absatz 2.1.2 beschrieben, ist das kritische dreiaxiale Spannungsniveau bei dem das Material anfängt zu zerreißen.



▲ **Bild 9**: *Beispiel von Kavitäten in einer Probe, mit Kamera (20x) bei einem bestimmten Spannungsniveau aufgenommen*

▼ **Bild 10**: *Zugbeanspruchung in Bezug auf die Anzahl beobachteter Kavitäten in zwei Beschichtungsmaterialien*



Um die Kavitationsfestigkeit eines Beschichtigungsmaterials zu messen wurde eine Prüfmethode ab einer gehärteten Folie entwickelt.

3.1.1 Messkonfiguration. Grundsätzlich ist die Weise in der man eine dreiaxiale Zugspannung in einem Beschichtungsmaterial verursacht einfach: man erhöht das Volumen des gummiartigen Beschichtungsmaterials. Die Beschichtung ist gehärtet und haftet zwischen zwei flachen Oberflächen, die in einer Zugprüfmaschine getrennt werden. Mit der gesteuerten Erhöhung des Abstands zwischen den zwei Platten wird eine dreiaxiale Zugbeanspruchung in der Beschichtung erzeugt. Die Konfiguration ist derart entworfen, daß die Beschichtungsdicke unter 5% des Durchmessers der Platten liegt. Da diese sehr dünne Beschichtungslage an den Platten begrenzt ist, ist die seitliche Schrumpfung der Beschichtung eingeschränkt. Demzufolge wird eine dreiaxiale Zugbeanspruchung gleichmäßig im Beschichtungsmaterial erzeugt. Um reproduzierbare Werte der Kavitationsfestigkeit zu erreichen, ist das Ausrichten der Einstellung wichtig, da dies die Spannungsverteilung in der Probe beeinflußt. Um außerdem die Entwicklung der Anzahl der Kavitäten mit Last in einer reproduzierbaren Weise untersuchen zu können, muß die Steifheit der Konfiguration hoch sein (d. h. die Übereinstimmung sollte niedrig sein) um die Lagerung der elastischen Energie in der Messkonfiguration zu minimieren.

3.1.2 Vorbereitung der Probe. Die Vorbereitung der Probe ist in Bild 8 dargestellt. Um während des Versuchs eine Delaminierung zu vermeiden, ist eine geeignete Vorbereitung der Oberflächen der Glasplatten und der Quarzstäbe erforderlich. Zunächst wurden die Oberflächen aufgeraut, indem mit Einsatz von Karborundpulver poliert wurde.

Die Glas- und Quarzteile wurden dann in einem Ofen bei 600°C eine Stunde lang rein verbrannt, und die Oberflächen mit Aceton gespült und getrocknet. Nachträglich wurden die Oberflächen mit einer Lösung von Silanhaftvermittler behandelt – Methacryloxypropyltrimethoxysilan (A174 von Witco) wurde dabei eingesetzt.

Die Silanlage wurde gehärtet, indem die behandelten Glas- oder Quarzplatten 5 bis 10 Minuten lang in einen Ofen bei 90°C gelegt wurden. Nach dieser Vorbehandlung, wurde ein Tröpfchen Harz auf die Glasplatte gelegt und mit dem Quarzstab bedeckt.

Die Foliendicke wurde bei ca. 100µm mit einem Mikrometer aus zwei Platten eingestellt. Die Probe wurde mit einer 1 J/cm^2 Dosis gehärtet, mit Einsatz eines Fusion F600W UV-D Lampensystems.

Beschicht-ung	E'	σ_{cav}	Verhältnis
	(MPa)	(MPa)	σ_{cav} /E'
A	0.37	0.95	2.6
B	0.97	1.21	1.2
C	1.33	2.5	1.9
D	1.2	2.8	2.3
E	0.9	2.1	2.3
F	0.64	1.51	2.4

▲ **Tabelle 1**: *Die gemessenen Eigenschaften der Kavitationsfestigkeit der ausgewählten Primärbeschichtungen*

3.1.3 Messung der Kavitationsfestigkeit. Die Probe wurde in das Zugprüfgerät gelegt (Zwick Typ 1484). Die Ziehgeschwindigkeit betrug 20µm/min. Ab Versuchsbeginn nahm eine Videokamera, die mit einem Mikroskop mit 20-facher Vergrößerung verbunden war, das Verhalten der Folie auf, während auch das auf der Folie ausgeübte Spannungsniveau gezeigt wurde. *Bild 9* zeigt eine Abbildung der Probe, die von der Videokamera erfaßt wurde, mit vielen bereits gebildeten Kavitäten. Auf dem Videoband wurde die Anzahl an Kavitäten aufgezeichnet, die abhängig von der angewandten Spannung erschienen, wie in Bild 10 dargestellt.

Es wurde festgestellt, daß die Spannungen bei denen die erste Kavität beobachtet wurde, sich bei unterschiedlichen Beschichtungsmaterialien alle auf einem ähnlichen Niveau befanden. Jedoch begannen die Spannungsniveaus deutliche Unterschiede unter den verschiedenen Beschichtungen zu zeigen, je mehr sich die Kavitäten bildeten. In dieser Prüfmethode wurde der Spannungswert, der der Bildung von 10 Kavitäten entspricht, ausgewählt, um die Kavitationsfestigkeit der gemessenen Beschichtung darzustellen. Zum Beispiel wurden die in Bild 10 dargestellten Beschichtungen als Beschichtungen mit Kavitationsfestigkeitswerten von je 0,96 MPa und 1,49 MPa gemessen.

3.2 Primärbeschichtungen mit hoher Kavitationsfestigkeit

Wie in Absatz 2.1.2 beschrieben wurde, tritt die Beschichtungskavitation auf, wenn die dreiaxiale Zugbeanspruchung die Kavitationsfestigkeit des Beschichtungsmaterials überschreitet. Um die Gefahr einer Beschichtungskavitation zu reduzieren, gelten zwei effektive Ansätze: 1) Reduzierung des Niveaus der thermischen Spannung, und/oder 2) Erhöhung der Kavitationsfestigkeit der Beschichtung. Das Niveau der thermischen Spannung wird durch beide Beschichtungslagen beeinflußt, wobei die Sekundärbeschichtung eine viel wichtigere Rolle als die Primärbeschichtung spielt. Andererseits ist die Kavitationsfestigkeit eine innewohnende Eigenschaft der Primärbeschichtung.

Eine Primärbeschichtung mit hoher Kavitationsfestigkeit ist immer wünschenswert, um die Robustheit der beschichteten Faser zu sichern, unter den Bedingungen der thermischen Spannung und allen potentiellen mechanischen Spannungen, die während der Verarbeitung, Handhabung und Verlegung im Feld erscheinen. In der *Tabelle 1* sind mehrere Beispiele von Primärbeschichtungen mit unterschiedlichem Verhalten der Kavitationsfestigkeit dargestellt.

Die Kavitationsfestigkeit (σ_{cav}) wurde anhand der im Absatz 3.1 beschriebenen Prüfmethode gemessen. Die Werte des Speichermoduls E' bei Raumtemperatur von DMA und das Verhältnis von σ_{cav}/E' sind ebenfalls aufgelistet.

Wie im Absatz 2.1.2 erwähnt, sollte die Kavitationsfestigkeit eines idealen Gummis (5/6)E entsprechen. Aus der *Tabelle 1* ist ersichtlich, daß alle Beschichtungen eine Kavitationsfestigkeit aufweisen, die höher als der entsprechende Module ist, was wiederum anzeigt, daß die Beschichtungen nicht mit der perfekten Elastizität übereinstimmen. Der Modul, der der Vernetzungsdichte der Beschichtung entspricht, spielt immer noch eine wichtige Rolle bei der Bestimmung der Kavitationsfestigkeit eines Beschichtungsmaterials. Jedoch kann durch einen geeigneten Molekularniveauentwurf der Polymervernetzungstruktur eine hohe Kavitationsfestigkeit erzielt werden, unabhängig vom Beschichtungsmodul. Mit anderen Worten, können ideal weiche, jedoch starke Beschichtungen mit einem hohen Verhältnis zwischen Kavitationsfestigkeit und Modul hergestellt werden. Der niedrige Modul kommt einem besseren Mikrobiegeverhalten zugute.

Aus der *Tabelle 1* ist ersichtlich, daß die Beschichtung A den niedrigen Modul besitzt, jedoch ist die entsprechende Kavitationsfestigkeit auch die niedrigste (<1 MPa). In der Tat, zeigte die Faser mit dieser Beschichtung eindeutige Kavitäten die sich aus dem Kühlverfahren nach dem Faserziehen ergeben. Beschichtung B, mit einer Kavitationsfestigkeit, die 1,21 MPa entspricht, wird als stark genug betrachtet, um der thermischen Spannung zu widerstehen, auf die man während der Faserkühlung stößt. An der Faser wurde keine Kavität mit der Beschichtung B beobachtet. Theoretisch analysiert, ist dieses Niveau der Kavitationsfestigkeit ausreichend hoch im Vergleich zur berechneten ~0.8 MPa thermischen Spannung in der Primärbeschichtung. Jedoch entspricht das Verhältnis von σ_{cav}/E' der Beschichtung B nur 1,2, das niedrigste aller Beschichtungen.

Dieser Beschichtungstyp wurde als geeignet betrachtet, den normalen Spannungssituationen zu widerstehen, hat jedoch sein volles Potential, ein hoch robustes Beschichtungsmaterial zu werden, nicht realisiert. Andererseits zeigen die Beschichtungen C, D, E und F die gewünschten hohen Eigenschaften der Kavitationsfestigkeit. Der Modul der Beschichtung C oder der Beschichtung D ist im typischen Bereich unter den handelsüblichen Primärbeschichtungen. Jedoch ist deren Kavitationsfestigkeit derart konzipiert, daß sie ein außerordentlich hohes Niveau durch eine optimale Molekularstruktur der Vernetzungsstrukturen aufweisen.

Beschichtung E hat ein mittel bis niedriges Modulniveau (kombiniert mit niedriger T_g), das entwickelt wurde um bei Monomode- sowie Multimodefaser eingesetzt zu werden. Die Kavitationsfestigkeit dieser Beschichtung befindet sich immer noch in einem sehr hohen Niveau (2,1 MPa) und ermöglicht ein hohes Verhältnis von σ_{cav}/E' (2.3). Die Beschichtung F bietet einen hervorragenden Mikrobiegewiderstand, der dem ultraniedrigem Modul (und der niedrigen T_g) zugeschrieben wird. Gleichzeitig wurde auch ein ausreichend hohes Niveau der Kavitationsfestigkeit (1,51 MPa) erzielt, mit einem Verhältnis von σ_{cav}/E', das 2,4 entspricht. Für ultraweiche Beschichtungen wie dies der Fall ist, sind besondere Maßnahmen zu treffen, um die Eigenschaft einer guten Kavitationsfestigkeit in der Beschichtungsstruktur zu integrieren. Anderenfalls besteht eine mögliche Gefahr im Falle der Entwicklung von Beschichtungskavitation und verschlechterter Eigenschaften der Faserdämpfung.

Solche Situationen, wie z. B. jene der Beschichtung A, wo die Kavitäten bereits nach dem Ziehen in der Faser waren, können somit leicht erkannt werden. Die verborgene Gefahr liegt in Situationen, wo die Kavitäten in der Beschichtung stufenweise eine Dämpfungserhöhung im Feld bilden und verursachen können, wenn die Faser durch die Umgebungstemperaturzyklen läuft oder eine lange Zeit bei niedrigen Temperaturen bleibt, z. B. in Unterseekabeln. Ein sorgfältig entworfenes hochwertiges Beschichtungssystem trägt nicht nur zu einer erstklassigen Faserleistung bei, sondern bietet auch eine bessere langfristige Zuverlässigkeit der Lichtwellenleiter.

4. Schlußfolgerungen

Die Kavitation der Primärbeschichtung wurde auf umfangreiche Weise als mögliches Ausfallverhalten in zweilagigen beschichteten Lichtwellenleitern erforscht. Die Triebkraft für die Beschichtungskavitation ist eine dreiaxiale Zugbeanspruchung, die durch eine innere thermische Spannung oder eine äußere mechanische Wirkung verursacht werden kann. Die Beschichtung unterliegt dem Kohäsivbruch wenn die dreiaxiale Zugspannung die Kavitationsfestigkeit der Beschichtung überschreitet. Eine Prüfmethode wurde entwickelt, um die Kavitationsfestigkeit eines Beschichtungsmaterials quantitativ auszuwerten. Durch Verstehen des Kavitationsmechanismus der Beschichtung und Einblicke in den Kavitationswiderstand der Beschichtung, wurde es ermöglicht, Beschichtungmaterialien mit einer hohen Kavitationsfestigkeit zu entwickeln, um den beschichteten Fasern unter potentiellen thermischen und mechanischen Spannungen Robustheit zu geben. Es wurden hohe Verhältnisse zwischen Kavitationsfestigkeit und Modulen erzielt, um die erwünschten Primärbeschichtungen mit niedrigen Modulen/niedriger T_g zu leisten, für einen verbesserten Mikrobiegeschutz, in Kombination mit einer hohen Kavitationsfestigkeit. ■

5. Literatur

[1] D Gloge, 'Optical-fiber Packaging and Its Influence on Fiber Straightness and Loss', The Bell System Technical J, 54(2), 245-262 (1975)

[2] W W King, 'Thermally Induced Stresses in an Optical - Fiber Coating', J of Lightwave Technology, 9(8), 952-953 (1991)

[3] W W King and C J Aloisio, 'Thermomechanical Mechanism for Delaminations of Polymer Coatings from Optical Fibers', J of Electronic Packaging, 119, 133-137 (1997)

[4] P L Tabaddor, C J Aloisio, C H Plagianis, C R Taylor, V Kuck and P G Simpkins, 'Mechanics of Delamination Resistance Testing', International Wire and Cable Symposium Proceedings, p 725 (1998)

[5] C J Aloisio, W W King and R C Moore, 'A Viscoelastic Analysis of Thermally Induced Residual Stresses in Dual Coated Optical Fibers', International Wire and Cable Symposium Proceedings, p 139 (1995)

[6] A N Gent and P B Lindley, 'Internal Rupture of Bonded Rubber Cylinders in Tension', Proc Roy Soc A, 249, 1958

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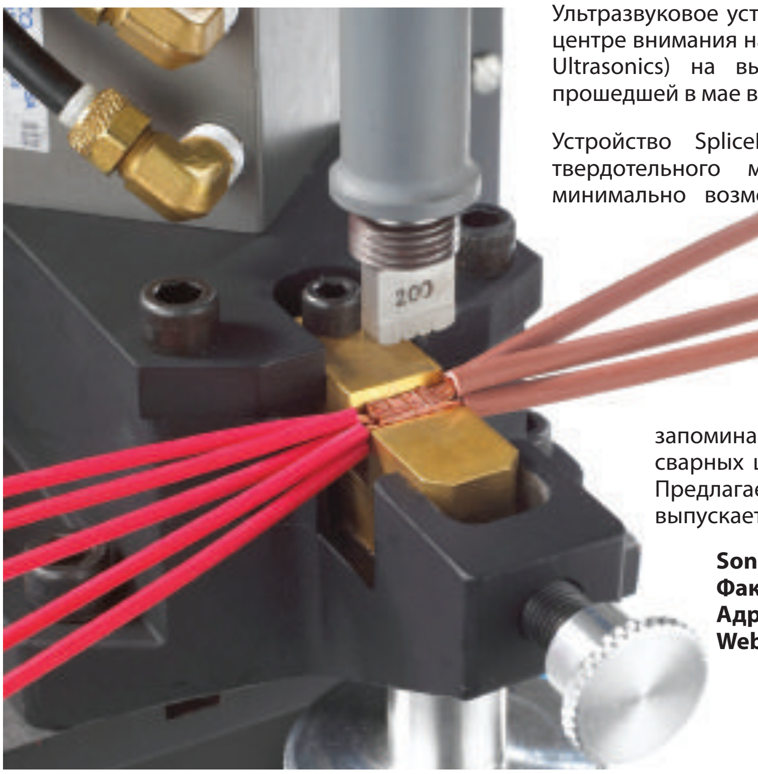
В центре внимания – ультразвуковая сварка



▲ *Ультразвуковое устройство для сращивания проводов SpliceRite™*

Ультразвуковое устройство для сращивания проводов SpliceRite™ было в центре внимания на стенде компании «Сонобонд алтрасоникс» (Sonobond Ultrasonics) на выставке Electrical Wire Processing Technology Expo, прошедшей в мае в г. Милуоки (США).

Устройство SpliceRite предназначено для получения безупречного твердотельного металлургического соединения с использованием минимально возможного падения напряжения и при минимальном уровне энергопотребления. Аппарат устраняет необходимость обрезки, пайки, обжатия или протравки и быстро сращивает жгуты проводов без образования дуговых разрядов, искр или сварочного дыма и без плавления проводов. Он может также работать с лужеными или сильно окисленными проводами. В устройстве используется микропроцессорный контроллер, который обеспечивает возможность запоминания и вызова до 250 рабочих режимов при выполнении сварных швов с контролем по высоте, мощности или времени. Предлагаемое устройство ультразвуковой сварки металла выпускается в двух модификациях: мощностью 1500 и 2500 ватт.

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Кабель ПТВН свяжет Финляндию и Швецию

Компания «Нексанс» (Nexans) получила контракт на сумму около 150 млн. евро от компании «Фингрид» (Fingrid Oyj), оператора сетей энергоснабжения Финляндии, и от компании «Свенска крафтнет» (Svenska Kraftnät), государственного коммунального предприятия, управляющего национальной энергетической системой Швеции. Контракт предусматривает производство и прокладку подводного силового кабеля постоянного тока высокого напряжения (ПТВН) для Fenno-Skan 2 – новой линии электропередач, соединяющей сети Финляндии и Швеции.

«Нексанс» поставит примерно 200 км специального сплошного маслонаполненного кабеля с пропиткой вязким нестекающим составом для подводных и наземных участков линии электропередач Fenno-Skan 2. При сечении медного проводника, равном 2000 мм², этот кабель станет самым мощным ПТВН кабелем, произведенным компанией «Нексанс» до настоящего времени.

Прокладка подводного кабеля на морских глубинах порядка 100 м будет осуществляться принадлежащим компании «Нексанс» кабелеукладочным судном «Скагеррак» и намечена на весну 2011 года. Кабель будет поставлен двумя непрерывными длинами приблизительно по 100 км каждая, таким образом, на морском участке потребуется использование только одной муфты.

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700-ая скруточная машина – тяжеловес

▲ *Последняя машина Drum Twister – самая большая машина этого типа*

«Годер груп» (Gauder Group) с удовлетворением объявляет о заключении важного контракта на поставку линии общей скрутки Drum Twister для компании «Сауди кейбл компани» (Saudi Cable Company).

Новейшая линия Drum Twister является семисотой, поставленной компанией «Годер» для нужд кабельной промышленности, и будет самой большой линией этого типа. Данная линия, предназначенная для производства высоковольтных силовых кабелей, будет рассчитана под четырехметровую приемную катушку и на вес 30 тонн.

Группа компаний «Пуртье – Годер груп» (Pourtier – Gauder Group) много лет является поставщиком компании «Сауди кейбл» – ведущего производителя полного ассортимента кабельной продукции на Ближнем Востоке.

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Инвестиции в производство кабельных барабанов

Компания «Мадем» (Madem), которая уже имеет производственные мощности в Бразилии, Испании и США, планирует открыть новый завод в Королевстве Бахрейн в конце текущего года. «Мадем» ежемесячно производит около 500 контейнеров разборных деревянных барабанов и продает их в более чем в 40 стран, вероятно, всем основным производителям проволочно-кабельной продукции.

В 2008 году компания «Мадем» планирует инвестировать 5 млн. долларов США на строительство высокотехнологичного завода по производству фанеры, который сможет ежемесячно выпускать 70 контейнеров фанерных щек для барабанов.

«Мадем» тесно сотрудничает с клиентами, предлагая изменения в спецификациях, позволяющие добиться экономии затрат клиентов», – говорит коммерческий директор группы компаний «Мадем» Леандро Маццоккато (Leandro Mazzoccato).

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Первичные покрытия с высокой кавитационной стойкостью для оптических волокон

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Аннотация

Хорошо известно, что конструкции, сочетающие в себе мягкие первичные покрытия с жесткими вторичными покрытиями, обеспечивают хорошую защиту для оптических волокон с двухслойным покрытием от повреждений при микроизгибах. Однако применение таких двухслойных конструкций ведет к появлению температурного напряжения в системе покрытия из-за разницы в тепловом расширении или сжатии двух слоев покрытия. Возникновение трехосного растягивающего напряжения может привести к появлению внутренних разрывов в мягком первичном покрытии. Возможным дефектом является кавитация первичного покрытия, которая может негативно сказаться на характеристиках затухания волокна. В данной работе обсуждается механизм образования кавитации в покрытии в зависимости от различных типов внешних сил. Вводится понятие кавитационной стойкости первичного покрытия в качестве ключевого параметра для получения надежной системы покрытия с высокими эксплуатационными характеристиками, обладающего необходимой низкой чувствительностью к микроизгибам в сочетании с высокой кавитационной стойкостью.

1. Введение

Одним из основных преимуществ конструкции оптического волокна с двухслойным покрытием является улучшенная защита от микроизгибов по сравнению с той, которую обеспечивает однослойное покрытие. Мягкое первичное покрытие, которое выступает в качестве буферного слоя, в сочетании с жестким вторичным покрытием, действующим в качестве защитного слоя, обеспечивает идеальное сопротивление изгибу, позволяющее волокнам выдерживать внешние напряжения в кабельной системе.

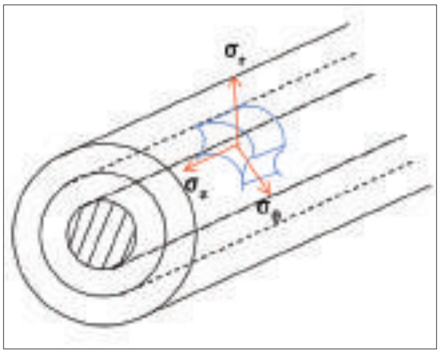
[1] Температурное напряжение в системе с двухслойным покрытием неизбежно возникает по причине различного теплового расширения и сжатия стекла, первичного и вторичного покрытий. В стандартных одномодовых или многомодовых волокнах с высококачественными двухслойными покрытиями не отмечается увеличения затухания выше допустимых величин при циклическом изменении температур, так как температурное напряжение равномерно распределяется по окружности волокна. Однако у волокон с определенным количеством дефектов в системе покрытия, особенно в первичном покрытии, уже при комнатной температуре может отмечаться высокий уровень затухания из-за потерь на микроизгибы, при этом затухание может существенно расти при снижении температуры вследствие неравномерного температурного напряжения, вызванного этими дефектами. Возможными дефектами первичного покрытия являются отдельные частицы, гелевые структуры, кристаллические включения, нарушения геометрических параметров, отслаивания и пустоты.

Как отслоения, так и пустоты связаны с растягивающими напряжениями в первичном покрытии теплового или механического происхождения. В то время как отслаивание первичного покрытия от стекла хорошо изучено [3, 4], возможности образования пустот при внутреннем разрыве первичного покрытия рассмотрены недостаточно.

Хотя первичные покрытия обычно обладают очень высокой растяжимостью при линейном растягивающем напряжении, при создании трехосного растягивающего напряжения в материале покрытия могут возникнуть внутренние разрывы. Компания «ДСМ десотек» (DSM Desotech) в последние годы провела углубленные исследования для изучения этого вида вероятных дефектов. Изучен механизм возникновения пустот в первичном покрытии, и разработаны первичные покрытия с высокой кавитационной стойкостью путем подбора соответствующего молекулярного дизайна сети поперечных связей в структуре покрытий.

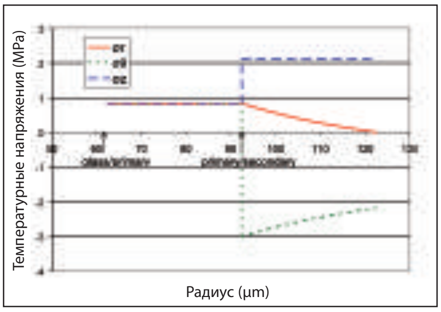
2. Механизм образования пустот в слое первичного покрытия

Причиной образования пустот в первичном покрытии является трехосное растягивающее напряжение, которое при достижении высокого уровня может превысить предел кавитационной



▲ **Рис. 1.** *Трехосные температурные напряжения в системе с двухслойным покрытием*

▼ **Рис. 2.** *Расчетные температурные напряжения в системе с двухслойным покрытием*



стойкости покрытия и вызвать когезионное разрушение структуры покрытия. В зависимости от источника напряжения можно выделить два возможных типа трехосных растягивающих напряжений в покрытии. Напряжение может быть температурным и вызываться изменением температуры или обуславливаться действием внешних механических сил.

2.1 Образование пустот под действием температурных напряжений

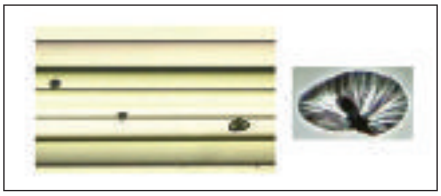
2.1.1 Температурные напряжения в системе с двухслойным покрытием

Хорошо известно, что температурные напряжения присутствуют в системе волокна с покрытием [2-5]. Создание трехосного напряжения в первичном покрытии, как показано на рис. 1, обусловлено несовпадением коэффициентов теплового расширения стекла, первичного и вторичного покрытий.

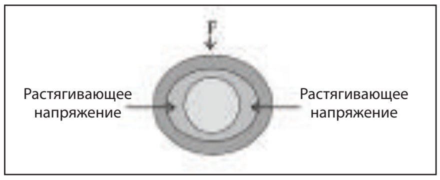
Исходя из основных принципов сопротивления материалов, можно рассчитать трехосное напряжение, которое складывается из радиального напряжения σr, касательного напряжения $\sigma\theta$ и осевого напряжения σz. На рис. 2 представлено распределение расчетных значений напряжения в типичной системе с двухслойным покрытием, где толщина каждого слоя покрытия равна 30 мкм, модуль Юнга E1 = 1 МПа, E2 = 1 ГПа, коэффициенты линейного теплового расширения $\alpha 1 = 3 \times 10^{-4}$/K, $\alpha 2 = 1 \times 10^{-4}$/K и коэффициенты Пуассона $\nu 1 = 0{,}5$, $\nu 2 = 0{,}4$. Температура системы снижается на 30 ºC для моделирования напряжения в системе покрытий, возникающего, когда волокно с покрытием охлаждается с температуры волочения до комнатной температуры. Несмотря на то что температура покрытия при УФ-отверждении может достигать 100 ºC, температурное напряжение начинает увеличиваться только тогда, когда температура падает ниже Tg вторичного покрытия (~50 ºC).

Три составляющих напряжения в первичном покрытии являются растягивающими и все находятся на одном уровне, как показано на рис. 2. Это означает, что напряжение в первичном покрытии при комнатной температуре является гидростатическим растягивающим напряжением. Оно повышается при дальнейшем понижении температуры до значения температуры Tg первичного покрытия (обычно ~-20 ºC), при которой первичное покрытие также переходит в стекловидное состояние. Расчетное растягивающее напряжение в первичном покрытии равняется ~0,8 МПа при комнатной температуре, как показано на рис. 2. Из-за вязкоупругого свойства вторичного покрытия реальный уровень напряжения должен быть ниже его расчетного значения и уменьшаться со временем по мере того, как во вторичном покрытии происходит релаксация напряжения при температурах ниже Tg [5].

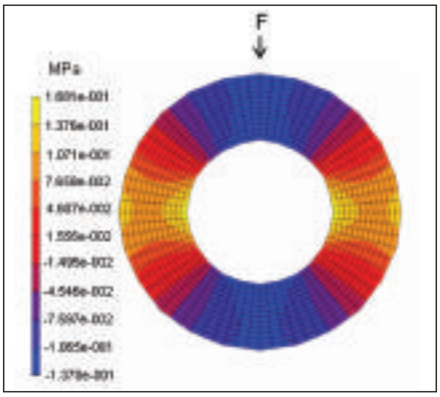
Хотя для стандартных волокон с двойным покрытием риск возникновения кавитации покрытия при температурном напряжении является небольшим, при оценке некоторых типов покрытий, обсуждаемых ниже, следует проявлять осторожность. Новая тенденция разработки первичных покрытий включает в себя дальнейшее уменьшение их модуля и Tg для улучшения буферной защиты при микроизгибе в широком диапазоне температур. В системе покрытия этого типа растягивающее напряжение продолжает нарастать, в то время как температура начинает падать, однако первичное покрытие остается в резиноподобном состоянии. Как показано на рис. 3, расчетное растягивающее напряжение линейно возрастает при уменьшении температуры. Релаксация напряжения вторичного покрытия при низких температурах также происходит значительно медленнее. В дополнение к риску высокого температурного напряжения, первичное покрытие с более низким модулем может также быть более склонно к кавитации из-за меньшей плотности сшивания. По этой причине очень важно, чтобы первичные покрытия с низким модулем и низкой Tg были тщательно разработаны и обладали высокой кавитационной стойкостью за счет оптимизации структуры сети сшивок. Всестороннее понимание природы кавитационной стойкости УФ-отверждаемых материалов покрытий на молекулярном уровне позволяет разрабатывать системы покрытий, сочетающих улучшенную защиту от повреждений при микроизгибах и высокую кавитационную стойкость, что дает возможность обеспечить устойчивые эксплуатационные характеристики волокна в широком диапазоне температур. Другим примером ситуации с высоким риском образования пустот является волокно с более толстыми, чем обычно, слоями покрытия. Растягивающее напряжение в первичном слое волокна с упорядоченно-неупорядоченной структурой и с толщиной слоя «стекло-покрытие» 125, 350, 500 мкм рассчитано и отражено на графике, представленном на рис. 3. Растягивающее напряжение в первичном покрытии этого волокна в 2,8 раза превышает уровень напряжения в первичном покрытии стандартного волокна с покрытием



▲ **Рис. 4.** *Пустоты в слое первичного покрытия, вызванные циклическим изменением температуры в 500-мкм волокне, при 40-кратном увеличении (слева) и при 200-кратном увеличении (справа)*

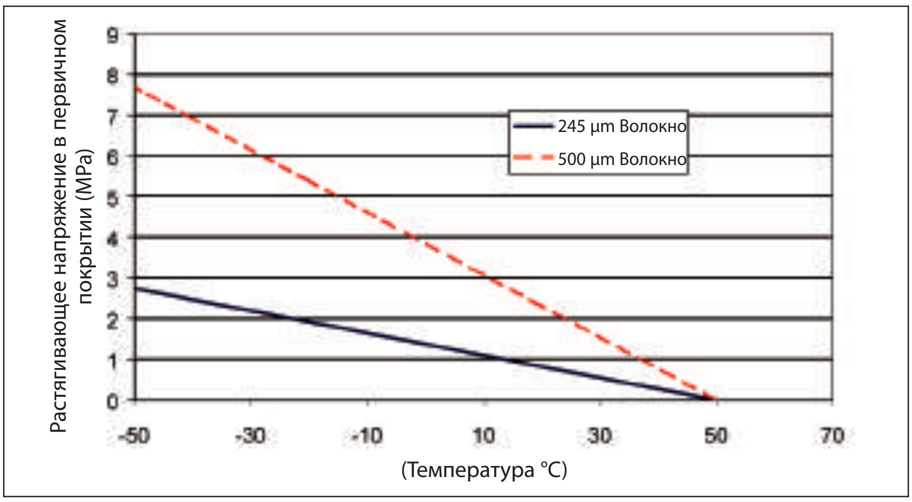


▲ **Рис. 5.** *Схема локализованных растягивающих напряжений в первичном покрытии, вызванных под воздействием поперечного механического усилия*



▲ **Рис. 6.** *Среднее нормальное напряжение в слое первичного покрытия под воздействием поперечного механического усилия, рассчитанное методом конечных элементов*

▼ **Рис. 3.** *Зависимость расчетного температурного напряжения от температуры для обычного 250-мкм волокна (предполагается, что напряжение начинает возникать ниже температуры Tg (~50 °C) вторичного покрытия)*



наружным диаметром 245 мкм. Таким образом, волокна с более толстыми слоями покрытия должны включать первичное покрытие с высокой кавитационной стойкостью в сочетании с вторичным покрытием, обладающем более быстрой релаксацией напряжения.

2.1.2 Образование пустот в первичном покрытии. На рис. 4 показаны полученные под микроскопом изображения пустот, сформировавшихся в волокне с покрытием наружным диаметром 500 мкм при цикличном температурном колебании в интервале от 85 °C до -60 °C. В слое первичного покрытия наблюдаются разрывы различного размера неправильной формы. Тот факт, что разрывы покрытия широко раскрыты и представляют собой полости, указывает на присутствие трехосного растягивающего напряжения в первичном слое при комнатной температуре.

Из теории механики разрушения известно, что параметр, представляющий сопротивляемость материала возникновению кавитации, называется кавитационной стойкостью. Когда трехосное напряжение достигает этой критической точки, материал начинает разрушаться, и в нем образуются внутренние пустоты. Расчеты, которые были подтверждены экспериментально, показывают, что для идеальной резины трехосное напряжение, необходимое для того, чтобы очень маленькое сферическое отверстие могло неограниченно раздуться, составляет (5/6)E, где E – модуль Юнга [6]. Любой микроскопический дефект сшивки материала может стать местом появления разрыва. Это означает, что для первичного покрытия с модулем 1 МПа трехосное растягивающее напряжение, равное 0,83 МПа, уже может вызвать образование пустот в соответствии с механизмом неограниченного роста, если материал покрытия ведет себя как идеальная резина. При правильном подборе молекулярного строения структуры сшивки покрытия можно достичь желаемого высокого уровня сопротивления кавитации, при этом кавитационная стойкость может значительно превышать модуль покрытия.

В обладающих высокой кавитационной стойкостью первичных покрытиях данного типа небольшие раковины не будут неограниченно развиваться, и материал не будет иметь разрывов даже при относительно высоком уровне растягивающего напряжения, которое может присутствовать в первичном покрытии.

2.2 Образование пустот под действием механических напряжений

В дополнение к гидростатическому растягивающему напряжению, вызванному температурными колебаниями, образованию пустот в первичных покрытиях может также способствовать анизотропное трехосное напряжение, обусловленное механическим воздействиям на волокно с покрытием. Ранее уже сообщалось, что разрывы покрытия наблюдались под воздействием высокого усилия натяжения при протяжке волокна через перемоточное устройство для проведения испытаний покрытия на сопротивление отслаиванию [4].

Когда внешнее механическое усилие воздействует на волокно с покрытием, слои покрытия деформируются, и в результате в материале покрытия возникает участок с неравномерным напряжением.

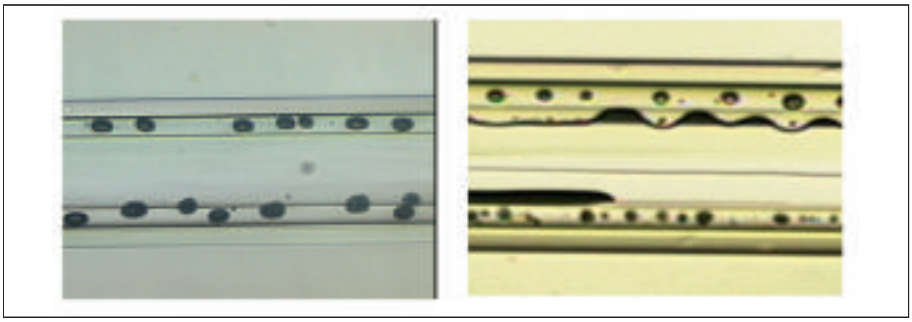
На рис. 5 схематично показана деформация слоев покрытия под воздействием поперечного усилия F. Так как материал вторичного покрытия гораздо тверже, чем материал первичного покрытия, вторичный слой ведет себя как пустотелая трубка, подвергающаяся боковому сдавливанию, причем профиль трубки становится овальным, а толщина покрытия не меняется. Первичное покрытие с обеих сторон связано со стеклом и вторичным покрытием, что приводит к его внутренней деформации. Участки первичного покрытия по направлению приложения усилия сжимаются, а участки, перпендикулярные направлению приложения усилия, удлиняются. Поле напряжения на этих удлиненных участках имеет значительную трехосную составляющую, которая может вызвать кавитацию в первичном покрытии, если величина напряжения превысит кавитационную стойкость этого покрытия.

На рис. 6 показано поле среднего нормального напряжения, рассчитанное методом конечных элементов для слоя первичного покрытия волокна с размерами наружного диаметра 125, 240, 410 мкм в условиях смоделированного воздействия поперечного усилия.

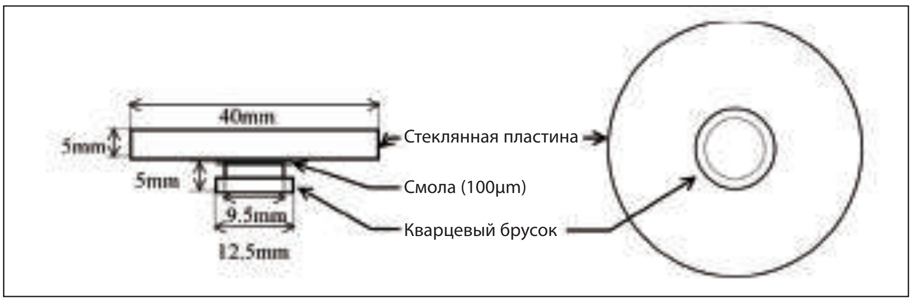
Результат вычислений количественно показывает поля напряжения, изменяющиеся от поля сжатия (-) до поля растяжения (+). Как показано на рис. 6, самому большому растягивающему напряжению подвергаются участки, перпендикулярные направлению приложения усилия и ближайшие к обеим сторонам границы между стеклом и первичным покрытием, а также между первичным покрытием и вторичным покрытием. На этих участках в случае приложения поперечного механического усилия возможность возникновения кавитации наиболее велика.

На рис. 7 представлено несколько примеров пустот в первичном покрытии, намеренно созданных механическими поперечными ударными воздействиями. Поперечное усилие должно динамически меняться в зависимости от скорости удара в направлении вдоль волокна (скользящее усилие) или перпендикулярно волокну (ударное усилие). Статическое поперечное усилие может привести только к отслаиванию. Механическое ударное воздействие, результаты которого показаны на рис. 7, было создано с помощью металлического стержня диаметром 1 мм, поступательно перемещаемого в направлении вдоль волокна. Было изготовлено приспособление, при помощи которого металлический стержень подключался к автоматическому прибору для определения сопротивления истиранию, при этом контроль скорости и величины прилагаемого усилия осуществлялся путем размещения на приспособлении грузов различной массы. На уровень напряжения в покрытии оказывают влияние как величина усилия, так и скорость удара. При очень низкой скорости чаще

▼ **Рис. 7.** *Примеры образования пустот и отслаиваний в слое первичного покрытия при механическом поперечном ударном воздействии*

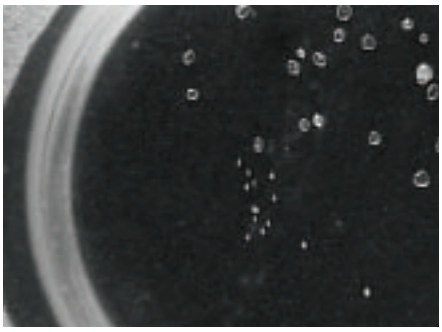


▼ **Рис. 8.** *Положение образца при испытании на кавитационную стойкость*



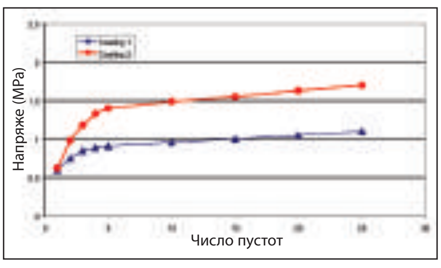
происходит отслаивание покрытия, нежели кавитация в нем. Причина этого может заключаться в том, что небольшое пятно отслаивания, формирующееся в момент первоначального контакта, распространяется вдоль волокна и высвобождает растягивающее напряжение в покрытии. При скоростях от средней до высокой могут образовываться пустоты, и (или) может происходить отслаивание (см. рис. 7). Распространение пустот ограничено боковыми участками с двух сторон, что согласуется с теоретическими расчетами.

Пустоты и отслаивания представляют собой два встречно развивающихся вида повреждений. Они могут возникать отдельно или одновременно, в зависимости от уровня адгезии и кавитационной стойкости конкретного покрытия. Уровень адгезии первичного покрытия к стеклу должен соответствовать усилию, необходимому для снятия верхнего слоя при разделке. Высокая кавитационная стойкость всегда желательна для первичного покрытия, так как она помогает улучшить защищенность волокна с покрытием. Следует, однако, помнить, что любое волокно с покрытием получит в конечном итоге повреждения в виде отслаивания и (или) кавитации, когда механическое воздействие увеличится до определенного уровня. В то время как температурное напряжение является характерным свойством самой конструкции с двухслойным покрытием, механическое напряжение происходит от внешних источников. Следует избегать любого воздействия аномально высокого давления на волокна в процессе волочения, намотки,



▲ **Рис. 9.** *Пример пустот в образце, зафиксированных камерой (20-кратное увеличение) при некотором уровне напряжения*

▼ **Рис. 10.** *График зависимости числа зарегистрированных пустот от величины растягивающего напряжения в двух материалах покрытия*



контрольных испытаний и транспортной обработки.

3. Кавитационная стойкость первичных покрытий

3.1 Испытание на кавитационную стойкость

Физической сущностью кавитационной стойкости, описанной в п. 2.1.2, является достижение критического уровня трехосного напряжения, при котором материал начинает разрушаться. Для измерения кавитационной стойкости материала покрытия из отвержденной пленки была разработана специальная методика испытаний.

3.1.1 Измерительная установка. В принципе получить трехосное растягивающее напряжение в материале покрытия очень просто: надо увеличить объем резиноподобного материала покрытия. Покрытие отверждается и приклеивается между двумя плоскими пластинами, которые затем разделяются в разрывной машине. При управляемом увеличении расстояния между двумя пластинами в покрытии наводится трехосное растягивающее напряжение. Установка спроектирована таким образом, что толщина покрытия составляет менее 5 % от величины диаметра пластин. Ввиду того, что этот очень тонкий слой покрытия находится между поверхностями пластин, боковое сжатие покрытия носит ограниченный характер. Соответственно, трехосное растягивающее напряжение создается в материале покрытия равномерно. Для того чтобы получить воспроизводимые значения кавитационной стойкости, важно провести юстировку установки, так как это влияет на распределение напряжений в образце. Кроме того, для того чтобы иметь возможность изучить воспроизводимыми методами процесс увеличения количества пустот с ростом нагрузки, установка должна обладать высокой жесткостью (т.е. малой деформируемостью) с целью минимизации накопления упругой энергии в измерительной установке.

3.1.2 Подготовка образца. Положение образца показано на рис. 8. Для исключения возможности отслаивания во время эксперимента поверхности стеклянных пластин и кварцевых брусков должны быть соответствующим образом подготовлены. Сначала поверхностям была придана шероховатость путем полировки с использованием карборундового порошка. Затем стеклянные и кварцевые части были дочиста отожжены в печи при температуре 600 °C в течение одного часа, а поверхности были промыты ацетоном и просушены. После этого поверхности были обработаны раствором усилителя адгезии на основе силана – использовался метакрилоксипропилтриметоксисилан (A174 компании «Витко» (Witco)). Слой

Покрытие	E'	σ_{cav}	Коэффициент
	(MPa)	(MPa)	σ_{cav} /E'
A	0.37	0.95	2.6
B	0.97	1.21	1.2
C	1.33	2.5	1.9
D	1.2	2.8	2.3
E	0.9	2.1	2.3
F	0.64	1.51	2.4

▲ **Таблица 1.** *Измеренные показатели кавитационной стойкости отдельных первичных покрытий*

силана был подвергнут вулканизации путем помещения обработанных стеклянных или кварцевых пластин в печь с температурой 90 °C на 5-10 минут. После такой предварительной обработки капля смолы была нанесена на стеклянную поверхность и накрыта кварцевым бруском. Толщина полученной пленки устанавливалась равной приблизительно 100 мкм, для чего использовался микрометр с двумя пластинами. Образец подвергался отверждению дозой облучения, равной 1 Дж/см^2, с использованием лампы Fusion F600W UV-D.

3.1.3 Измерение кавитационной стойкости. Образец был помещен в разрывную машину (типа Zwick 1484). Скорость растягивания составляла 20 мкм/мин. С начала эксперимента реакция пленки записывалась на видеокамеру, прикрепленную к микроскопу с 20-кратным увеличением, которая также фиксировала уровень напряжения, приложенного к пленке. На рис. 9 показано изображение образца с большим количеством уже образовавшихся пустот, сделанное видеокамерой. Число зафиксированных на видеопленке пустот в функциональной зависимости от приложенного напряжения графически представлено на рис. 10.

Обнаружено, что уровни напряжений, при которых наблюдалось образование первой пустоты, были примерно одинаковыми для различных материалов покрытий. Однако с увеличением числа образовавшихся пустот уровни напряжения для разных покрытий начали явно различаться. При этом методе испытаний в качестве репрезентативной величины кавитационной стойкости испытуемого покрытия было выбрано значение напряжения, соответствующее образованию 10 пустот. Например, покрытиям, представленным на рис. 10, были присвоены значения кавитационной стойкости 0,96 МПа и 1,49 МПа, соответственно.

3.2 Первичные покрытия с высокой кавитационной стойкостью

Как обсуждалось в п. 2.1.2, кавитация в покрытии происходит, когда трехосное растягивающее напряжение превышает уровень кавитационной стойкости материала покрытия. Для того чтобы уменьшить риск возникновения кавитации в покрытии, существуют два эффективных способа, а именно: 1) уменьшить уровень температурного напряжения и (или) 2) увеличить кавитационную стойкость покрытия. Уровень температурного напряжения зависит от обоих слоев покрытия, причем вторичное покрытие играет более важную роль, чем первичное покрытие. С другой стороны, кавитационная стойкость – это характерное свойство первичного покрытия. Высокая кавитационная стойкость первичного покрытия всегда желательна, так как она обеспечивает увеличение защищенности волокна с покрытием в условиях температурного напряжения и любых возможных механических напряжений, испытываемых во время технологической и транспортной обработки, а также при развертывании на месте эксплуатации.

В таблице 1 представлены несколько примеров первичных покрытий с различной кавитационной стойкостью. Кавитационная стойкость (σcav) измерялась с использованием метода испытаний, описанного в п. 3.1. Указаны также значения динамического модуля упругости E′ при комнатной температуре на основании данных динамомеханического анализа и отношения σcav /E′.

Как уже указывалось в п. 2.1.2, кавитационная стойкость идеальной резины должна быть равной (5/6)E. Как видно из таблицы 1, у каждого из покрытий кавитационная стойкость выше его модуля, что указывает на то, что покрытия не соответствуют требованиям по идеальной упругости. Модуль, соответствующий плотности сшивки покрытия, тем не менее, играет важную роль в определении кавитационной стойкости материала покрытия. Однако при правильном конструировании структуры сшивки полимера на молекулярном уровне высокой кавитационной стойкости можно добиться независимо от модуля упругости покрытия. Другими словами, можно получить идеально мягкие, но прочные покрытия с высоким соотношением «кавитационная стойкость-модуль упругости». Низкий модуль позволяет добиться лучшей сопротивляемости микроизгибам.

Из таблицы 1 следует, что у покрытия A самый низкий модуль, однако его кавитационная стойкость также самая низкая (<1 МПа). Действительно, в волокне с этим покрытием было зафиксировано появление больших пустот в процессе охлаждения после волочения волокна. Покрытие B с кавитационной стойкостью, равной 1,21 МПа, считается достаточно прочным, чтобы противостоять температурному напряжению, возникающему во время охлаждения. В волокне с покрытием B пустоты не наблюдались. Теоретический анализ также показывает, что данный уровень кавитационной стойкости значительно выше расчетного температурного напряжения в первичном покрытии, равного ~0,8 МПа. Однако отношение σcav/E′ покрытия B составляет всего 1,2, что является самым низким показателем среди всех покрытий. Считается, что этот тип покрытия отвечает необходимым требованиям и может выдержать среднее по силе напряжение, но в то же время не в полной мере реализует свой потенциал и не является материалом покрытия, обеспечивающим высокую защищенность волокна.

С другой стороны, покрытия C, D, E и F демонстрируют необходимую высокую кавитационную стойкость. Модуль покрытия C или покрытия D находится на уровне, стандартном для коммерческих первичных покрытий. Однако их кавитационная стойкость находится на исключительно высоком уровне благодаря использованию при их разработке оптимальной молекулярной структуры сшивки. Модуль покрытия E находится на умеренно низком уровне (в сочетании с низкой Tg), при этом покрытие было разработано для использования как в одномодовых, так и в многомодовых волокнах. Кавитационная стойкость этого покрытия, тем не менее, находится на очень высоком уровне (2,1 МПа), что позволяет достичь высокого значения отношения σcav/E′ (2,3). Покрытие F обеспечивает отличное сопротивление микроизгибу, что объясняется крайне низким модулем (и низкой Tg). В то же время достаточно высокий уровень кавитационной стойкости (1,51 МПа) также обеспечен при значении отношения σcav/E′, достигающем 2,4. Для сверхмягких покрытий, подобных этому, следует принимать особые меры, чтобы включить свойство хорошей кавитационной стойкости в структуру покрытия. В противном случае существует риск развития кавитации покрытия и ухудшения показателей затухания волокна.

Легко идентифицируются случаи, такие как с покрытием A, в котором пустоты уже присутствуют в волокне после волочения. Скрытый риск присутствует в тех случаях, когда пустоты в покрытии могут образовываться постепенно, становясь причиной усиления затухания в условиях эксплуатации, когда волокно проходит через температурные циклы окружающей среды или находится в течение долгого времени при низкой температуре, например, в подводных кабелях. Тщательно разработанное высококачественное покрытие не только вносит свой вклад в обеспечение высоких эксплуатационных характеристик волокна, но также гарантирует повышенную надежность оптических волокон в долгосрочной перспективе.

4. Выводы

Проведено всестороннее изучение кавитации в первичном покрытии в качестве возможного вида повреждения двухслойных оптических волокон с покрытием. Первопричиной возникновения кавитации покрытия является трехосное растягивающее напряжение, которое может быть обусловлено внутренним температурным напряжением или внешним механическим воздействием. Разрыв межмолекулярного сцепления происходит, когда трехосное растягивающее напряжение превышает кавитационную стойкость покрытия. Для количественной оценки кавитационной стойкости материала покрытия был разработан соответствующий метод испытаний. После того, как был понят механизм кавитации покрытия и получено полное представление о сопротивляемости материала покрытия возникновению кавитации, стало возможным разрабатывать материалы покрытия с высокой кавитационной стойкостью для того, чтобы получить волокно с покрытием, обладающим высокой степенью защищенности от возможных температурных и механических напряжений. Получено хорошее соотношение высокой кавитационной стойкости и модуля упругости, обеспечивающее создание доступных первичных покрытий, демонстрирующих желаемое соотношение малого модуля упругости и низкой Tg и обладающих улучшенной защитой от микроизгибов в сочетании с высокой кавитационной стойкостью. ■

5. Справочная литература

[1] D Gloge, 'Optical-fiber Packaging and Its Influence on Fiber Straightness and Loss', The Bell System Technical J, 54(2), 245-262 (1975)

[2] W W King, 'Thermally Induced Stresses in an Optical - Fiber Coating', J of Lightwave Technology, 9(8), 952-953 (1991)

[3] W W King and C J Aloisio, 'Thermomechanical Mechanism for Delaminations of Polymer Coatings from Optical Fibers', J of Electronic Packaging, 119, 133-137 (1997)

[4] P L Tabaddor, C J Aloisio, C H Plagianis, C R Taylor, V Kuck and P G Simpkins, 'Mechanics of Delamination Resistance Testing', International Wire and Cable Symposium Proceedings, p 725 (1998)

[5] C J Aloisio, W W King and R C Moore, 'A Viscoelastic Analysis of Thermally Induced Residual Stresses in Dual Coated Optical Fibers', International Wire and Cable Symposium Proceedings, p 139 (1995)

[6] A N Gent and P B Lindley, 'Internal Rupture of Bonded Rubber Cylinders in Tension', Proc Roy Soc A, 249, 1958

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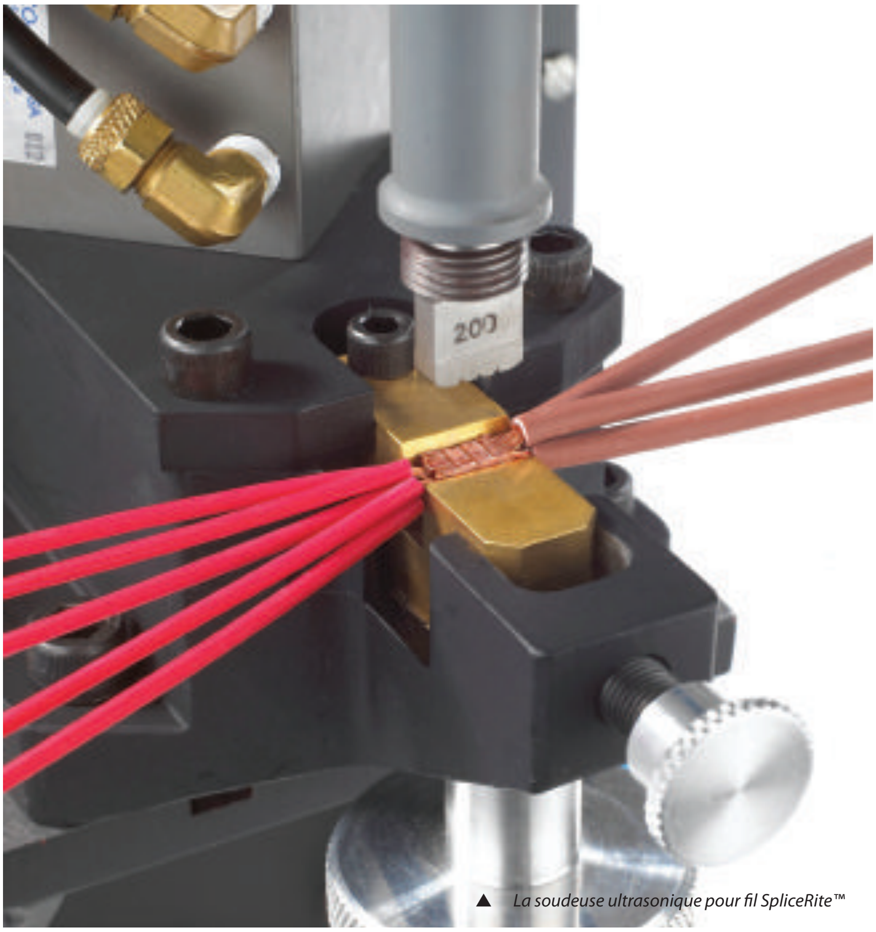
Soudage ultrasonique en exposition

La machine à souder ultrasonique SpliceRite™ a été au centre de l'attention dans le stand de Sonobond Ultrasonics durant l'exposition Electrical Wire Processing Technology Expo qui s'est tenue au mois de mai dans l'état de Milwaukee aux États-Unis.

La machine à souder SpliceRite a été conçue pour créer des soudures métallurgiques en utilisant la chute de tension la plus basse possible tout en réduisant au minimum la consommation d'énergie. La nouvelle machine à souder élimine la nécessité de serrage, soudage, sertissage ou soudage par immersion, en permettant de souder rapidement des faisceaux de fils sans produire aucun arc, aucune étincelle, ni fumée ou fondre les fils. En outre, il est possible de souder des fils étamés ou très oxydés.

Comme dans le cas d'autres machines à souder pour métaux de Sonobond, la machine à souder pour fil SpliceRite™ est équipée d'un système breveté Wedge-Reed. Ce système génère une force vibratoire élevée combinée avec un accouplement d'amplitude réduite. Le système permet également d'orienter l'énergie à ultrasons à haute fréquence à travers la buse de soudage à la surface entre les métaux à souder. L'énergie vibratoire disperse les oxydes et les pellicules superficielles entre les pièces de fabrication. De cette manière, une véritable liaison métallurgique est créée sans entraîner la fusion des matériaux.



▲ *La soudeuse ultrasonique pour fil SpliceRite™*

Sonobond Ultrasonics – États-Unis
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Câble HVDC pour l'interconnexion entre la Finlande et la Suède

Nexans a remporté un contrat d'environ 150 millions d'euros auprès de Fingrid Oyj, opérateur du réseau de transport d'électricité en Finlande, et Svenska Kraftnät, l'entreprise publique qui gère le réseau électrique national en Suède. Le contrat porte sur la fabrication et l'installation d'un câble d'énergie sous-marin HVDC (courant continu haute tension) pour Fenno-Skan 2 qui assurera la nouvelle interconnexion entre les deux pays. Nexans fournira environ 200km de câble massif spécial, à huile, de type MIND (Mass Impregnated Non-Draining, isolation à matière stabilisée), destiné aux tronçons tant sous-marins que terrestres de l'interconnexion Fenno-Skan 2.

Avec une section cuivre de 2 000mm^2, il s'agira du câble HVDC de plus grande capacité produit par Nexans à ce jour.

La pose de la ligne sous-marine, à une profondeur maximale de 100m, qui sera réalisée par le navire câblier du Groupe, le CS Skagerrak, est prévue pour le printemps 2011. Le câble sera livré en deux tronçons continus d'une centaine de kilomètres chacun, de sorte qu'une seule jonction en mer sera nécessaire.

"Ce contrat majeur conforte le rang de Nexans comme principal fabricant et installateur de câbles d'énergie high-tech destinés aux interconnexions sous-marines", a déclaré Patrick Barth, directeur de l'activité haute tension.

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La 700ème assembleuse est également la plus lourde

▲ *La récente assembleuse à réception tournante est le modèle le plus grand de ce genre*

Le Groupe Gauder est fier d'annoncer un important contrat pour la fourniture d'une ligne d'assembleuses à réception tournante à Saudi Cable Company.

Cette toute dernière ligne d'assembleuses à réception tournante est la 700ème fournie par Gauder à l'industrie du câble et elle sera la plus grande dans son genre. La ligne pour la production de câbles d'alimentation haute tension sera projetée pour loger des enrouleurs de 4 mètres et d'un poids de 30 tonnes.

Pourtier – société faisant partie du groupe Gauder- est un fournisseur de longue date de la société Saudi Cable, l'un des plus importants producteurs d'une gamme complète de câbles au Moyen Orient.

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Investissement d'un producteur de bobines

Madem qui possède des établissements de production au Brésil, en Espagne et aux Etats-Unis, est sur le point de démarrer un nouvel établissement au Bahreïn. Avec une production mensuelle d'environ 500 conteneurs de bobines en bois démontables, la société commercialise ses produits dans plus de 40 pays.

En 2008, Madem investira 5 millions de dollars américains dans une installation de bois contre-plaqué haute technologie, conçue pour la production de 70 conteneurs de brides en bois contre-plaqué par mois.

"Les clients de par le monde sont à la recherche de nouvelles idées et Madem offre de nouveaux kits pour emballages, un nouveau système de blocage des douilles et la possibilité d'effectuer des interventions d'assemblage sur place. Madem travaille en contact étroit avec ses clients en suggérant des modifications aux spécifications qui permettront à leurs clients de réduire les coûts", a déclaré Leandro Mazzoccato.

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▲ *Gauche: Leandro Mazzoccato – Directeur des ventes du Groupe Madem; Centre: Roger Santasusana – Directeur Euromadem Spain SL; Droite: Gino F Mazzoccato – Directeur et Président du Groupe Madem*

Revêtements primaires à haute résistance à la cavitation pour les fibres optiques

Par [1]Huimin Cao, DSM Desotech Inc, Elgin, Illinois, EE UU,
[2]Markus Bulters et [2]Paul Steeman, de DSM Research, Geleen, Pays Bas

Résumé

Il bien connu que, dans les fibres optiques à double revêtement, le système constitué par un revêtement primaire souple combiné avec un revêtement secondaire rigide offre une bonne protection de la fibre contre les microcourbures. Toutefois, ce système de revêtement à double couche génère également des contraintes thermiques résultant de la différence entre la dilatation et la contraction thermique des deux couches de revêtement. Lorsque soumis à une contrainte triaxiale, le revêtement primaire souple peut subir des ruptures internes. La cavitation du revêtement primaire représente une possible modalité de rupture susceptible de compromettre les performances de l'atténuation de la fibre.

Cet article analyse le mécanisme de cavitation du revêtement quant aux différents types de forces déterminant le phénomène. La résistance à la cavitation du revêtement primaire est présentée comme une propriété clé permettant d'obtenir un système de revêtement robuste, à prestations élevées, avec une basse sensibilité aux microcourbures associée à une haute résistance à la cavitation.

1. Introduction

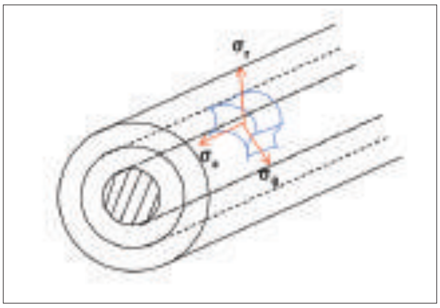
Un des principaux avantages du système de revêtement à double couche pour les fibres optiques consiste à obtenir une meilleure protection contre les microcourbures par rapport au revêtement à une seule couche.

Le système constitué par un revêtement primaire souple, faisant fonction de couche tampon, associé à un revêtement secondaire rigide, faisant fonction de couche de protection, offre une résistance à la flexion idéale aux fibres optiques pour supporter les contraintes externes typiques des réseaux de câblage.

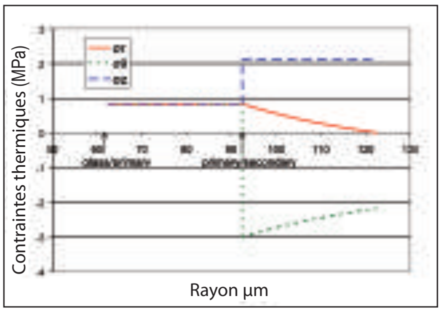
[1]La contrainte thermique dans le système de revêtement à double couche est inévitable du fait des différentes dilatations et contractions thermiques du verre, du revêtement primaire et du revêtement secondaire. Les fibres standard monomodales ou multimodales caractérisées par des revêtements à double couche haute qualité ne présentent aucune augmentation de l'atténuation en dehors des spécifications au cours de la variation cyclique de la température, puisque les contraintes thermiques sont distribuées uniformément autour de la fibre. Toutefois, dans les fibres présentant une certaine quantité de défauts dans le système de revêtement, surtout dans le revêtement primaire, l'on peut remarquer un haut niveau d'atténuation à température ambiante dû aux pertes par microflexion, et l'atténuation peut augmenter drastiquement au rythme de la diminution de la température due à la contrainte thermique non uniforme transmise par les défauts. Les défauts potentiels dans le revêtement primaire comprennent des particules et des gelées, des formations de cristaux, des irrégularités géométriques, le délaminage et des cavités.

Le délaminage et les cavités sont associés aux contraintes thermiques dans le revêtement primaire induites thermiquement ou mécaniquement. Alors que le délaminage du verre du revêtement primaire a été étudié à fond,[3, 4] la possibilité de formation de cavités dues à la rupture interne du revêtement primaire n'a pas été suffisamment analysée.

Bien que les revêtements primaires présentent en général une haute valeur d'allongement lorsqu'ils sont soumis à des contraintes uniaxiales, le matériau de revêtement peut développer des ruptures internes si soumis à des contraintes triaxiales. Une recherche approfondie a été menée auprès de DSM Desotech pendant ces dernières années pour étudier ce mode de rupture potentiel.



▲ **Figure 1**: *Contraintes thermiques triaxiales dans un système de revêtement à double couche*



▲ **Figure 2**: *Contraintes thermiques calculées dans un système de revêtement à double couche*

Le mécanisme de formation de cavités dans le revêtement primaire a été étudié et, à travers une conception moléculaire appropriée de la structure de réticulation des revêtements, on a développé des revêtements primaires à haute résistance à la cavitation.

2. Mécanisme de formation des cavités dans la couche de revêtement primaire

La cause de formation des cavités dans le revêtement primaire est représentée par la contrainte triaxiale qui, pour des valeurs élevées, peut dépasser la résistance à la cavitation du revêtement et causer la rupture de cohésion de la structure du revêtement. Deux types de contraintes triaxiales, d'origines différentes, peuvent être présents dans le revêtement: la contrainte peut être induite thermiquement par la variation de la température ou induite par des forces mécaniques externes.

2.1 Cavités induites par contraintes thermiques

2.1.1 Contraintes thermiques dans les systèmes de revêtement à double couche. Il a été confirmé que les contraintes thermiques sont présentes dans un système de fibres revêtues.[2-5] La contrainte triaxiale dans le revêtement primaire, comme illustré à la *Figure 1*, est causée par la différence entre les coefficients de dilatation thermique du verre, du revêtement primaire et du revêtement secondaire.

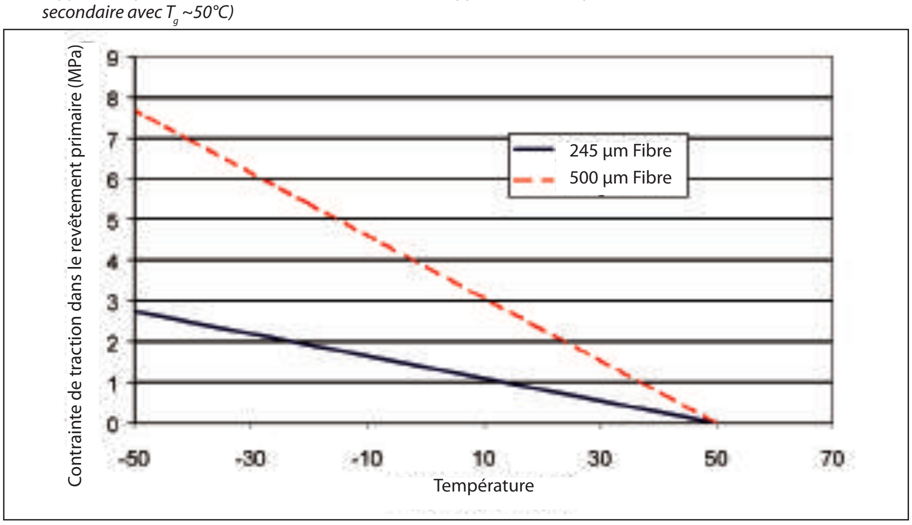
Sur la base de la théorie mécanique des matériaux, il est possible de calculer la contrainte triaxiale, qui est constituée par les composants de la contrainte radiale σr, la contrainte tangentielle σ_θ et la contrainte axiale σ_z. La *Figure 2* montre la distribution de la contrainte calculée dans un système à double couche typique, où l'épaisseur de chaque couche est de 30µm, le module de Young E_1=1MPa, E_2=1GPa, les coefficients de dilatation thermique linéaire $\alpha_1=3x10^{-4}$/K, $\alpha_2=1x10^{-4}$/K et les coefficients de Poisson ν_1=0,5, ν_2=0,4. Le système est soumis à une variation de température de -30ºC, pour simuler la contrainte dans le système de revêtement lorsque la fibre revêtue est refroidie de la température de tréfilage à la température ambiante. Bien que la température dans le revêtement durant le cycle de vulcanisation à UV pourrait atteindre des valeurs arrivant jusqu'à 100ºC, la contrainte thermique ne commence à augmenter que lorsque la température descend au-dessous de la température de transition vitreuse (T_g ou *Glass Temperature*) du revêtement secondaire (~50ºC).

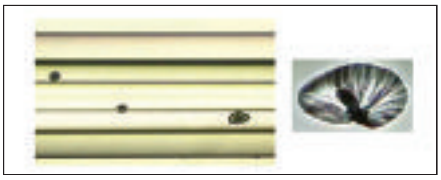
Les trois composants de la tension dans le revêtement primaire sont de traction et sont tous situés au même niveau, comme représenté à la *Figure 2*. Cela signifie que la tension dans le revêtement primaire à température ambiante est une contrainte hydrostatique: elle augmente au rythme de la diminution de la température jusqu'à atteindre le T_g du revêtement primaire (normalement ~-20ºC), lorsque même le revêtement primaire passe à l'état vitreux. La contrainte de traction calculée dans le revêtement primaire est de ~0,8MPa à température ambiante, comme représenté à la *Figure 2*. À cause de la propriété viscoélastique du revêtement secondaire, la contrainte effective devrait être inférieure à la contrainte calculée et diminuer au fil du temps alors que le revêtement secondaire est soumis à une relaxation en contrainte à des températures inférieures au T_g.[5]

Si d'un côté le risque de cavitation du revêtement due à la contrainte thermique est réduit dans les fibres conventionnelles à double revêtement, il faut évaluer avec attention certains types de systèmes de revêtement examinés ci-dessous. La nouvelle tendance dans le développement des revêtements primaires consiste à réduire davantage le module correspondant et le T_g afin d'offrir une meilleure protection de tamponnage contre les microcourbures dans une ample gamme de températures. Dans ce type de revêtement, la contrainte de traction continue à augmenter lorsque la température commence à diminuer; toutefois le revêtement primaire reste à l'état caoutchouteux.

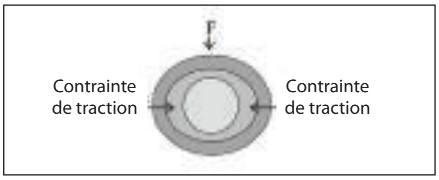
Comme illustré à la *Figure 3*, la contrainte de traction calculée augmente linéairement au rythme de la diminution de la température. En outre, la relaxation en contrainte du revêtement secondaire est beaucoup plus lente aux basses températures. Outre le risque de contraintes thermiques élevées, un revêtement primaire avec un

▼ **Figure 3**: *Contrainte thermique calculée par rapport à la température pour une fibre normale de 250 µm (en supposant que la contrainte commence à se développer à une température inférieure à celle du revêtement secondaire avec T_g ~50°C)*

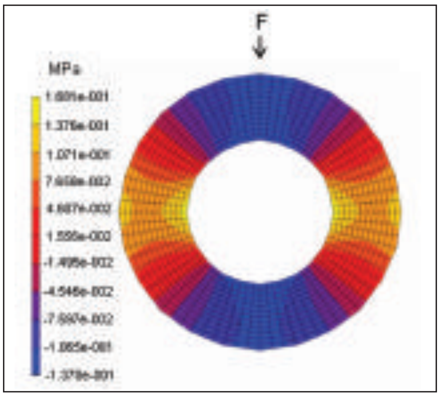




▲ **Figure 4**: *Cavités dans la couche du revêtement primaire induites par la variation cyclique de la température dans une fibre de 500 µm (gauche) 40x (droite) 200x*



▲ **Figure 5**: *Diagramme schématique des contraintes de traction localisées dans le revêtement primaire causées par une force mécanique latérale*



▲ **Figure 6**: *Contrainte normale dans la couche du revêtement primaire induite par une force mécanique latérale calculée moyennant l'Analyse des Éléments Finis*

module inférieur peut être susceptible de cavitation à cause de sa densité de réticulation inférieure. Il est donc essentiel que les revêtements primaires avec un module et un T_g réduits soient conçus soigneusement de façon à offrir une résistance à la cavitation élevée, en optimisant la structure de réticulation.

La connaissance approfondie au niveau moléculaire de la résistance à la cavitation des matériaux de revêtement vulcanisables à UV permet de développer des systèmes de revêtement caractérisés par des performances de microcourbure améliorées associées à une résistance à la cavitation élevée, pour offrir des fibres robustes dans une ample gamme de températures. Un autre exemple de situation à risque élevé en ce qui concerne la formation de cavités est représenté par la fibre caractérisée par des couches de revêtement plus épaisses par rapport à celles traditionnelles.

La contrainte de traction dans la couche primaire d'une fibre qui présente une structure de verre/revêtement avec un diamètre externe de 125/350/500 µm, est calculée et représentée graphiquement à la *Figure 3*. La valeur de la contrainte de traction dans le revêtement primaire de cette fibre est 2,8 fois supérieure à la valeur de la contrainte dans le revêtement primaire d'une fibre revêtue standard d'un diamètre extérieur de 245 µm. Il s'ensuit que les fibres présentant des couches de revêtement plus épaisses devraient être composées par un revêtement primaire à haute résistance à la cavitation associé avec un revêtement secondaire à relaxation en contrainte plus rapide.

2.1.2 Formation de cavités dans le revêtement primaire. La *Figure 4* montre des images au microscope de certaines cavités s'étant formées dans une fibre revêtue avec un diamètre extérieur de 500 µm, après une variation cyclique de la température entre 85ºC et -60ºC. Des ruptures du revêtement de forme irrégulière et de dimensions différentes peuvent être observées dans la couche du revêtement primaire. La présence de ruptures bien ouvertes dans le revêtement, représentées sous la forme de vides, indique l'existence d'une contrainte triaxiale dans la couche primaire à température ambiante.

Pour la théorie mécanique de la fracture, le paramètre représentant la résistance à la formation de cavités dans un matériau est défini résistance à la cavitation. Lorsqu'une contrainte triaxiale atteint ce point critique, le matériau commence à se déchirer et à former des cavités internes.

Il a été calculé et prouvé expérimentalement que dans le cas d'un caoutchouc idéal, la contrainte triaxiale pour élargir un trou sphérique de petites dimensions est égale à (5/6)E, où E représente le module de Young.[6] Tout défaut de réticulation microscopique dans le matériau peut constituer le point de rupture initial. Cela signifie que, pour un revêtement primaire de 1MPa, une contrainte de traction triaxiale de 0,83MPa peut déjà causer la formation de cavités selon un mécanisme d'accroissement illimité, dans le cas où le matériau de revêtement se conduirait comme un caoutchouc idéal. Avec une conception moléculaire appropriée de la structure réticulée du revêtement, l'on peut obtenir la résistance élevée à la cavitation désirée, avec des valeurs de résistance à la cavitation considérablement supérieures au module du revêtement.

Dans ce type de revêtement primaire à haute résistance à la cavitation, les cavités de petites dimensions ne s'accroîtront pas sans limites et le matériau ne subira aucune rupture même dans le cas de valeurs de contrainte de traction relativement élevées dans le revêtement primaire.

2.2 Cavités induites par contraintes mécaniques

Outre la contrainte hydrostatique et thermique, la formation de cavités dans les revêtements primaires peut être également causée par des contraintes triaxiales anisotropes résultant d'un impact mécanique sur la fibre revêtue. Durant quelques essais de résistance du revêtement au délaminage, réalisés en tirant la fibre à travers un système de rembobinage, il a été remarqué que le revêtement se déchire lorsque soumis à des tensions élevées.[4]

Lorsqu'une force mécanique extérieure est appliquée à une fibre revêtue, les couches de revêtement se déforment en générant un champ de contraintes non uniforme dans le matériau de revêtement. La *Figure 5* illustre schématiquement la déformation des couches de revêtement soumises à une force latérale F. Le revêtement secondaire étant un matériau beaucoup plus rigide que le revêtement primaire, la couche secondaire se conduit comme un tuyau vide, soumis à une pression latérale, passant de la forme tubulaire à une forme ovale, mais sans entraîner aucune déformation de l'épaisseur du revêtement.

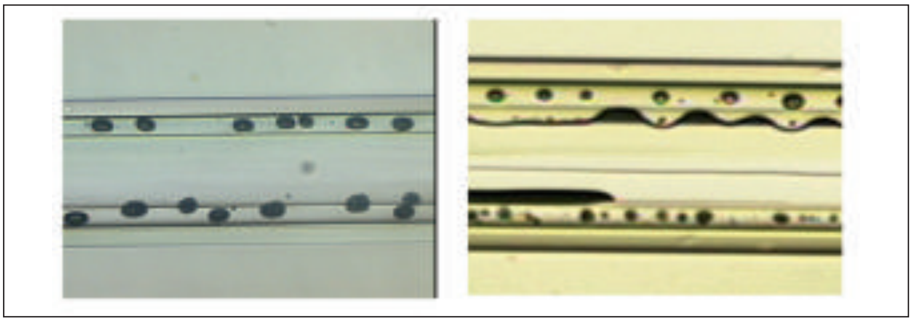
Le revêtement primaire est collé des deux côtés au verre et au revêtement secondaire, et il doit se déformer par force à l'intérieur. Les zones du revêtement primaire en direction de la force sont comprimées, et les zones perpendiculaires à la direction de la force sont soumises à un allongement. La contrainte de traction dans ces zones soumises à un allongement présente un composant triaxial significatif pouvant causer la cavitation du revêtement primaire au cas où la contrainte dépasserait la résistance à la cavitation du revêtement.

La *Figure 6* représente un champ de contrainte normal moyen calculé par l'Analyse des Éléments Finis dans la couche du revêtement primaire d'une fibre avec une géométrie d'un diamètre extérieur de 125/240/410 µm, soumise à une contrainte latérale simulée. Le résultat montre quantitativement les différents champs de contrainte allant de la contrainte de compression (-) à la contrainte de traction (+). Comme illustré par la *Figure 6*, les zones soumises à la contrainte de traction majeure sont constituées par les points perpendiculaires à la direction de la force appliquée et à proximité de l'un et l'autre côté des interfaces entre le verre et le revêtement primaire, et entre le revêtement primaire et le revêtement secondaire. Ce sont les zones où la cavitation est particulièrement susceptible de se manifester lorsqu'une force mécanique latérale est appliquée.

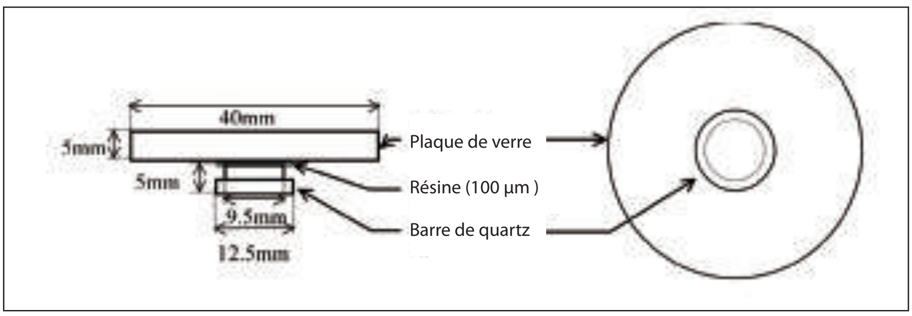
La *Figure 7* illustre quelques exemples de cavités induites intentionnellement dans le revêtement primaire, causées par des impacts mécaniques latéraux. La force latérale doit être dynamique avec la vitesse, soit longitudinalement (glissement), soit perpendiculairement (frappe). Une force latérale statique ne peut avoir pour résultat que le délaminage. Dans la *Figure 7*, l'impact mécanique a été créé en faisant glisser une barre métallique d'un diamètre de 1mm longitudinalement par rapport à la fibre.

Avec un appareil réalisé en attachant la barre métallique à un dispositif d'essai de frottement automatique, des vitesses contrôlées et des forces contrôlées ont été appliquées en ajoutant des poids différents à l'appareil. Tant la vitesse que la force d'impact influencent la contrainte induite dans le revêtement. À des vitesses très basses, le délaminage a lieu plutôt que la cavitation du revêtement.

▼ **Figure 7**: *Exemples de formation de cavités/délaminage dans la couche du revêtement primaire causés par impacts mécaniques latéraux*



▼ **Figure 8**: *Préparation de l'échantillon pour l'essai de résistance à la cavitation*



Cela peut dépendre du fait que la zone de délaminage réduite s'étant formée au contact initial avec la force, se propage le long de la fibre en relâchant la contrainte de traction dans le revêtement.

Comme représenté à la *Figure 7*, les cavités et/ou le délaminage peuvent être générés à partir de vitesses moyennes jusqu'à des vitesses élevées. Les cavités sont localisées dans les deux zones latérales, ce qui correspond à la théorie.

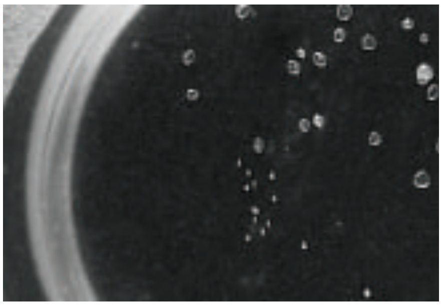
Les cavités et le délaminage sont des modalités d'erreur en concurrence. Elles peuvent être présentes individuellement ou simultanément, en fonction des caractéristiques d'adhésion et de la résistance à la cavitation d'un type particulier de revêtement.

Le niveau d'adhésion du revêtement primaire sur le verre doit être équilibré par rapport aux spécifications concernant la force de dénudage. Une résistance à la cavitation élevée du revêtement primaire est toujours préférable pour améliorer la robustesse de la fibre revêtue.

Toutefois, il faut considérer que toute fibre revêtue, au fil du temps, est susceptible de rupture par délaminage et/ou cavitation si l'impact mécanique augmente à un certain niveau.

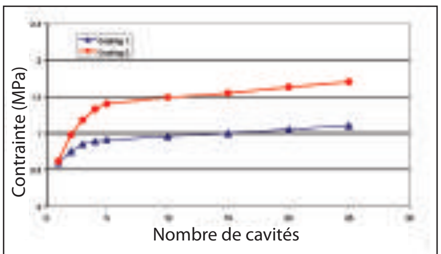
Alors que la tension thermique est une caractéristique intrinsèque du revêtement à double couche, la contrainte mécanique est générée par des causes extérieures.

Tout impact anormal à haute pression dans les fibres devrait être évité durant les processus de tréfilage, de bobinage, d'essai ou de manutention.



▲ **Figure 9**: *Exemple d'une cavité dans un échantillon enregistré avec caméra vidéo (20x) à un certain niveau de contrainte*

▼ **Figure 10**: *Contrainte de traction en relation au nombre de cavités observées dans deux matériaux de revêtement*



3. Résistance à la cavitation des revêtements primaires

3.1 Essai de résistance à la cavitation

Le concept physique de résistance à la cavitation comme décrit au point 2.1.2 est le niveau critique de contrainte triaxiale auquel un matériau commence à se déchirer. Pour mesurer la résistance à la cavitation du matériau de revêtement, une méthode d'essai a été développée en utilisant une pellicule vulcanisée.

3.1.1 Essai de mesure. En principe, la méthode pour induire une contrainte de traction triaxiale dans un matériau de revêtement est simple: on augmente le volume du matériau de revêtement similaire au caoutchouc. On vulcanise et on fait adhérer le revêtement entre deux surfaces plates, qui sont ensuite séparées dans une machine d'essai de traction. Avec l'augmentation contrôlée de la distance entre deux plaques, une contrainte de traction triaxiale est générée dans le revêtement. L'essai de mesure doit être conçu de manière à ce que l'épaisseur du revêtement soit inférieure à 5% du diamètre des plaques.

Étant donné que cette couche de revêtement très fine est limitée aux plaques, la contrainte latérale du revêtement est elle aussi limitée. Par conséquent, une contrainte de traction triaxiale uniforme est générée dans le matériau de revêtement. Afin d'obtenir des valeurs reproductibles de la résistance à la cavitation, l'alignement de l'essai de mesure est important, puisque ce dernier influence la distribution de la contrainte dans l'échantillon. En outre, pour étudier la relation existant entre le nombre de cavités générées et la charge appliquée de façon répétable, la rigidité de l'essai de mesure doit être élevée (c'est-à-dire que l'élasticité devrait être basse) pour réduire au minimum le stockage d'énergie élastique dans le système de mesure.

3.1.2 Préparation de l'échantillon. La préparation de l'échantillon est illustrée à la Figure 8. Afin d'éviter le délaminage au cours de l'essai, les surfaces des plaques de verre et les barres de quartz doivent être préparées correctement. Premièrement, les surfaces ont été rendues rugueuses par polissage en utilisant une poudre de carborundum. Ensuite, les pièces de verre et quartz ont été nettoyées dans un four à 600ºC pendant une heure et les surfaces ont été rincées avec de l'acétone et laissées sécher. Successivement, les surfaces ont été traitées avec une solution de promoteurs d'adhésion à base de silane (on a utilisé le Methacryloxypropyltrimethoxysilane A174 de Witco). La couche de silane à été vulcanisée en plaçant les plaques de verre traitées ou le quartz dans un four

Revête-ment	E'	σ_{cav}	Rapport
	(MPa)	(MPa)	σ_{cav} /E'
A	0.37	0.95	2.6
B	0.97	1.21	1.2
C	1.33	2.5	1.9
D	1.2	2.8	2.3
E	0.9	2.1	2.3
F	0.64	1.51	2.4

▲ **Tableau 1**: *Propriétés de résistance à la cavitation mesurées de revêtements primaires sélectionnés*

à 90ºC pendant 5-10 minutes. Après ce prétraitement, une goutte de résine a été appliquée sur la plaque de verre et elle a été couverte avec la barre de quartz. Une pellicule de l'épaisseur d'environ 100 µm a été préparée en utilisant un micromètre à deux plaques. L'échantillon a été vulcanisé avec une dose de 1J/cm^2, en utilisant un système à lampes UV-D Fusion F600W.

3.1.3 Mesure de la résistance à la cavitation. L'échantillon a été placé dans l'appareil d'essai de traction (type Zwick 1484). La vitesse de traction était égale à 20 µm/min. Au début de l'essai, une caméra vidéo connectée à un microscope avec un agrandissement de 20x, a enregistré le comportement de la pellicule, en montrant également le niveau de traction exercée sur la pellicule.

La *Figure 9* représente une image de l'échantillon, capturée par la caméra vidéo, avec de nombreuses cavités déjà formées. Grâce à l'enregistrement vidéo, le nombre de cavités présentes a été tracé en fonction de la contrainte appliquée comme illustré à la *Figure 10*.

Il a été remarqué que les contraintes auxquelles la première cavité a été observée, présentaient des valeurs similaires dans différents matériaux de revêtement. Toutefois, les niveaux de contrainte ont commencé à manifester des différences évidentes entre les différents revêtements au fur et à mesure que le nombre de cavités augmentait. Dans cette méthode d'essai, la valeur de contrainte correspondant à la formation de 10 cavités a été sélectionnée pour représenter la résistance à la cavitation du revêtement mesuré. Par exemple, dans les revêtements indiqués à la *Figure 10*, on a mesuré des valeurs de résistance à la cavitation respectivement de 0,96 MPa et 1,49 MPa.

3.2 Revêtements primaires à résistance élevée à la cavitation

Comme précédemment illustré au point 2.1.2, la cavitation du revêtement a lieu lorsque la contrainte de traction triaxiale dépasse la résistance à la cavitation du matériau de revêtement. Pour réduire le risque de cavitation du revêtement, il existe deux approches efficaces: 1) réduire le niveau de contrainte thermique, et/ou 2) augmenter la résistance à la cavitation dans le revêtement. Le niveau de contrainte thermique est influencé par les deux couches de revêtement, où le revêtement secondaire joue un rôle très important par rapport au revêtement primaire. De l'autre côté, la résistance à la cavitation est une propriété intrinsèque du revêtement primaire. Un revêtement primaire à résistance élevée à la cavitation est toujours souhaitable pour garantir la robustesse de la fibre revêtue, dans des conditions de contrainte thermique et de toute contrainte mécanique potentielle se générant durant le processus, la manutention et l'installation dans le champ.

Le *Tableau 1* montre plusieurs exemples avec différents comportements de résistance à la cavitation. La résistance à la cavitation (σ_{cav}) a été mesurée en utilisant la méthode d'essai décrite au point 3.1. En outre il indique les valeurs du module de stockage E' à température ambiante de DMA et les rapports σ_{cav}/E'.

Comme examiné au point 2.1.2, la résistance à la cavitation d'un caoutchouc idéal devrait être égale à (5/6)E. Dans le *Tableau 1*, chaque revêtement présente une résistance à la cavitation supérieure à celle du module correspondant, ce qui indique que les revêtements ne correspondent pas à une élasticité parfaite.

Le module correspondant à la densité de réticulation du revêtement joue encore un rôle important dans la détermination de la résistance à la cavitation d'un matériau de revêtement. Toutefois, avec une structure de réticulation polymérique de densité moléculaire appropriée, il est possible d'obtenir une résistance à la cavitation élevée, indépendamment du module de revêtement. En d'autres termes, l'on peut réaliser des revêtements idéaux, souples mais résistants, caractérisés par un rapport élevé entre la résistance à la cavitation et le module. Un module réduit permet d'obtenir de meilleures performances de microcourbure.

Dans le *Tableau 1*, le Revêtement A présente le module inférieur; toutefois, la résistance à la cavitation correspondante est également la plus basse (<1MPa). En effet, la fibre avec ce type de revêtement a présenté des cavités évidentes résultant du processus de refroidissement après le tréfilage de la fibre. Le Revêtement B, avec une résistance à la cavitation égale à 1,21MPa, est considéré suffisamment résistant pour supporter la contrainte thermique durant le refroidissement de la fibre. Aucune cavité n'a été observée dans la fibre avec le Revêtement B. Même dans l'analyse théorique, le niveau de résistance à la cavitation est suffisamment supérieur par rapport à la contrainte thermique calculée de ~0,8MPa dans le revêtement primaire. Toutefois, le rapport σ_{cav}/E' du Revêtement B est égal à seulement 1,2, c'est-à-dire le plus bas parmi la totalité des revêtements. Ce type de revêtement est considéré apte à supporter des situations de contrainte normales, mais ne réalise pas complètement son potentiel jusqu'à devenir un matériau de revêtement hautement robuste.

Par contre, les Revêtements C, D, E et F présentent les propriétés de haute résistance à la cavitation désirées. Le module de Revêtement C ou du Revêtement D se trouve au niveau typique des revêtements primaires commerciaux. Toutefois, la résistance à la cavitation de ces revêtements, a été conçue pour présenter une valeur exceptionnellement élevée à travers une structure moléculaire de réticulation optimisée. Le Revêtement E présente une valeur de module moyen-bas (combiné avec T_g réduit), qui a été développé pour être appliqué dans les fibres monomodales et dans celles multimodales. La résistance à la cavitation de ce revêtement présente encore une valeur très élevée (2,1MPa) et permet un rapport élevé égal à σ_{cav}/E' (2.3).

Le Revêtement F offre une résistance excellente à la microcourbure attribuée au module ultra-bas (à T_g réduit). En même temps, on a également obtenu un niveau de résistance à la cavitation suffisamment élevé (1,51MPa) avec le rapport σ_{cav}/E' correspondant à 2,4. Pour les revêtements ultrasouples comme dans ce cas, des précautions spécifiques doivent être prises afin d'assurer à la structure de revêtement des performances de résistance à la cavitation satisfaisantes. Autrement, le développement de cavitation dans le revêtement et la détérioration des performances d'atténuation de la fibre représentent un risque possible.

Les situations comme celle du Revêtement A, où les cavités étaient déjà présentes dans la fibre après le tréfilage, peuvent être aisément identifiées. Le risque n'est pas évident dans des situations où les cavités dans le revêtement peuvent progressivement se produire et causer une augmentation de l'atténuation dans le champ, lorsque la fibre est soumise à des cycles de température ambiante ou reste dans des conditions de basse température pendant des périodes prolongées, comme par exemple dans le cas des câbles sous-marins.

Un système de revêtement haute qualité, projeté soigneusement, non seulement contribue à obtenir des performances optimales des fibres, mais offre également une majeure fiabilité des fibres optiques à long terme.

4. Conclusions

La cavitation des revêtements primaires a été amplement étudiée en tant que modalité de défaillance possible dans les fibres optiques à double revêtement. La cavitation du revêtement est causée par une contrainte de traction triaxiale pouvant être induite par des contraintes thermiques intérieures ou d'impacts mécaniques extérieurs. Le revêtement est susceptible de rupture cohésive lorsque la contrainte de traction triaxiale dépasse la résistance à la cavitation du revêtement. Une méthode d'essai a été développée pour évaluer quantitativement la résistance à la cavitation d'un matériau de revêtement.

La compréhension du mécanisme de cavitation et l'étude approfondie de la résistance à la cavitation du revêtement ont permis de concevoir des matériaux de revêtement résistant à la cavitation élevée pour fortifier la fibre revêtue lorsqu'elle est soumise à des contraintes thermiques et à des sollicitations mécaniques potentielles. On a obtenu des rapports élevés entre la résistance à la cavitation et le module, permettant de réaliser des revêtements primaires à module réduit/T_g réduit, d'améliorer la protection contre les microcourbures et d'offrir une résistance à la cavitation élevée. ■

5. Références

[1] D Gloge, 'Optical-fiber Packaging and Its Influence on Fiber Straightness and Loss', The Bell System Technical J, 54(2), 245-262 (1975)

[2] W W King, 'Thermally Induced Stresses in an Optical - Fiber Coating', J of Lightwave Technology, 9(8), 952-953 (1991)

[3] W W King and C J Aloisio, 'Thermomechanical Mechanism for Delaminations of Polymer Coatings from Optical Fibers', J of Electronic Packaging, 119, 133-137 (1997)

[4] P L Tabaddor, C J Aloisio, C H Plagianis, C R Taylor, V Kuck and P G Simpkins, 'Mechanics of Delamination Resistance Testing', International Wire and Cable Symposium Proceedings, p 725 (1998)

[5] C J Aloisio, W W King and R C Moore, 'A Viscoelastic Analysis of Thermally Induced Residual Stresses in Dual Coated Optical Fibers', International Wire and Cable Symposium Proceedings, p 139 (1995)

[6] A N Gent and P B Lindley, 'Internal Rupture of Bonded Rubber Cylinders in Tension', Proc Roy Soc A, 249, 1958

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Saldatura ultrasonica in esposizione

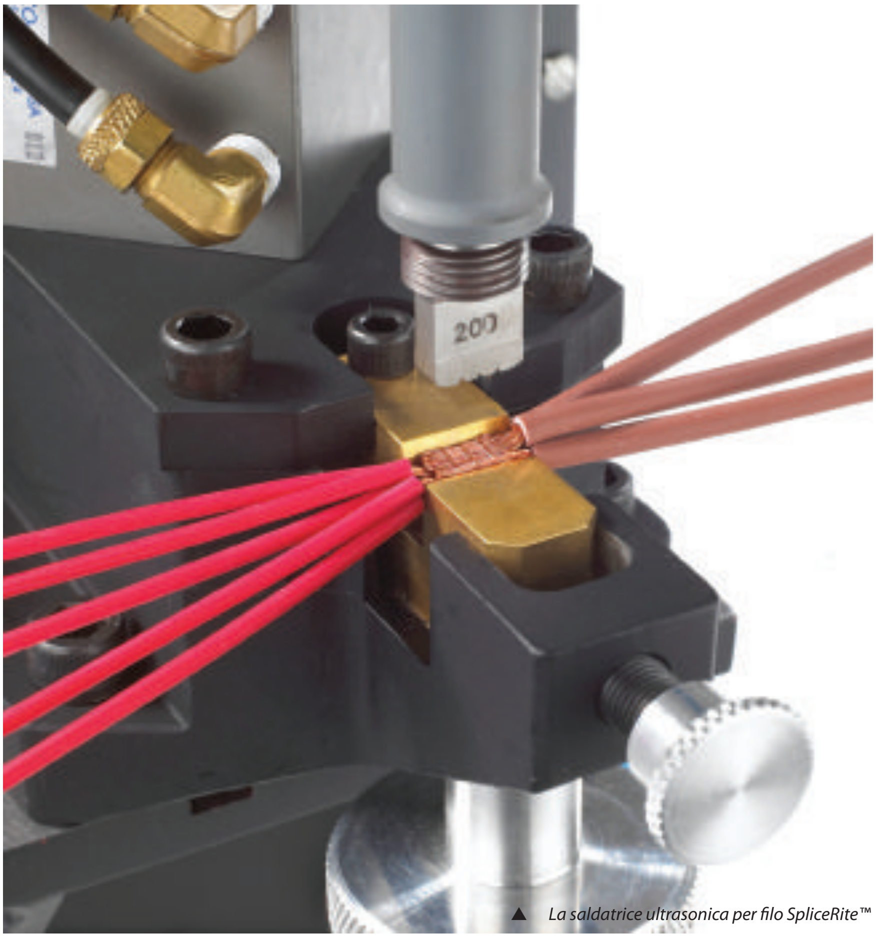
La saldatrice ultrasonica SpliceRite™ è stata al centro dell'attenzione nello stand di Sonobond Ultrasonics durante l'esposizione Electrical Wire Processing Technology Expo tenutasi a maggio nel Milwaukee (Stati Uniti).

La saldatrice SpliceRite è stata progettata per creare saldature metallurgiche solide utilizzando la caduta di tensione più bassa possibile e riducendo al minimo il consumo di energia.

La nuova saldatrice elimina la necessità di serrare, saldare, aggraffare o saldare per immersione, permettendo di saldare rapidamente fasci di fili senza produrre archi, scintille, fumi o fondere i fili. Si possono inoltre saldare fili stagnati o molto ossidati.

Come altre saldatrici ultrasoniche per metalli di Sonobond, la saldatrice per filo SpliceRite™ è equipaggiata con il sistema brevettato Wedge-Reed. Questo sistema produce una forza di vibrazione elevata combinata con un accoppiamento di ampiezza ridotto. Consente all'unità di orientare l'energia ad ultrasuoni ad alta frequenza attraverso l'ugello di saldatura alla superficie fra i metalli da saldare. L'energia vibratoria disperde gli ossidi e le pellicole superficiali fra i pezzi in lavorazione.

Tutte le saldatrici per metalli di Sonobond presentano punte di bloccaggio coniche realizzate in acciaio per utensili trattati termicamente.



▲ *La saldatrice ultrasonica per filo SpliceRite™*

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Cavo HVDC per l'interconnessione fra la Finlandia e la Svezia

Nexans si è aggiudicata un contratto del valore di circa 150 milioni di euro con la società Fingrid Oyj, operatore di rete per il trasporto dell'elettricità in Finlandia, e Svenska Kraftnät. Il contratto riguarda la fabbricazione e l'installazione di un cavo di potenza sottomarino HVDC (corrente continua ad alta tensione) per Fenno-Skan 2 che assicurerà la nuova interconnessione fra i due paesi.

Nexans fornirà circa 200km di cavo solido speciale, con isolamento di carta impregnata ad olio del tipo MIND (Mass Impregnated Non-Draining), destinati ai tratti sia sottomarini, sia terrestri dell'interconnessione Fenno-Skan 2. Caratterizzato da una sezione di rame di 2000mm^2, si tratterà del cavo HVDC della maggiore capacità realizzato da Nexans.

Questo progetto ha lo scopo di creare una nuova linea sottomarina di trasporto dell'elettricità (800MW, 500kV) che collega il sud della Finlandia e la Svezia su 200 km attraverso il golfo di Botnia. Questa linea costituirà una connessione bipolare con la linea esistente Fenno-Skan (550MW, 400kV), messa in servizio nel 1989, aumentando così del 40% la capacità di trasporto dell'energia fra i due paesi. Il cavo sarà consegnato in due tratti continui di un centinaio di chilometri ciascuno, in modo che sia necessaria una sola giunzione offshore.

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Il 700° torcitore a tamburo è il più pesante

▲ *Il recente torcitore a tamburo è il modello più grande del genere*

Il Gruppo Gauder è lieto di annunciare un importante contratto per la fornitura di una linea di torcitura a Saudi Cable Company.

Questa recentissima linea di torcitura è la 700ª fornita da Gauder all'industria del cavo e sarà la più grande del genere.

La linea per la produzione di cavi di alimentazione ad alta tensione sarà progettata per alloggiare un avvolgitore di 4 metri e del peso di 30 tonnellate.

Pourtier – società che fa parte del Gruppo Gauder, é fornitore di lunga data della società Saudi Cable, uno dei maggiori produttori di una gamma completa di cavi nel Medio Oriente.

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Investimento di un produttore di bobine

La società Madem che possiede stabilimenti di produzione in Brasile, Spagna e Stati Uniti, è in procinto di aprire quest'anno un nuovo stabilimento nel Regno del Bahrain. Con una produzione mensile di circa 500 contenitori di bobine di legno smontabili, la società commercializza i suoi prodotti in oltre 40 paesi e ad importanti produttori di filo e cavo.

Nel corso del 2008, Madem investirà 5 milioni di dollari americani in un impianto di legno compensato di alta tecnologia, progettato per produrre 70 contenitori di flangie di legno compensato al mese.

"I clienti di tutto il mondo sono alla ricerca di nuove idee e Madem offre nuovi kit per imballaggi, un nuovo sistema di bloccaggio delle boccole e la possibilità di effettuare interventi di assemblaggio in loco. Madem opera a stretto contatto con i suoi clienti suggerendo modifiche alle specifiche che consentiranno ai propri clienti di ridurre i costi," ha dichiarato Leandro Mazzoccato, direttore delle vendite del Gruppo Madem.

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Rivestimenti primari ad elevata resistenza alla cavitazione per le fibre ottiche

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Riassunto

É noto che nelle fibre ottiche a doppio rivestimento, il sistema costituito da un rivestimento primario morbido associato ad un rivestimento secondario rigido, offre una buona protezione della fibra contro le micropiegature. Tuttavia, questo sistema di rivestimento a doppio strato genera anche delle tensioni indotte termicamente dalla differenza fra dilatazione e contrazione termica dei due strati di rivestimento. Qualora sottoposto ad uno sforzo di trazione triassiale, è possibile che il rivestimento primario morbido subisca delle rotture interne.

La cavitazione del rivestimento primario rappresenta una possibile modalità di rottura che può compromettere le prestazioni di attenuazione della fibra. Il presente articolo analizza il meccanismo di cavitazione del rivestimento in relazione ai diversi tipi di forze che determinano il fenomeno. La resistenza alla cavitazione del rivestimento primario è presentata come una proprietà fondamentale che consente di ottenere un sistema di rivestimento robusto e con prestazioni elevate, caratterizzato da una ridotta sensibilità alle micropiegature associata ad un'elevata resistenza alla cavitazione.

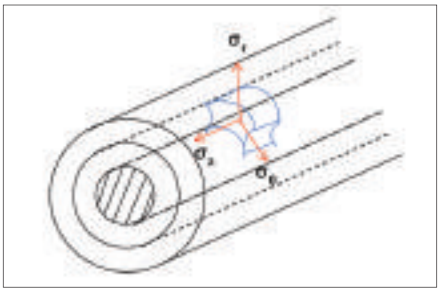
1. Introduzione

Uno dei principali vantaggi del sistema di rivestimento a doppio strato per le fibre ottiche consiste nell'ottenere una migliore protezione contro le micropiegature rispetto al rivestimento a strato singolo. Il sistema costituito da un rivestimento primario morbido, che funge da strato tampone, associato ad un rivestimento secondario rigido, che funge da strato protettivo, offre alle fibre ottiche un'ottima resistenza alla flessione per sopportare le sollecitazioni esterne in una rete di cavi.

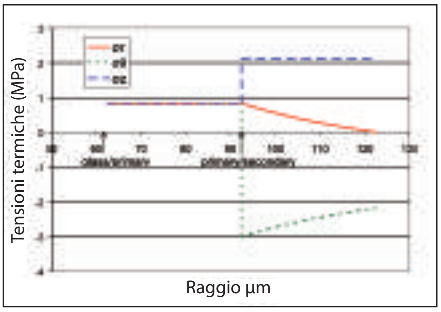
[1]Le tensioni termiche nel sistema di rivestimento a doppio strato sono inevitabili a causa delle diverse dilatazioni e contrazioni termiche del vetro, del rivestimento primario e del rivestimento secondario. Le fibre standard monomodali o multimodali caratterizzate da rivestimenti a doppio strato di alta qualità, non presentano alcun aumento dell'attenuazione al di fuori delle specifiche durante la variazione ciclica della temperatura, poiché le tensioni termiche sono distribuite uniformemente attorno alla fibra. Tuttavia, nelle fibre che presentano una certa quantità di difetti nel sistema di rivestimento, specialmente nel rivestimento primario, si nota un alto livello di attenuazione a temperatura ambiente dovuto alle perdite per micropiegature e l'attenuazione può aumentare drasticamente al diminuire della temperatura a causa della tensione termica non uniforme trasmessa dai difetti. I potenziali difetti nel rivestimento primario comprendono particelle e gel, formazioni di cristalli, irregolarità geometriche, delaminazione e cavità.

La delaminazione e le cavità sono entrambe associate agli sforzi di trazione nel rivestimento primario indotti termicamente o meccanicamente. Mentre la delaminazione dal vetro del rivestimento primario è stata studiata a fondo[3, 4], la possibilità di formazione di cavità dovute alla rottura interna del rivestimento primario non è stata analizzata adeguatamente.

Nonostante i rivestimenti primari possiedano normalmente un elevato valore di allungamento se sottoposti a sforzi di trazione uniassiale, il materiale di rivestimento può sviluppare rotture interne qualora sottoposto a sforzi di trazione triassiale. In questi ultimi anni, è stata condotta un'approfondita ricerca presso DSM Desotech per studiare questa



▲ **Figura 1**: *Tensioni termiche triassiali in un sistema di rivestimento a doppio strato*



▲ **Figura 2**: *Tensioni termiche calcolate in un sistema di rivestimento a doppio strato*

potenziale modalità di rottura. É stato studiato il meccanismo di formazione delle cavità nel rivestimento primario e, attraverso un'appropriata progettazione molecolare della struttura di reticolazione dei rivestimenti, sono stati sviluppati rivestimenti primari ad elevata resistenza alla cavitazione.

2. Meccanismo di formazione delle cavità nello strato di rivestimento primario

La formazione di cavità nel rivestimento primario è dovuta allo sforzo di trazione triassiale che, nel caso di valori elevati, può superare la resistenza alla cavitazione del rivestimento e causare la frattura di coesione della struttura del rivestimento. Il rivestimento può presentare due tipi di sforzi di trazione triassiale che hanno origini diverse: lo sforzo di trazione può essere indotto termicamente dalla variazione di temperatura, o indotto da forze meccaniche esterne.

2.1 Cavità indotte da tensioni termiche

2.1.1 Tensioni termiche in un sistema di rivestimento a doppio strato. É ampiamente confermato che le tensioni termiche sono presenti nel sistema di fibre rivestite.[2-5] Lo sforzo di trazione triassiale nel rivestimento primario, come illustrato nella *Figura 1*, è causato dalla differenza fra i coefficienti di dilatazione termica del vetro, del rivestimento primario e del rivestimento secondario.

Sulla base delle teorie meccaniche dei materiali, è possibile calcolare lo sforzo triassiale, costituito dalle componenti della tensione radiale σ_r, dalla tensione tangenziale σ_θ e dalla tensione assiale σ_z. La *Figura 2* illustra la distribuzione della tensione calcolata in un tipico sistema a doppio strato, ove ogni spessore dello strato è pari a 30 µm, il modulo di Young E_1=1MPa, E_2=1GPa, i coefficienti di dilatazione termica lineare $\alpha_1=3x10^{-4}$/K, $\alpha_2=1x10^{-4}$/K ed i rapporti di Poisson v_1=0,5, v_2=0,4. Il sistema è sottoposto ad una variazione di temperatura di -30ºC, per simulare la tensione nel sistema di rivestimento quando la fibra rivestita è raffreddata dalla temperatura di trafilatura alla temperatura ambiente. Sebbene la temperatura nel rivestimento durante il ciclo di vulcanizzazione ad UV potrebbe raggiungere valori fino a 100ºC, la tensione termica inizia ad aumentare solo quando la temperatura scende al di sotto della temperatura di transizione vetrosa (T_g) del rivestimento secondario (~50ºC).

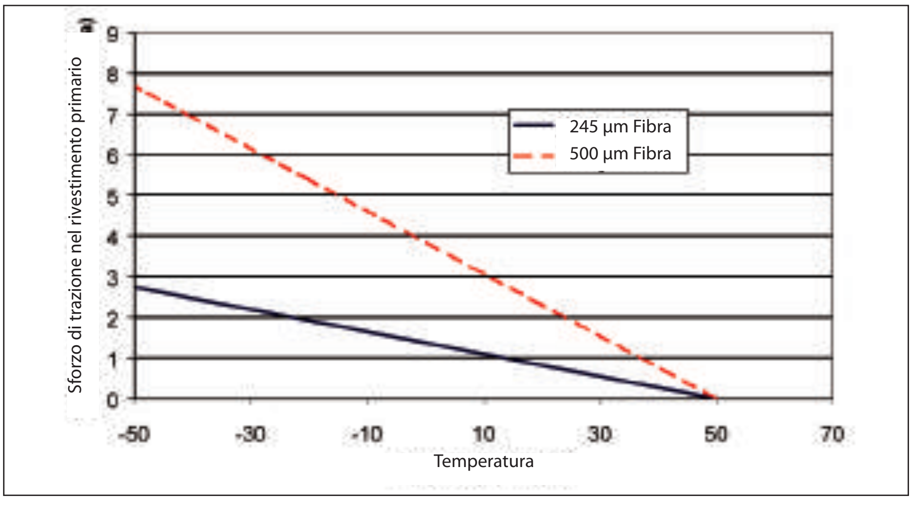
Le tre componenti della tensione nel rivestimento primario sono di trazione e si trovano tutte allo stesso livello, come illustrato nella *Figura 2*. Ciò significa che la tensione nel rivestimento primario a temperatura ambiente è una trazione idrostatica: aumenta al diminuire della temperatura fino a raggiungere il T_g del rivestimento primario (normalmente ~-20ºC), quando anche il rivestimento primario passa allo stato vetroso. Lo sforzo di trazione calcolato nel rivestimento primario è ~0,8MPa a temperatura ambiente, come illustrato nella *Figura 2*. A causa della proprietà viscoelastica del rivestimento secondario, lo sforzo effettivo dovrebbe essere inferiore allo sforzo calcolato e diminuire nel tempo mentre il rivestimento secondario viene sottoposto ad un rilassamento degli sforzi a temperature T_g inferiori.[5]

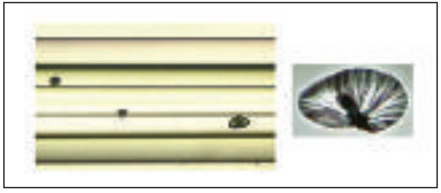
Mentre il rischio di cavitazione del rivestimento dovuta a tensione termica è ridotto nelle fibre tradizionali con doppio rivestimento, vanno valutati con attenzione alcuni tipi di sistemi di rivestimento come quelli esaminati qui di seguito. La nuova tendenza nello sviluppo dei rivestimenti primari consiste nel ridurre ulteriormente il relativo modulo e il valore T_g al fine di fornire una migliore protezione di tamponamento contro le micropiegature in un'ampia gamma di temperature.

In questo tipo di rivestimento, lo sforzo di trazione continua ad aumentare quando la temperatura inizia a diminuire; tuttavia il rivestimento primario rimane allo stato gommoso. Come illustrato nella *Figura 3*, lo sforzo di trazione calcolato aumenta linearmente al diminuire della temperatura. Il rilassamento degli sforzi del rivestimento secondario è inoltre molto più lento a basse temperature.

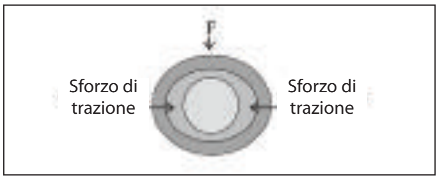
Oltre al rischio di alte tensioni termiche, un rivestimento primario con modulo ridotto può essere più suscettibile di cavitazione a causa della sua inferiore densità di reticolazione.

▼ **Figura 3**: *Tensione termica calcolata rispetto alla temperatura per una fibra normale di 250 µm (supponendo che la tensione inizia a svilupparsi ad una temperatura inferiore a quella del rivestimento secondario con T_g ~50°C)*

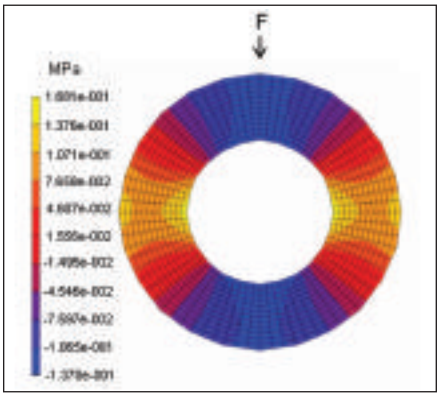




▲ **Figura 4**: *Cavità nello strato di rivestimento primario indotte da variazione ciclica della temperatura in una fibra di 500 µm (sinistra) 40x (destra) 200x*



▲ **Figura 5**: *Diagramma schematico degli sforzi di trazione localizzati nel rivestimento primario causati da una forza meccanica laterale*



▲ **Figura 6**: *Sforzo normale medio nello strato di rivestimento primario indotto da una forza meccanica laterale calcolato mediante l'Analisi ad Elementi Finiti*

É quindi molto importante che i rivestimenti primari con basso modulo e basso T_g siano progettati con cura da presentare un'elevata resistenza alla cavitazione, ottimizzando la struttura di reticolazione. La conoscenza profonda a livello molecolare della resistenza alla cavitazione dei materiali di rivestimento vulcanizzabili ai raggi ultravioletti consente di sviluppare sistemi di rivestimento con prestazioni di micropiegatura migliorate associate ad un'elevata resistenza alla cavitazione per offrire fibre robuste in un'ampia gamma di temperature.

Un altro esempio di situazione ad alto rischio per quanto riguarda la formazione di cavità, è rappresentato dalla fibra caratterizzata da strati di rivestimento più spessi rispetto a quelli tradizionali. Lo sforzo di trazione nello strato primario di una fibra che presenta una struttura di vetro/rivestimento con diametro esterno di 125/350/500 µm, è calcolato e rappresentato graficamente nella *Figura 3*. Il valore dello sforzo di trazione nel rivestimento primario di questa fibra è 2,8 volte maggiore del valore dello sforzo nel rivestimento primario di una fibra rivestita standard con diametro esterno di 245 µm.

Pertanto, le fibre che presentano strati di rivestimento più spessi dovrebbero essere composte da un rivestimento primario ad elevata resistenza alla cavitazione combinato con un rivestimento secondario che consenta un rilassamento degli sforzi più rapido.

2.1.2 Formazione di cavità nel rivestimento primario. La *Figura 4* mostra delle immagini al microscopio di alcune cavità formatesi in una fibra rivestita con diametro esterno di 500 µm, dopo una variazione ciclica della temperatura fra 85ºC e -60ºC. Si possono osservare rotture del rivestimento di forma irregolare di varie dimensioni nello strato di rivestimento primario. La presenza di rotture del rivestimento ben aperte, sotto forma di vuoti, indica l'esistenza di sforzi di trazione triassiale nello strato primario a temperatura ambiente.

Per la teoria della meccanica della frattura, si definisce resistenza alla cavitazione il parametro che rappresenta tale resistenza in un materiale. Quando uno sforzo triassiale raggiunge questo punto critico, il materiale inizia a rompersi e a formare cavità interne. É stato calcolato e provato sperimentalmente che per una gomma ideale, lo sforzo triassiale per allargare un foro sferico molto piccolo è pari a (5/6)E, dove E rappresenta il modulo di Young.[6] Qualsiasi difetto di reticolazione microscopico nel materiale può costituire il punto di rottura iniziale. Ciò significa che, per un rivestimento primario di 1MPa, uno sforzo di trazione triassiale di 0,83MPa può già causare la formazione di cavità secondo il meccanismo di crescita illimitata, qualora il materiale di rivestimento si comporti come una gomma ideale. Con un'appropriata progettazione molecolare della struttura reticolata del rivestimento, si può ottenere l'elevata resistenza alla cavitazione desiderata, con valori che superano in modo significativo il modulo del rivestimento.

In questo tipo di rivestimento primario ad elevata resistenza alla cavitazione, le piccole cavità non cresceranno illimitatamente ed il materiale non si romperà nemmeno nel caso di valori di sforzo di trazione relativamente alti nel rivestimento primario.

2.2 Cavità indotte da sollecitazioni meccaniche

Oltre allo sforzo idrostatico e termico, la formazione di cavità nei rivestimenti primari può essere causata anche da sforzi triassiali anisotropici risultanti da un impatto meccanico nella fibra rivestita. Durante alcuni test di resistenza del rivestimento alla delaminazione, realizzati tirando la fibra attraverso un sistema di riavvolgimento, è stato osservato che il rivestimento si strappa se sottoposto a tensioni elevate.[4]

Quando si applica una forza meccanica esterna ad una fibra rivestita, gli strati di rivestimento si deformano generando un campo di sforzo non uniforme nel materiale di rivestimento. La *Figura 5* illustra schematicamente la deformazione degli strati di rivestimento sottoposti ad una forza laterale F. Poiché il rivestimento secondario è costituito da un materiale molto più rigido del rivestimento primario, lo strato secondario si comporta come un tubo vuoto, sottoposto a pressione laterale, che passa dalla forma tubolare ad una forma ovale, ma senza che lo spessore del rivestimento si deformi. Il rivestimento primario è fissato da entrambi i lati al vetro ed al rivestimento secondario, ed è forzato a deformarsi internamente. Le aree del rivestimento primario lungo la direzione della forza sono compresse, e le aree perpendicolari alla direzione della forza sono sottoposte ad allungamento. Lo sforzo di trazione in queste aree sottoposte ad allungamento presenta una componente triassiale significativa che può causare cavitazione del rivestimento primario qualora lo sforzo superi la resistenza alla cavitazione del rivestimento.

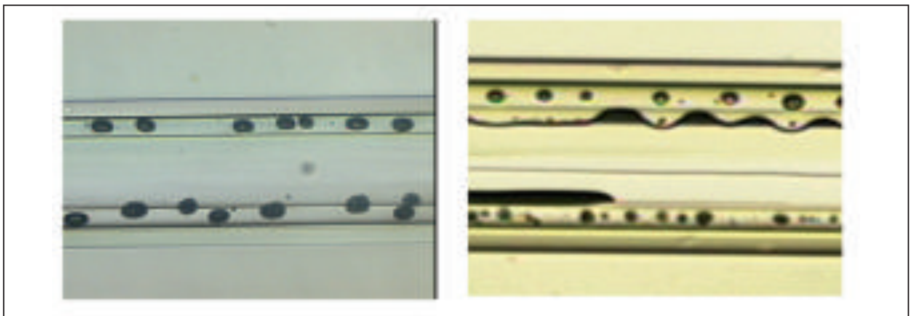
La *Figura 6* evidenzia un campo di sforzo normale medio calcolato mediante l'Analisi ad Elementi Finiti nello strato di rivestimento primario di una fibra con una geometria del diametro esterno di 125/240/410 µm, sottoposta ad una forza laterale simulata.

Il risultato mostra quantitativamente i diversi campi di sforzo che variano dallo sforzo di compressione (-) allo sforzo di trazione (+). Come illustrato dalla *Figura 6*, le aree sottoposte allo sforzo di trazione maggiore sono i punti perpendicolari alla direzione della forza applicata e vicino ad entrambi i lati delle interfacce fra il vetro ed il rivestimento primario, e fra il rivestimento primario ed il rivestimento secondario. Queste sono le aree ove la cavitazione presenta maggiore probabilità di iniziare a manifestarsi quando viene applicata una forza meccanica laterale.

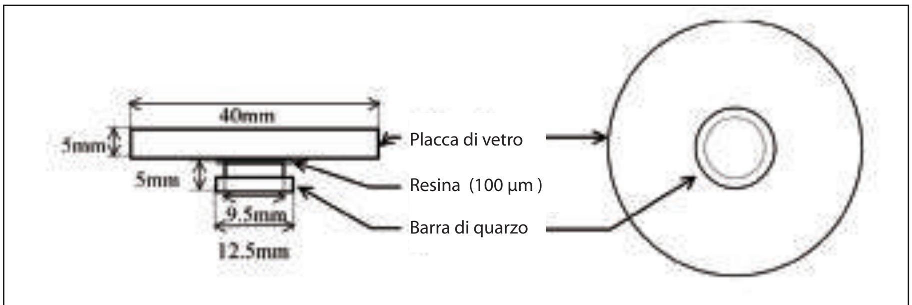
La *Figura 7* mostra qualche esempio di cavità indotte intenzionalmente nel rivestimento primario, causate da impatti laterali meccanici. La forza laterale deve essere dinamica con la velocità, o longitudinalmente (scivolamento) o perpendicolarmente (colpo). Una forza laterale statica può condurre solo a delaminazione. Nella *Figura 7*, l'impatto meccanico è stato creato facendo scivolare una barra metallica del diametro di 1mm longitudinalmente rispetto alla fibra. Con un'apparecchiatura realizzata attaccando la barra di metallo ad un tester di sfregamento automatico, sono state applicate velocità controllate e forze controllate aggiungendo vari pesi alla stessa. Sia la forza, sia la velocità d'impatto influenzano lo sforzo indotto nel rivestimento. A velocità molto basse, si produce delaminazione piuttosto che cavitazione del rivestimento. Ciò può accadere poiché la ridotta area di delaminazione che si forma al contatto iniziale con la forza, si propaga lungo la fibra rilasciando lo sforzo di trazione nel rivestimento. Come illustrato nella *Figura 7*, le cavità e/o la delaminazione possono generarsi da medie ad alte velocità. Le cavità sono localizzate nelle due aree laterali, in accordo con la teoria.

Cavità e delaminazione sono due modalità di errore in concorrenza. Possono essere presenti individualmente o contemporaneamente, secondo le caratteristiche di adesione e la resistenza alla cavitazione

▼ **Figura 7**: *Esempi di formazione di cavità/delaminazione nel rivestimento primario causate da impatti meccanici laterali*



▼ **Figura 8**: *Preparazione del campione per la prova di resistenza alla cavitazione*



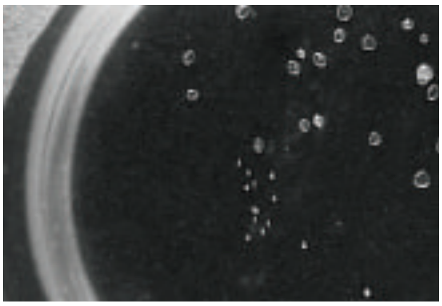
di un certo tipo di rivestimento. Il livello di adesione al vetro del rivestimento primario dovrebbe essere equilibrato rispetto ai requisiti di forza di pelatura. Un'elevata resistenza alla cavitazione del rivestimento primario è sempre preferibile per migliorare la robustezza della fibra rivestita. Tuttavia, si deve tenere conto che qualsiasi fibra rivestita si deteriorerà con il tempo per delaminazione e/o cavitazione se l'impatto meccanico aumenta ad un certo livello. Mentre la tensione termica è caratteristica intrinseca del rivestimento a doppio strato, lo sforzo meccanico è generato da cause esterne. Qualsiasi anomalo impatto ad alta pressione nelle fibre dovrebbe essere evitato durante i processi di trafilatura, bobinatura, prove e movimentazione.

3. Resistenza alla cavitazione dei rivestimenti primari

3.1 Prova di resistenza alla cavitazione

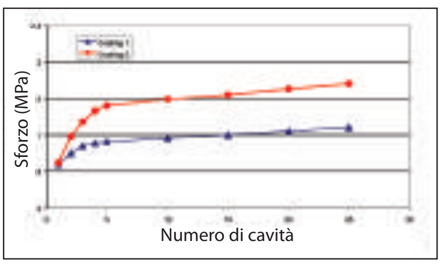
Il concetto fisico di resistenza alla cavitazione come descritto al punto 2.1.2 è il livello critico di sforzo triassiale al quale un materiale inizia a rompersi. Per misurare la resistenza alla cavitazione del materiale di rivestimento è stato sviluppato un metodo di prova utilizzando una pellicola vulcanizzata.

3.1.1 Test di misurazione. In linea di principio, il modo per indurre uno sforzo di trazione triassiale in un materiale di rivestimento è semplice: si aumenta il volume del materiale di rivestimento simile alla gomma.



▲ **Figura 9**: *Esempio di cavità in un campione registrate con videocamera (20x) ad un certo livello di tensione*

▼ **Figura 10**: *Sforzo di trazione in relazione al numero di cavità osservate in due materiali di rivestimento*



Si vulcanizza e si fa aderire il rivestimento fra due superfici piane, che vengono quindi separate in una macchina di prova di trazione. Con l'aumento controllato della distanza fra le due placche, si genera uno sforzo di trazione triassiale nel rivestimento.

Il test deve essere configurato in modo tale che lo spessore del rivestimento sia inferiore al 5% del diametro delle placche. Poiché questo strato di rivestimento molto sottile è delimitato dalle placche, la contrazione laterale del rivestimento è anch'essa limitata. Di conseguenza, si crea uno sforzo di trazione triassiale uniforme nel materiale di rivestimento. Per ottenere valori riproducibili della resistenza alla cavitazione, l'allineamento del test di misurazione è importante, poiché ciò influenza la distribuzione dello sforzo nel campione. Inoltre, per poter studiare la relazione esistente tra il numero di cavità che si creano e il carico applicato in un modo ripetibile, la rigidità del test di misurazione deve essere elevata (cioè la cedevolezza dovrebbe essere bassa) per ridurre al minimo l'immagazzinaggio di energia elastica nel sistema di misura.

3.1.2 Preparazione del campione. La preparazione del campione è illustrata nella Figura 8. Per evitare la delaminazione nel corso dell'esperimento, le superfici delle placche di vetro e le barre di quarzo devono essere preparate adeguatamente. In primo luogo, le superfici sono state irruvidite mediante lucidatura utilizzando una polvere di carburo al silicio. Quindi i pezzi di vetro e quarzo sono stati puliti in un forno a 600ºC per un'ora, e le superfici sono state risciacquate con acetone e lasciate asciugare. Successivamente, le superfici sono state trattate con una soluzione di promotore di adesione a base di silano (è stato utilizzato il Methacryloxypropyltrimethoxysilane A174 di Witco). É stato vulcanizzato lo strato di silano collocando le placche di vetro trattato o quarzo in un forno a 90ºC per 5-10 minuti. Dopo questo pretrattamento, è stata applicata una goccia di resina sulla placca di vetro ed è stata coperta con la barra di quarzo. É stata preparata una pellicola dello spessore di circa 100 μm utilizzando un micrometro a due placche. Il campione è stato vulcanizzato con una dose di 1J/cm^2, utilizzando un sistema di lampade UV-D Fusion F600W.

3.1.3 Misurazione della resistenza alla cavitazione. Il campione è stato posto nell'apparato di prova di trazione (tipo Zwick 1484). La velocità di trazione era pari a 20 μm/min. Quando è stato iniziato l'esperimento, una videocamera, collegata ad un microscopio con un ingrandimento 20x, ha registrato il comportamento della pellicola, mostrando anche i valori dello sforzo applicato alla pellicola. La *Figura 9* mostra un'immagine del campione, catturata dalla videocamera,

Rivesti-mento	E'	σ_{cav}	Rapporto
	(MPa)	(MPa)	σ_{cav}/E'
A	0.37	0.95	2.6
B	0.97	1.21	1.2
C	1.33	2.5	1.9
D	1.2	2.8	2.3
E	0.9	2.1	2.3
F	0.64	1.51	2.4

▲ **Tabella 1**: *Proprietà di resistenza alla cavitazione misurate di rivestimenti primari selezionati*

con numerose cavità già formate. La videoregistrazione ha evidenziato il numero di cavità che appaiono in funzione dello sforzo applicato, come illustrato nella *Figura 10*.

Si è notato che gli sforzi ai quali è stata osservata la prima cavità presentavano tutti valori simili in diversi materiali di rivestimento. Tuttavia, i valori di sforzo hanno iniziato a mostrare evidenti differenze fra diversi rivestimenti al formarsi di un maggior numero di cavità. In questo metodo di prova, è stato selezionato il valore di sforzo corrispondente alla formazione di 10 cavità per rappresentare la resistenza alla cavitazione del rivestimento misurato. Ad esempio, nei rivestimenti indicati nella *Figura 10*, sono stati misurati valori di resistenza alla cavitazione rispettivamente di 0,96 MPa e 1,49 MPa.

3.2 Rivestimenti primari ad elevata resistenza alla cavitazione

Come precedentemente illustrato al punto 2.1.2, la cavitazione del rivestimento si verifica quando lo sforzo di trazione triassiale supera la resistenza alla cavitazione del materiale di rivestimento. Per ridurre il rischio di cavitazione del rivestimento, esistono due approcci efficaci: 1) ridurre il livello di tensione termica, e/o 2) aumentare la resistenza alla cavitazione nel rivestimento. Il livello di tensione termica è influenzato da entrambi gli strati di rivestimento, fra i quali il rivestimento secondario gioca un ruolo molto più importante rispetto al rivestimento primario.

D'altro canto, la resistenza alla cavitazione è una proprietà intrinseca del rivestimento primario. Un rivestimento primario ad elevata resistenza alla cavitazione è sempre auspicabile per garantire la robustezza della fibra rivestita, in condizioni di tensione termica e di qualunque potenziale sollecitazione meccanica che si verifichi durante l'elaborazione, la manipolazione e l'installazione in campo.

La *Tabella 1* mostra numerose esempi di rivestimenti primari con diversi comportamenti di resistenza alla cavitazione.

La resistenza alla cavitazione (σ_{cav}) è stata misurata utilizzando il metodo di prova descritto al punto 3.1. Sono inoltre indicati i valori del modulo di immagazzinaggio E' a temperatura ambiente da DMA ed i rapporti σ_{cav}/E'.

Come discusso al punto 2.1.2, la resistenza alla cavitazione di una gomma ideale dovrebbe essere pari a (5/6)E. Nella *Tabella 1*, ciascun rivestimento presenta una resistenza alla cavitazione superiore a quella del modulo corrispondente, il che indica che i rivestimenti non corrispondono ad una perfetta elasticità. Il modulo corrispondente alla densità di reticolazione del rivestimento, gioca ancora un ruolo importante nel determinare la resistenza alla cavitazione di un materiale di rivestimento.

Tuttavia, con una struttura di reticolazione polimerica di densità molecolare adeguata, è possibile ottenere un'elevata resistenza alla cavitazione, indipendentemente dal modulo di rivestimento. In altre parole, si possono realizzare rivestimenti ideali, morbidi ma resistenti, caratterizzati da un elevato rapporto fra resistenza alla cavitazione e modulo. Un modulo ridotto permette di ottenere migliori prestazioni di micropiegatura.

Nella *Tabella 1*, il Rivestimento A presenta il modulo più basso; tuttavia, anche la corrispondente resistenza alla cavitazione è la più bassa (<1MPa). In effetti, la fibra con questo rivestimento ha presentato cavità evidenti risultanti dal processo di raffreddamento dopo la trafilatura della fibra. Il Rivestimento B, con resistenza alla cavitazione pari a 1,21MPa, è considerato sufficientemente resistente per sopportare la tensione termica durante il raffreddamento della fibra. Non sono state osservate cavità nella fibra con il Rivestimento B. Anche nell'analisi teorica, il livello di resistenza alla cavitazione è sufficientemente più elevato rispetto alla tensione termica calcolata di ~0,8MPa nel rivestimento primario. Tuttavia, il rapporto σ_{cav}/E' del Rivestimento B è pari a solo 1,2, il più basso fra tutti i rivestimenti. Questo tipo di rivestimento è considerato adeguato per sopportare situazioni di sforzo normali, ma non realizza interamente il proprio potenziale da convertirsi in un materiale di rivestimento altamente robusto.

D'altro canto, i Rivestimenti C, D, E ed F evidenziano le proprietà di elevata resistenza alla cavitazione desiderate. Il modulo del Rivestimento C o del Rivestimento D si colloca al tipico livello dei rivestimenti primari commerciali. Tuttavia, la resistenza alla cavitazione di tali rivestimenti è stata concepita per presentare un valore eccezionalmente alto mediante una struttura molecolare di reticolazione ottimizzata.

Il Rivestimento E presenta un valore del modulo medio-basso (combinato con basso T_g), che è stato sviluppato per essere applicato sia nelle fibre monomodali che in quelle multimodali. La resistenza alla cavitazione di questo rivestimento presenta ancora un valore molto elevato (2,1Mpa) e consente un elevato rapporto σ_{cav}/E' (2.3). Il Rivestimento F offre una resistenza alla micropiegatura eccellente attribuita al modulo ultra-basso (e T_g basso). Contemporaneamente, si è anche ottenuto un livello di resistenza alla cavitazione sufficientemente elevato (1,51MPa) con il rapporto σ_{cav}/E' corrispondente a 2,4. Per rivestimenti ultramorbidi come in questo caso, devono essere prese particolari precauzioni per assicurare alla struttura di rivestimento buone prestazioni di resistenza alla cavitazione . Altrimenti, lo sviluppo di cavitazione nel rivestimento e il deterioramento delle prestazioni di attenuazione della fibra costituiscono un rischio possibile.

Le situazioni come il Rivestimento A, in cui le cavità erano già presenti nella fibra dopo la trafilatura, possono essere facilmente identificate. Il rischio non è evidente in situazioni in cui le cavità nel rivestimento possono generarsi gradualmente e causare un aumento dell'attenuazione in campo, quando la fibra è sottoposta a cicli di temperatura ambiente oppure resta in condizioni di bassa temperatura per lunghi periodi di tempo, come ad esempio nel caso dei cavi sottomarini. Un sistema di rivestimento di alta qualità, progettato accuratamente, non solo contribuisce al conseguimento di prestazioni ottimali delle fibre, ma offre anche una maggiore affidabilità delle fibre ottiche a lungo termine.

4. Conclusioni

La cavitazione dei rivestimenti primari è stata studiata estesamente come possibile modalità di guasto nelle fibre ottiche a doppio rivestimento. La cavitazione del rivestimento è causata da uno sforzo di trazione triassiale che può essere indotto da tensioni termiche interne o da impatti meccanici esterni.

Il rivestimento è soggetto a rottura coesiva quando lo sforzo di trazione triassiale supera la resistenza alla cavitazione del rivestimento. É stato sviluppato un metodo di prova per valutare quantitativamente la resistenza alla cavitazione di un materiale di rivestimento.

La comprensione del meccanismo di cavitazione e lo studio approfondito della resistenza alla cavitazione del rivestimento hanno consentito di progettare materiali di rivestimento con una elevata resistenza alla cavitazione per conferire robustezza alla fibra rivestita quando sottoposta a potenziali tensioni termiche e a sollecitazioni meccaniche. Si sono ottenuti elevati rapporti fra resistenza alla cavitazione e modulo, che consentono di realizzare rivestimenti primari a basso modulo/basso T_g, di migliorare la protezione contro le micropiegature ed offrire un'elevata resistenza alla cavitazione. ■

5. Riferimenti bibliografici

[1] D Gloge, 'Optical-fiber Packaging and Its Influence on Fiber Straightness and Loss', The Bell System Technical J, 54(2), 245-262 (1975)

[2] W W King, 'Thermally Induced Stresses in an Optical - Fiber Coating', J of Lightwave Technology, 9(8), 952-953 (1991)

[3] W W King and C J Aloisio, 'Thermomechanical Mechanism for Delaminations of Polymer Coatings from Optical Fibers', J of Electronic Packaging, 119, 133-137 (1997)

[4] P L Tabaddor, C J Aloisio, C H Plagianis, C R Taylor, V Kuck and P G Simpkins, 'Mechanics of Delamination Resistance Testing', International Wire and Cable Symposium Proceedings, p 725 (1998)

[5] C J Aloisio, W W King and R C Moore, 'A Viscoelastic Analysis of Thermally Induced Residual Stresses in Dual Coated Optical Fibers', International Wire and Cable Symposium Proceedings, p 139 (1995)

[6] A N Gent and P B Lindley, 'Internal Rupture of Bonded Rubber Cylinders in Tension', Proc Roy Soc A, 249, 1958

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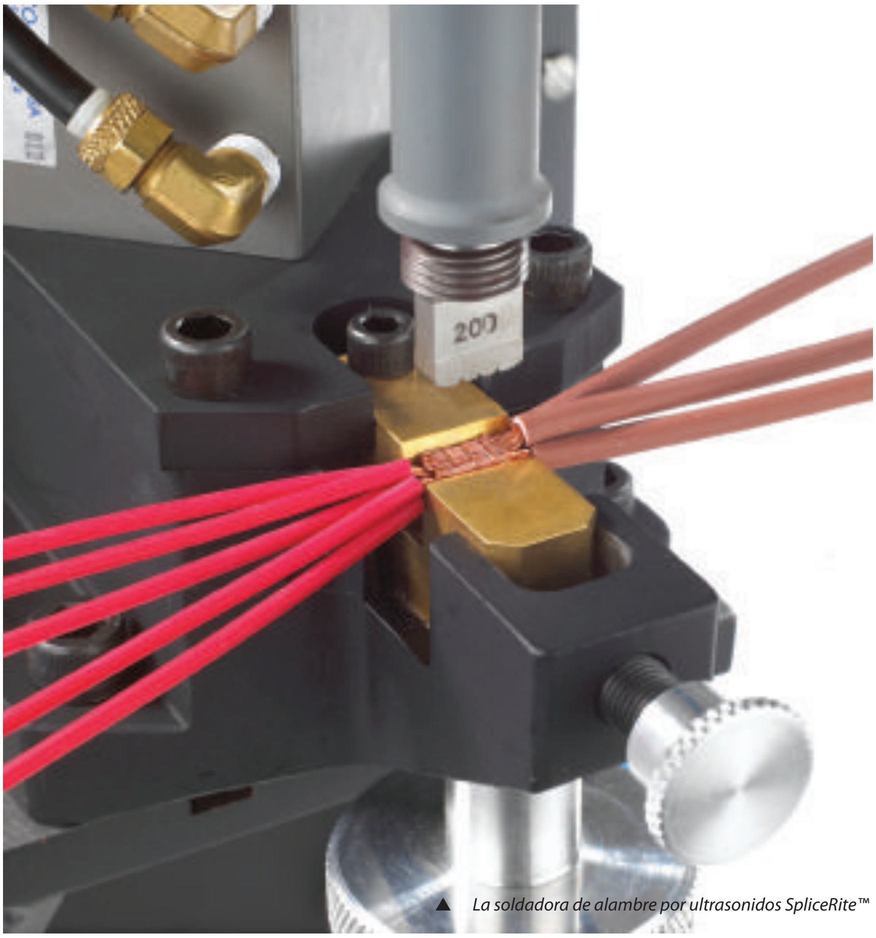
Ultrasonidos en la feria

La soldadora de alambre por ultrasonidos SpliceRite™ ha sido centro de atención en el stand de Sonobond Ultrasonics durante el Electrical Wire Processing Technology Expo de mayo en Milwaukee, Estados Unidos.

SpliceRite ha sido diseñada para realizar soldaduras metalúrgicas sólidas utilizando una caída de tensión lo más baja posible y reduciendo al mínimo el consumo de energía. La nueva soldadora evita tener que sujetar con grapas, estañar, engarzar o soldar por inmersión las piezas, permitiendo soldar rápidamente fajos de alambres sin producir arcos, chispas, humos o fundir los alambres. Además, puede soldar también alambres estañados o muy oxidados.

La soldadora está equipada con un controlador con microprocesador que puede almacenar y recuperar hasta 250 trabajos, produciendo soldaduras en base a altura, energía o tiempo, y está disponible con potencias de 1500 y 2500 vatios.

Todas las soldadoras de metal Sonobond, incluida la soldadora de alambre por ultrasonidos SpliceRite™, presentan puntas de bloqueo cónicas de acero para herramientas tratado en caliente. Estas puntas pueden durar hasta 300.000 soldaduras y permiten cambiar las herramientas rápidamente. Las máquinas de Sonobond presentan también la ventaja de ser fáciles de usar sin necesidad de gran capacitación.



▲ *La soldadora de alambre por ultrasonidos SpliceRite™*

Sonobond Ultrasonics – Estados Unidos
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Cable HVDC para proveer un enlace entre Finlandia y Suecia

Nexans se ha adjudicado un contrato de aproximadamente 150 millones de euros de Fingrid Oyj, operadora de sistemas de suministro eléctrico de Finlandia, y Svenska Kraftnät. El contrato comprende la fabricación e instalación de un cable de alimentación submarino HVDC (High Voltage Direct Current) para Fenno-Skan 2, la nueva línea de interconexión eléctrica entre Finlandia y Suecia.

Nexans suministrará aproximadamente 200 km de cable MIND (Mass Impregnated Non-Draining) especial, con aislamiento de papel impregnado en aceite, tanto para los elementos submarinos como para los de tierra de la línea de interconexión Fenno-Skan 2. Con una sección transversal de 2.000mm^2 de cobre, será el cable HVDC de mayor capacidad fabricado hasta ahora por Nexans.

El proyecto HVDC Fenno-Skan 2 establecerá una nueva conexión submarina de 800MW, 500KV para el suministro de electricidad entre el sur de Finlandia y Suecia, siguiendo un recorrido de 200km a través del Golfo de Botnia. Tendrá una configuración bipolar con el enlace Fenno-Skan existente de 550MW, 400kV.

El cable será suministrado en dos tramos continuos de aproximadamente 100 km, y por lo tanto, requerirá un solo punto de unión costa afuera.

Nexans – Francia
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La 700a es un peso pesado

▲ *La última cableadora de tambor es el modelo más grande de su categoría*

El Grupo Gauder se complace en anunciar un importante contrato para una línea de cableado de tambor que será suministrada a Saudi Cable Company. Esta última línea de cableado de tambor es la 700a suministrada por Gauder a la industria del cable y será la más grande de su categoría.

La línea, que producirá cable de alimentación de alta tensión, será diseñada para contener un carrete de enrollado de 4 metros y 30 toneladas de peso.

Saudi Cable, importante fabricante de una gama completa de cables en Medio Oriente, es cliente del grupo Pourtier – Gauder desde hace mucho tiempo.

Pourtier - Gauder Group – Francia
Fax: +33 1 64 26 61 10
Email: sales.pourtier@gaudergroup.com
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Nueva inversión de un productor de carretes

La compañía Madem, que tiene ya plantas de producción en Brasil, España y Estados Unidos, abrirá este año una planta nueva en Bahrain. Con una producción de aproximadamente 500 contenedores de carretes de madera desmontables al mes, la compañía comercializa sus productos en más de 40 países a importantes productores de alambre y cable.

En 2008, Madem invertirá 5 millones de dólares americanos en una planta de madera contrachapada de alta tecnología, que producirá 70 contenedores de bridas de madera contrachapada al mes.

"Los clientes de todo el mundo buscan ideas nuevas; Madem ofrece un nuevo kit de embalaje, un nuevo sistema de bloqueo con casquillo y la posibilidad de efectuar el ensamblaje in situ. Madem trabaja en estrecho contacto con sus clientes, sugiriendo cambios de especificaciones que permitirá reducir costes" afirma el director de ventas del grupo Madem, Leandro Mazzoccato.

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▲ *Izquierda: Leandro Mazzoccato, director de ventas del Grupo Madem; Centro: Roger Santasusana, director de Euromadem Spain SL; Derecha: Gino F Mazzoccato, director y presidente del Grupo Madem*

Revestimientos primarios de alta resistencia a la cavitación para fibras ópticas

Por [1]Huimin Cao, DSM Desotech Inc, Elgin, Illinois, EE UU,
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Resumen

Todos sabemos muy bien que, en fibras ópticas de doble capa de revestimiento, el sistema formado por un revestimiento primario blando combinado con un revestimiento secundario duro constituye una buena protección contra las micro-curvaturas. Sin embargo, este diseño de doble capa genera también tensiones térmicas en el sistema de revestimiento por la diferencia de dilatación y contracción térmica entre las dos capas de revestimiento. Sometido a esfuerzo de tracción triaxial, el revestimiento primario blando puede sufrir roturas internas.

La cavitación es decir, la formación de cavidades en el revestimiento primario, es un defecto que puede ser perjudicial para las prestaciones de atenuación de la fibra. En este estudio se analiza el mecanismo de cavitación del revestimiento examinando los diferentes tipos de fuerzas que determinan el fenómeno. La resistencia a la cavitación del revestimiento primario es presentada como una propiedad clave para obtener un sistema de revestimiento sólido de altas prestaciones, con las características requeridas de baja sensibilidad a las microcurvaturas y de alta resistencia a la cavitación.

1. Introducción

Una de las ventajas principales del diseño de revestimiento de doble capa para fibras ópticas es que ofrece mayor protección contra las microcurvaturas respecto al revestimiento de una sola capa. El sistema formado por un revestimiento primario blando, que actúa como capa de amortiguación, combinado con un revestimiento secundario duro, que actúa como capa de protección, ofrece una resistencia al doblado ideal para las fibras ópticas que permite soportar los esfuerzos externos típicos de las instalaciones de cables.

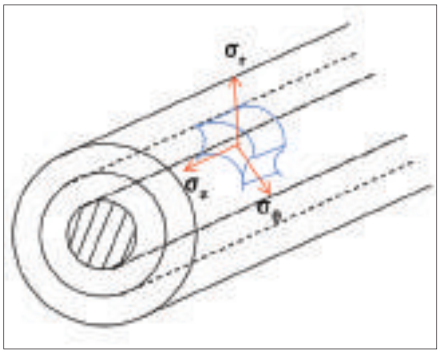
[1]La tensión térmica en el sistema de revestimiento de doble capa es inevitable, debido a las diferentes dilataciones y contracciones térmicas del vidrio, del revestimiento primario y del revestimiento secundario. Las fibras estándares mono-modo o multimodo con revestimientos de doble capa de alta calidad no presentan un aumento de atenuación fuera de las especificaciones durante la variación cíclica de la tempe- ratura, porque la tensión térmica es distribuida uniformemente alrededor de la fibra.

Sin embargo, en el caso de fibras con una cierta cantidad de defectos en el sistema de revestimiento, especialmente en el revestimiento primario, se puede observar un alto nivel de atenuación a temperatura ambiente, debido a pérdidas por microcurvatura, y la atenuación puede aumentar drásticamente al bajar de la temperatura a causa de la tensión térmica no uniforme transmitida por los defectos. Los defectos potenciales en el revestimiento primario incluyen partículas y geles, formación de cristales, irregularidades geométricas, delaminación y cavidades.

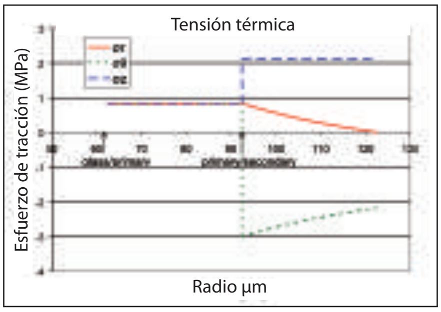
Tanto la delaminación como las cavidades están asociadas a esfuerzos de tracción en el revestimiento primario inducidos térmicamente o mecánicamente.

Aunque la delaminación desde el vidrio del revestimiento primario ha sido bien analizada,[3, 4] la posibilidad de formación de cavidades debida a la rotura interna del revestimiento primario no ha sido orientada debidamente.

Aunque los revestimientos primarios suelen tener un alto valor de alargamiento cuando están sometidos a esfuerzos de tracción uniaxial, el material de revestimiento puede sufrir roturas internas por esfuerzos de tracción triaxial. En los últimos años DSM Desotech ha llevado a cabo un trabajo de investigación detallado sobre este modo de rotura.



▲ **Figura 1**: *Tensiones térmicas triaxiales en un sistema de revestimiento de doble capa*



▲ **Figura 2**: *Tensiones térmicas calculadas en un sistema de revestimiento de doble capa*

Se ha estudiado el mecanismo de formación de cavidades en el revestimiento primario y, a través de un diseño molecular apropiado de la estructura de reticulación de los revestimientos, se ha podido obtener revestimientos primarios de alta resistencia a la cavitación.

2. Mecanismo de formación de cavidades en la capa de revestimiento primario

La formación de cavidades en el revestimiento primario es debida al esfuerzo de tracción triaxial que, para valores elevados, puede exceder la resistencia a la cavitación del revestimiento y causar la rotura cohesiva de la estructura del revestimiento. Se pueden tener dos tipos de esfuerzos triaxiales en el revestimiento, de orígenes diferentes: el esfuerzo puede ser inducido térmicamente por la variación de temperatura, o inducido por fuerzas mecánicas externas.

2.1 Cavidades inducidas por tensión térmica

*2.1.1 Tensiones térmicas en sistemas de revestimiento de doble capa*Se ha comprobado que en un sistema de fibra revestida[2-5] hay tensiones térmicas. El esfuerzo triaxial en el revestimiento primario, como se ilustra en la *Figura 1*, es causado por la diferencia de coeficientes de dilatación térmica del vidrio, del revestimiento primario y del revestimiento secundario.

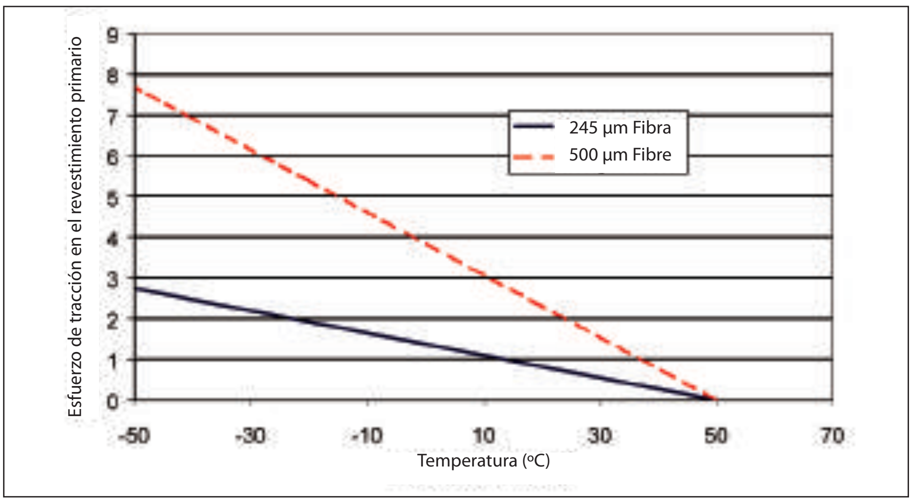
En base a la teoría de la mecánica de materiales, es posible calcular el esfuerzo triaxial, que consiste en las componentes de esfuerzo radial σ_r, esfuerzo tangencial σ_θ y esfuerzo axial σ_z. La *Figura 2* muestra la distribución del esfuerzo calculada en un típico sistema de doble capa, donde el espesor de cada capa de revestimiento es 30 µm, el módulo de Young E_1=1MPa, E_2=1GPa, los coeficientes de dilatación térmica lineal $\alpha_1=3x10^{-4}/K$, $\alpha_2=1x10^{-4}/K$ y las relaciones de Poisson ν_1=0,5, ν_2=0,4. El sistema es sometido a un cambio de temperatura de -30ºC, para simular la tensión en el sistema de revestimiento, cuando la fibra revestida se enfría desde la temperatura del proceso de estirado hasta la temperatura ambiente.

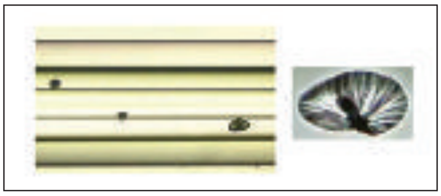
Aunque la temperatura en el revestimiento durante el curado con UV pueda alcanzar valores de hasta 100ºC, la tensión térmica inicia a aumentar solamente cuando la temperatura cae por debajo de la temperatura de transición del vítrea (T_g) del revestimiento secundario (~50ºC).

Las tres componentes de la tensión en el revestimiento primario son de tracción, y están todas al mismo nivel, como se ilustra en la *Figura 2*. Esto significa que la tensión en el revestimiento primario a temperatura ambiente es un esfuerzo hidrostático: aumenta al disminuir más la temperatura, hasta alcanzar la T_g del revestimiento primario (normalmente ~-20ºC), cuando el revestimiento primario pasa también a estado vítreo. El esfuerzo de tracción calculado en el revestimiento primario es ~0,8MPa a temperatura ambiente, como se ilustra en la *Figura 2*. Debido a la propiedad viscoelástica del revestimiento secundario, el nivel de esfuerzo efectivo debería ser más bajo que el esfuerzo calculado, y disminuir con el tiempo mientras que el revestimiento secundario experimenta relajación de esfuerzos a temperaturas "sub-T_g".[5]

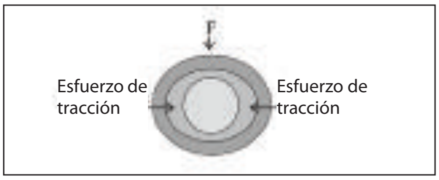
Aunque el riesgo de cavitación del revestimiento debida a tensión térmica es bajo en las fibras de doble revestimiento convencionales, se deben evaluar con atención ciertos tipos de sistemas de revestimiento como los examinados a continuación. La nueva tendencia en el desarrollo de los revestimientos primarios es reducir más su módulo y su T_g para ofrecer mejor protección de amortiguación contra las microcurvaturas en una amplia gama de temperaturas. En este tipo de sistema de revestimiento, el esfuerzo de tracción continúa aumentando cuando la temperatura inicia a disminuir, pero el revestimiento primario permanece en estado gomoso. Como se ilustra en la *Figura 3*, el esfuerzo de tracción calculado aumenta linealmente al disminuir la temperatura. La relajación de esfuerzos en el revestimiento secundario es también más lenta a temperaturas bajas. Además del riesgo de altas tensiones térmicas, un revestimiento primario con módulo bajo puede ser también más propenso a cavitación, debido a su más baja densidad de reticulación.

▼ **Figura 3**: Tensión térmica calculada frente a temperatura para una fibra normal de 250 µm (suponiendo que el esfuerzo inicia a generarse a una temperatura del revestimiento secundario inferior a Tg ~50°C)

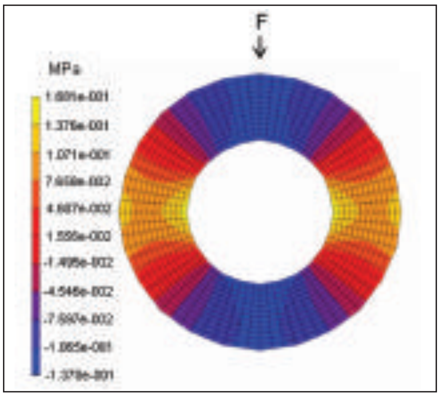




▲ **Figura 4**: *Cavidades en la capa de revestimiento primario causadas por ciclos de temperatura en una fibra de 500 µm (izquierda) 40x (derecha) 200x*



▲ **Figura 5**: *Esquema de los esfuerzos de tracción localizados en el revestimiento primario causados por una fuerza mecánica lateral*



▲ **Figura 6**: *Esfuerzo normal medio en la capa de revestimiento primario inducido por una fuerza mecánica lateral calculado con el análisis de elementos finitos*

Por lo tanto, es muy importante que los revestimientos primarios con bajo módulo y baja T_g sean diseñados con atención para tener una alta resistencia a la cavitación optimizando la estructura de reticulación. El conocimiento detallado a nivel molecular de la resistencia a la cavitación de los materiales de revestimiento curado con UV permite desarrollar sistemas de revestimiento con prestaciones de microcurvatura mejoradas además de una alta resistencia a la cavitación, para asegurar fibras robustas en una amplia gama de temperaturas.

Otro ejemplo de situación de alto riesgo por lo que se refiere a la formación de cavidades, es el caso de una fibra con capas de revestimiento más espesas que las convencionales. El esfuerzo de tracción en la capa primaria de una fibra que presenta una estructura vidrio/revestimiento de 125/350/500 µm de diámetro externo, está calculado y también ilustrado gráficamente en la *Figura 3*.

El valor del esfuerzo de tracción en el revestimiento primario de esta fibra es 2,8 veces mayor que el esfuerzo en el revestimiento primario de una fibra revestida estándar de 245 µm de diámetro externo. Por lo tanto, las fibras que tienen capas de revestimiento más espesas deberían estar compuestas por un revestimiento primario de alta resistencia a la cavitación combinado con un revestimiento secundario que permita relajar los esfuerzos más rápido.

2.1.2 Formación de cavidades en el revestimiento primario. La *Figura 4* muestra imágenes de microscopio de algunas cavidades que se han formado en una fibra revestida de 500 µm de diámetro externo, después de ciclos de temperatura de entre 85ºC y -60ºC. Se pueden observar roturas del revestimiento de varias dimensiones en la capa de revestimiento primario. La presencia de roturas del revestimiento expuestas y formando huecos indica la existencia de esfuerzos de tracción triaxial en la capa primaria a temperatura ambiente.

Según la teoría de la mecánica de fractura, se define resistencia a la cavitación el parámetro que representa dicha resistencia. Cuando un esfuerzo triaxial alcanza este punto crítico, el material empieza a romperse y a formar cavidades internas. Se ha calculado y probado experimentalmente que en el caso de un caucho ideal, el esfuerzo triaxial para agrandar sin límite un agujero redondo muy pequeño es (5/6 E), donde E representa el módulo de Young.

[6]Cualquier defecto microscópico de reticulación en el material puede constituir el punto de rotura inicial. Esto significa que, para un revestimiento primario de 1MPa, un esfuerzo de tracción triaxial de 0,83MPa puede ya causar la formación de cavidades según el mecanismo de crecimiento ilimitado, si el material de revestimiento se comporta como un caucho ideal. Con un diseño molecular adecuado de la estructura reticulada del revestimiento, se puede obtener la alta resistencia a la cavitación deseada, con valores que exceden significativamente el módulo del revestimiento.

En este tipo de revestimientos primarios de alta resistencia a la cavitación, las pequeñas cavidades no crecerán ilimitadamente y el material no se romperá incluso cuando está sometido a esfuerzos de tracción relativamente altos en el revestimiento primario.

2.2 Cavidades inducidas por tensión térmica

Además del esfuerzo hidrostático inducido térmicamente, la formación de cavidades en los revestimientos primarios puede ser causada también por esfuerzos triaxiales anisotrópicos consecuencia de un impacto mecánico en la fibra revestida.

Durante pruebas de resistencia del revestimiento a la delaminación, realizadas tirando la fibra a través un equipo de rebobinado, se ha observado que el revestimiento se desgarra cuando es sometido a tensiones elevadas.[4]

Cuando se aplica una fuerza mecánica externa a una fibra revestida, las capas de reve stimiento se deforman y generan un campo de esfuerzo no uniforme en el material de revestimiento. La *Figura 5* ilustra esquemáticamente la deformación de las capas de revestimiento bajo una fuerza lateral F Dado que el revestimiento secundario es un material mucho más duro que el revestimiento primario, la capa secundaria se comporta como un tubo vacío que, presionado lateralmente, cambia su forma tubular en ovalada sin sufrir deformaciones en el espesor del revestimiento. El revestimiento primario es unido por ambos lados al vidrio y al revestimiento secundario, y es forzado a deformarse internamente. Las áreas del revestimiento primario a lo largo de la dirección de la fuerza son comprimidas, y las áreas perpendiculares a la dirección de la fuerza son estiradas. El esfuerzo de tracción en estas áreas estiradas presenta una componente triaxial significativa que puede causar cavitación del revestimiento primario, si el esfuerzo excede la resistencia a la cavitación del revestimiento.

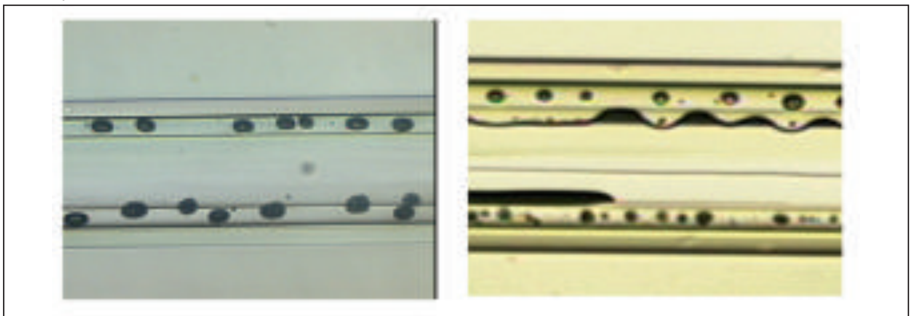
La *Figura 6* muestra un campo de esfuerzo normal medio calculado con el análisis de los elementos finitos en la capa de revestimiento primario de una fibra con una configuración de 125/240/410 µm de diámetro externo, sometida a una fuerza lateral simulada.

El resultado muestra cuantitativamente los diferentes campos de esfuerzo que varían de esfuerzo de compresión (-) a esfuerzo de tracción (+). Como se ilustra en la *Figura 6*, las áreas sometidas al esfuerzo de tracción más alto son los puntos perpendiculares a la dirección de la fuerza aplicada y cerca de ambos lados de las interfaces entre el vidrio y el revestimiento primario, y entre el revestimiento primario y el secundario. Estas son las áreas donde la cavitación tiene mayores probabilidades de iniciar cuando se aplica una fuerza mecánica lateral.

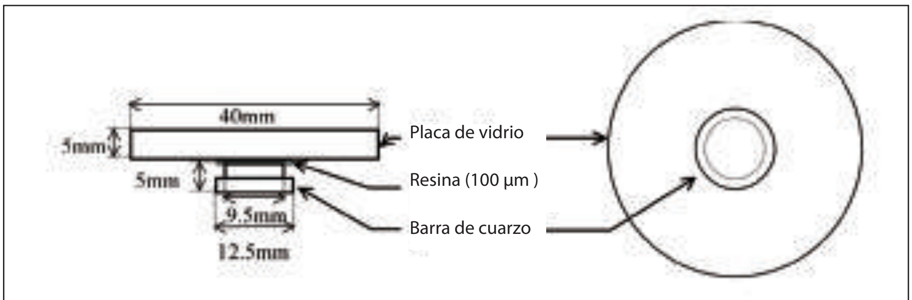
La *Figura 7* muestra algunos ejemplos de cavidades inducidas intencionalmente en el revestimiento primario, causadas por impactos laterales mecánicos. La fuerza lateral debe ser dinámica con velocidad ya sea longitudinalmente (deslizamiento) ya sea perpendicularmente a la fibra (golpe). Una fuerza lateral estática puede dar lugar solamente a delaminación. En la , el impacto mecánico ha sido creado deslizando una barra de metal de 1mm de diámetro longitudinalmente respecto a la fibra. Con un dispositivo de prueba preparado acoplando la barra de metal a un probador de frotamiento automático se han aplicado velocidades y fuerzas controladas añadiendo varios pesos al dispositivo. Tanto la fuerza como la velocidad de impacto afectan al esfuerzo inducido en el revestimiento. A velocidades muy bajas, se produce delaminación en lugar de cavitación en el revestimiento. Esto puede ser debido a que la pequeña área de delaminación que se forma al entrar en contacto con la fuerza se propaga a lo largo de la fibra y relaja el esfuerzo de tracción en el revestimiento. De velocidades medianas a altas, las cavidades y/o la delaminación pueden producirse como se indica en la *Figura 7*. Las cavidades están localizadas en las dos áreas laterales, de acuerdo con la teoría.

Cavidades y delaminación son dos modos de rotura concurrentes.

▼ **Figura 7**: Ejemplos de formación de cavidades/delaminación en el revestimiento primario causados por impactos mecánicos laterales



▼ **Figura 8**: Preparación de la muestra para la prueba de resistencia a la cavitación



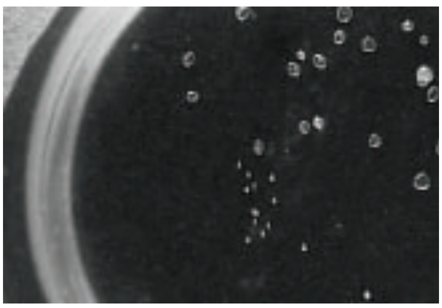
Pueden estar presentes individual o simultáneamente, según las características de adhesión y la resistencia a la cavitación de un cierto revestimiento. El nivel de adhesión al vidrio del revestimiento primario debe ser equilibrado según los requisitos de fuerza de pelado. Siempre conviene tener un revestimiento primario con resistencia alta a la cavitación para mejorar la solidez de la fibra revestida. Sin embargo, se debe tener en cuenta que cualquier fibra se romperá con el tiempo por delaminación y/o cavitación, cuando se aumente el impacto mecánico a un cierto nivel. A pesar de que la tensión térmica es propia del diseño de doble revestimiento, el esfuerzo mecánico es generado por causas externas. Todo impacto de alta presión anómalo en las fibras debería ser evitado durante los procesos de trefilado, devanado, prueba o manejo.

3. Resistencia a la cavitación de los revestimientos primarios

3.1 Prueba de resistencia a la cavitación

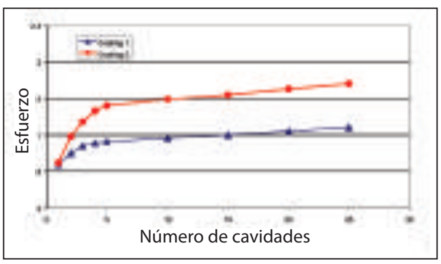
El concepto físico de resistencia a la cavitación, como se ha descrito en el apartado 2.1.2, es el nivel crítico de esfuerzo triaxial a partir del cual un material empieza a romperse. Se ha desarrollado un método de prueba para medir la resistencia a la cavitación del material de revestimiento usando una película curada.

3.1.1 Configuración de la prueba de medición Básicamente, el modo de inducir un esfuerzo de tracción triaxial en un material de revestimiento es simple: se aumenta el volumen del material de revestimiento similar al caucho. Se cura y se pega el revestimiento entre dos superficies planas, que luego se separan con un equipo de prueba de tracción. Con el aumento controlado de la distancia entre las dos placas, se genera un esfuerzo de tracción triaxial en el revestimiento.



▲ **Figura 9**: *Ejemplo de cavidades en una muestra grabadas con la cámara de vídeo (20x) a determinados valores de esfuerzo*

▼ **Figura 10**: *Esfuerzo de tracción en relación con el número de cavidades observadas en dos materiales de revestimiento*



La prueba debe ser configurada de manera que el espesor del revestimiento sea inferior al 5% del diámetro de las placas. Dado que esta capa de revestimiento tan fina está contenida por las placas, la contracción lateral del revestimiento también es limitada. Por consiguiente, se crea un esfuerzo de tracción triaxial uniforme en el material de revestimiento. Para obtener valores de resistencia a la cavitación repetibles, la alineación del sistema de prueba es importante, dado que una alineación incorrecta influye sobre la distribución del esfuerzo en la muestra. Además, para poder estudiar la relación que existe entre el número de cavidades que se crean y la carga aplicada de manera repetible, la configuración de prueba debe tener una rigidez elevada (es decir, su capacidad de flexionarse bajo la aplicación de una fuerza debe ser baja) para reducir al mínimo el almacenamiento de energía elástica en el sistema de medición.

3.1.2 Preparación de la muestra. La preparación de la muestra está ilustrada en la Figura 8. Para evitar la delaminación durante el experimento, las superficies de las placas de vidrio y las barras de cuarzo deben ser preparadas correctamente.

Primero, se ha dado rugosidad a las superficies usando un polvo de carborundo. Luego, se han limpiado las piezas de vidrio y cuarzo en un horno a 600ºC por una hora, se han enjuagado las superficies con acetona y se han dejado secar. Más tarde, se han tratado las superficies con una solución de promotor de adhesión a base de silano (se ha usado Methacryloxypropyltrimethoxysilane A174 de Witco). Se ha curado la capa de silano poniendo las placas de vidrio tratado o cuarzo en un horno a 90ºC por 5-10 minutos. Después de este tratamiento previo, en la placa de vidrio se ha versado una gota de resina, que ha sido cubierta con la barra de cuarzo. Se ha preparado una película de unos 100 µm de espesor usando un micrómetro de dos placas. La muestra ha sido curada con una cantidad de 1J/cm^2, usando un sistema de lámpara UV-D Fusion F600W.

3.1.3 Medición de la resistencia a la cavitación. La muestra ha sido puesta en el equipo de prueba de tracción (tipo Zwick 1484). La velocidad de tiro era 20 µm/min. Cuando se inició el experi-mento, una cámara de vídeo, acoplada a un microscopio con ampliación 20x, registró el comportamiento de la película, mostrando también los valores del esfuerzo aplicado a la película. La *Figura 9* muestra una imagen de la muestra, tomada por la cámara de vídeo, con muchas cavidades ya formadas. La grabación permitió trazar el número de cavidades que aparecen en función del esfuerzo aplicado, como se ilustra en la *Figura 10*.

Revesti-miento	E'	σ_{cav}	Relación
	(MPa)	(MPa)	σ_{cav} /E'
A	0.37	0.95	2.6
B	0.97	1.21	1.2
C	1.33	2.5	1.9
D	1.2	2.8	2.3
E	0.9	2.1	2.3
F	0.64	1.51	2.4

▲ **Tabla 1**: *Propiedades de resistencia a la cavitación medidas de revestimientos primarios seleccionados*

Se observó que los esfuerzos que generaban la primera cavidad tenían valores similares en diferentes materiales de revestimiento. Sin embargo, los valores de esfuerzo empezaron a mostrar claras diferencias entre los distintos revestimientos al formarse un número de cavidades mayor. En este método de prueba se ha seleccionado el valor de esfuerzo correspondiente a la formación de 10 cavidades para representar la resistencia a la cavitación del revestimiento medido. Por ejemplo, en los revestimientos indicados en la *Figura 10* se han medido valores de resistencia a la cavitación de 0,96MPa y 1,49Mpa respectivamente.

3.2 Revestimientos primarios con alta resistencia a la cavitación.

Como se ha ilustrado antes en el apartado 2.1.2, la cavitación del revestimiento se produce cuando el esfuerzo de tracción triaxial excede la resistencia a la cavitación del material de revestimiento. Para reducir el riesgo de cavitación del revestimiento, los dos métodos eficaces son 1) reducir el nivel de tensión térmica, y/o 2) aumentar la resistencia a la cavitación. El nivel de tensión térmica es influenciado por las dos capas de revestimiento, donde el revestimiento secundario juega un papel más importante que el revestimiento primario. Por otro lado, la resistencia a la cavitación es una característica propia del revestimiento primario. Un revestimiento primario con alta resistencia a la cavitación representa siempre un factor fundamental para asegurar la robustez de la fibra revestida en caso de tensión térmica y posibles esfuerzos mecánicos durante su elaboración, manejo e instalación en campo.

La *Tabla 1* muestra varios ejemplos de revestimientos primarios con diferentes comportamientos de resistencia a la cavitación. La resistencia a la cavitación (σ_{cav}) ha sido medida usando el método de prueba descrito en el apartado 3.1. Los valores del módulo de almacenamiento E' a temperatura ambiente de DMA y las relaciones σ_{cav}/E' también están indicadas.

Como se ha ilustrado en el apartado 2.1.2, la resistencia a la cavitación de un caucho ideal debería ser (5/6)E. En la *Tabla 1*, cada revestimiento tiene una resistencia a la cavitación más alta que su módulo, lo que indica que los revestimientos no presentan elasticidad perfecta. El módulo, correspondiente a la densidad de reticulación del revestimiento, sigue jugando un papel importante en la determinación de la resistencia a la cavitación del material de revestimiento.

Sin embargo, con una estructura de reticulación polimérica de densidad molecular adecuada, se puede obtener una alta resistencia a la cavitación, independientemente del módulo del revestimiento. En otras palabras, se pueden realizar revestimientos ideales blandos pero resistentes con una relación alta entre resistencia a la cavitación y módulo. Un módulo bajo permite obtener mejores prestaciones de microcurvatura.

En la *Tabla 1*, el Revestimiento A tiene el módulo más bajo y sin embargo, su resistencia a la cavitación también es la más baja (<1MPa). En efecto, la fibra con este revestimiento ha revelado cavidades evidentes resultado del proceso de enfriamiento después del trefilado de la fibra. El Revestimiento B, con resistencia a la cavitación igual a 1,21MPa, es considerado bastante resistente para soportar la tensión térmica generada durante el enfriamiento de la fibra. No se han observado cavidades en la fibra con el Revestimiento B. También del análisis teórico, este nivel de resistencia a la cavitación es bastante más alto que la tensión térmica calculada de ~0,8MPa del revestimiento primario. Sin embargo, la relación σ_{cav}/E' del Revestimiento B es solamente 1,2, la más baja de todos los revestimientos. Este tipo de revestimiento es considerado adecuado para soportar situaciones de esfuerzo normales, pero no consigue aprovechar todo su potencial como para convertirse en un material de revestimiento sumamente fuerte.

Por otro lado, los Revestimientos C, D, E y F tienen las propiedades de alta resistencia a la cavitación deseadas. El módulo del Revestimiento C o del Revestimiento D está en el rango de valores típicos de los revestimientos primarios comerciales.

Sin embargo, la resistencia a la cavitación de estos revestimientos está prevista a valores muy altos disponiendo de una estructura molecular de reticulación optimizada.

El Revestimiento E tiene un valor de módulo medio-alto (combinado con baja T_g), que ha sido desarrollado para ser aplicado en fibras monomodo y multimodo. La resistencia a la cavitación de este revestimiento presenta todavía valores muy altos (2,1Mpa) y permite una relación σ_{cav}/E' alta (2.3). El Revestimiento F ofrece una resistencia a la microcurvatura excelente atribuida al módulo ultra bajo (y T_g baja). Al mismo tiempo, se ha alcanzado un nivel de resistencia a la cavitación bastante alto (1,51MPa), con una relación σ_{cav}/E' de 2,4. Con revestimientos ultra blandos como éste se deben tomar precauciones especiales para dar una buena resistencia a la cavitación a la estructura de revestimiento. De lo contrario, el riesgo de cavitación en el revestimiento y de deterioro de las prestaciones de atenuación de la fibra es posible.

Las situaciones como la del Revestimiento A, donde las cavidades estaban ya presentes en la fibra después del trefilado, pueden ser fácilmente reconocidas. El riesgo no tan evidente se encuentra en situaciones donde las cavidades en el revestimiento se pueden formar gradualmente y causar un aumento de atenuación en campo, cuando la fibra está sometida a ciclos de temperatura ambiente o queda a bajas temperaturas por períodos de tiempo largos, como por ejemplo en el caso de los cables submarinos. Un sistema de revestimiento de alta calidad, diseñado con detenimiento, no solo ofrece prestaciones de de primera en las fibras, sino que ofrece también mayor fiabilidad a largo plazo a las fibras ópticas.

4. Conclusiones

La cavitación de los revestimientos primarios ha sido examinada exhaustivamente como posible modo de rotura posible en fibras ópticas con doble revestimiento.

La cavitación del revestimiento es causada por el esfuerzo de tracción triaxial que puede ser inducido por tensión térmica interna o impacto mecánico externo. El revestimiento se rompe cohesiva- mente cuando el esfuerzo de tracción triaxial excede la resistencia a la cavitación del revestimiento.

Se ha desarrollado un método de prueba para evaluar cuantitativamente la resistencia a la cavitación de un material de revestimiento.

La comprensión del mecanismo de cavitación y el estudio de la resistencia a la cavitación del revestimiento han permitido diseñar materiales de revestimiento de resistencia a la cavitación elevada para dar solidez a la fibra revestida sometida a potenciales tensiones térmicas y esfuerzos mecánicos.

Se han obtenidos relaciones altas entre resistencia a la cavitación y módulo, que permiten obtener revestimientos primarios con bajo módulo/baja T_g, mejorar la protección contra las microcurvaturas, y ofrecer resistencia a la cavitación elevada. ■

5. Referencias

[1] D Gloge, 'Optical-fiber Packaging and Its Influence on Fiber Straightness and Loss', The Bell System Technical J, 54(2), 245-262 (1975)

[2] W W King, 'Thermally Induced Stresses in an Optical - Fiber Coating', J of Lightwave Technology, 9(8), 952-953 (1991)

[3] W W King and C J Aloisio, 'Thermomechanical Mechanism for Delaminations of Polymer Coatings from Optical Fibers', J of Electronic Packaging, 119, 133-137 (1997)

[4] P L Tabaddor, C J Aloisio, C H Plagianis, C R Taylor, V Kuck and P G Simpkins, 'Mechanics of Delamination Resistance Testing', International Wire and Cable Symposium Proceedings, p 725 (1998)

[5] C J Aloisio, W W King and R C Moore, 'A Viscoelastic Analysis of Thermally Induced Residual Stresses in Dual Coated Optical Fibers', International Wire and Cable Symposium Proceedings, p 139 (1995)

[6] A N Gent and P B Lindley, 'Internal Rupture of Bonded Rubber Cylinders in Tension', Proc Roy Soc A, 249, 1958

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