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ISSN 1463-2438

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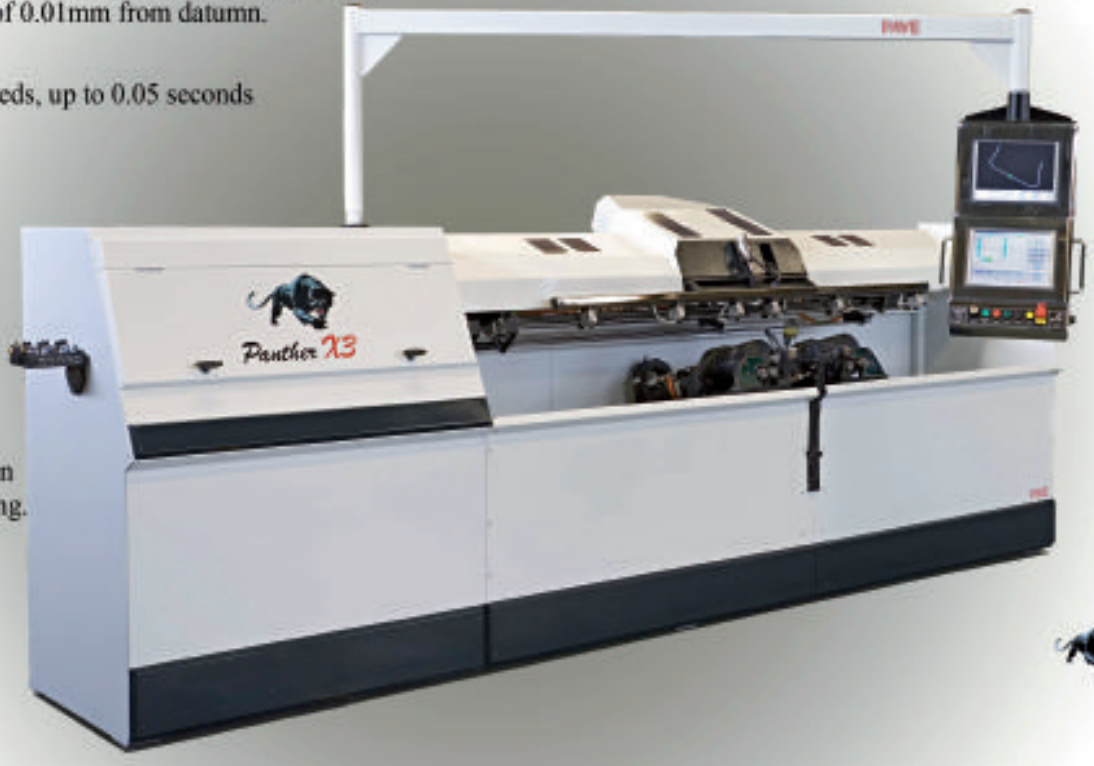

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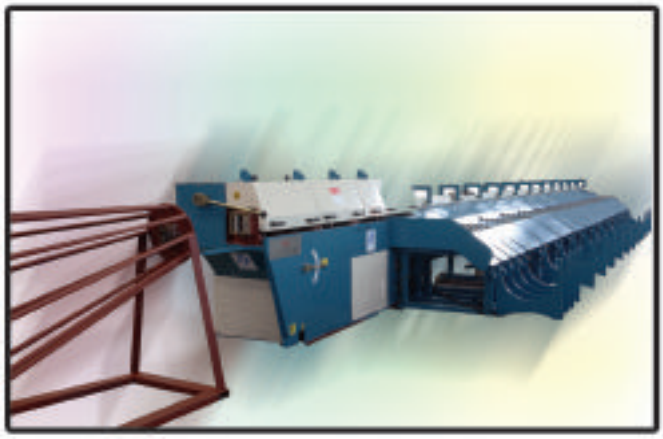

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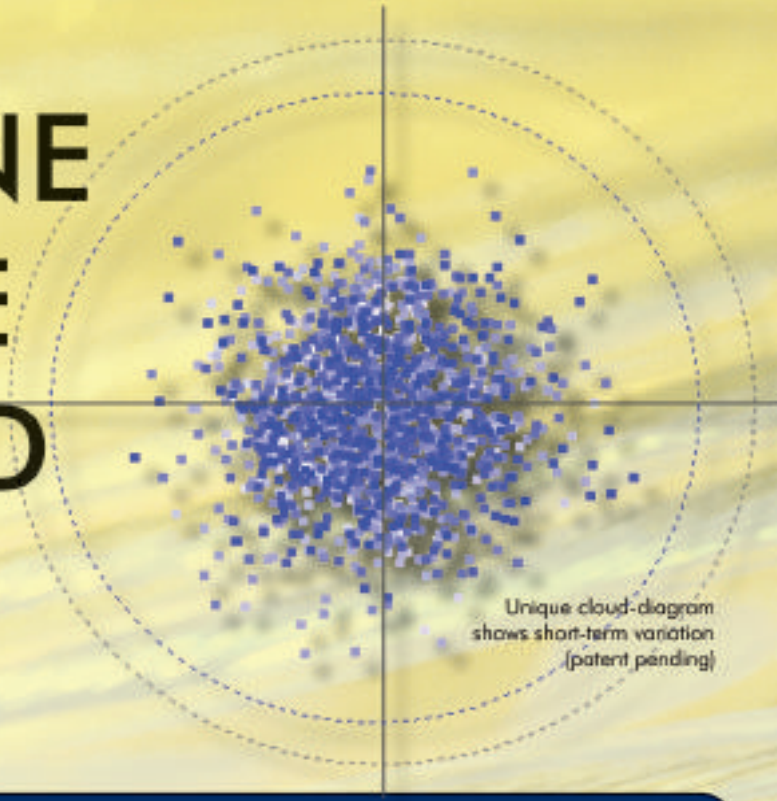
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Getting to grips...

Welcome to the May issue of EuroWire, my first issue as editor.

Having previously worked within broad based engineering and metalworking publications, wire 2008 became my crash course in the technicalities of the wire industry. Walking around the vast halls of the Düsseldorf show, and with the help of exhibitors and colleagues alike, the technology and the industry gradually began to unfold.

wire 2008 was a varied and vibrant trade show reflecting, it seems, a varied and vibrant industry sector.

The positive atmosphere was a welcome relief amidst the media predictions of recession. Not that these were overlooked; there was discussion everywhere of the gloomy forecasts, but even producers of major capital equipment were reporting lively interest on their stands, and confirmed sales.

I had the pleasure of meeting many enthusiasts taking a real pride in their technology, their products and their company. Optimism is infectious, and I hope that both visitors and exhibitors at wire 2008 took it to heart and back to their offices, as I have brought it back to my new office at EuroWire.

As editor, it will be my aim to continue the excellent standard set by my predecessor, David Bell, and to continue to reflect the mood and movement of the industry while maintaining EuroWire's reputation for news, views and technical information.

Of course, this means I have to ask you, readers and subscribers, to play a part. When you have news, let me know about it; or do you have expertise in an area of wire or cable production that you'd be prepared to share in a technical article? Again, let me know and we can keep the wire and cable industry informed.

As I write this I'm already preparing for June's Wire Expo in Pittsburgh, while some of you will also be planning for EuroBlech 2008 and wire China; clearly 2008 is a busy year in wire!

Time I found some stout walking shoes.

Gill Watson

The International Magazine for the Wire and Cable Industries

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Front cover: Zumbach Electronic AG
See page 104 for further details

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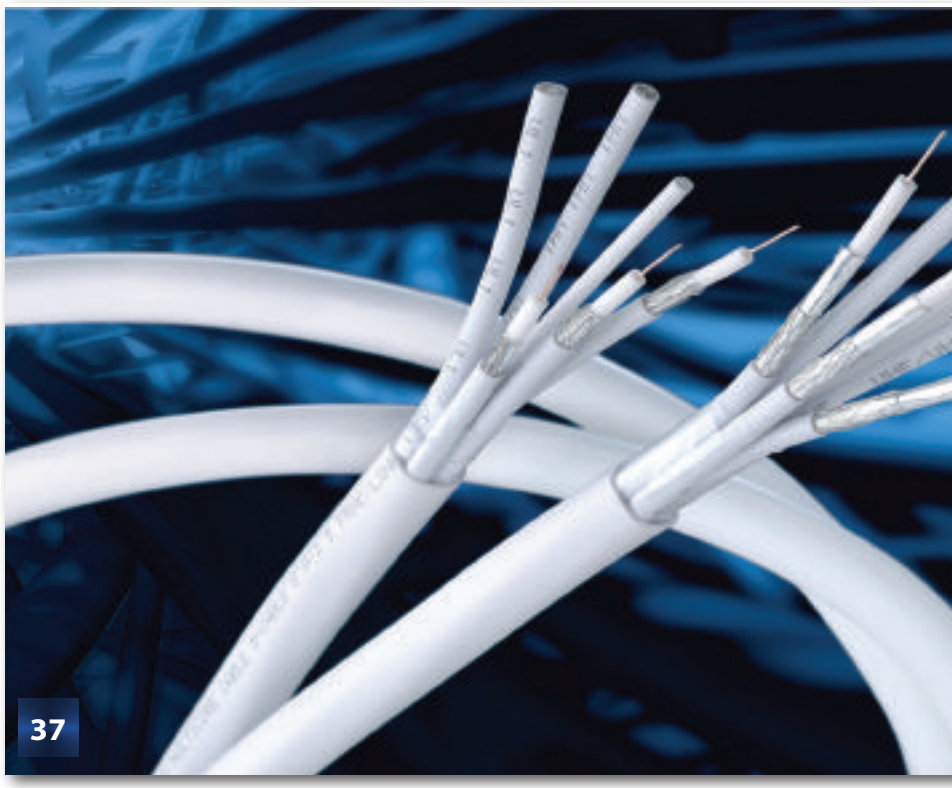

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In The Next Issue

Preview of EuroBlech 2008

Features On

- Taping, armouring & sheathing of cables
- New developments in fibre optics

Getting Technical

High cavitation strength primary coatings for optical fibres

WIRES & FASTENERS UKRAINE 2008

June

17-20: **Wires & Fasteners 2008** – trade exhibition – Kiev, Ukraine
Organisers: TDS Expo
Fax: +380 44 596 9374
Email: info@weldexpo.com.ua
Website: www.weldexpo.com.ua
International Exhibit Sales: INTRAS Ltd
Fax: +44 1926 314755
Email: intras@intras.co.uk
Website: www.wire-ukraine.com

June

7-11: **Wire Expo 2008** – trade exhibition – Pittsburg USA
Organisers: Wire Association Int
Fax: +1 203 453 8384
Email: info@wirenet.org
Website: www.wirenet.org

17-20: **Wires & Fasteners 2008** – trade exhibition – Kiev, Ukraine
Organisers: TDS Expo
Fax: +380 44 596 9374
Email: info@weldexpo.com.ua
Website: www.weldexpo.com.ua
International Exhibit Sales: INTRAS Ltd
Fax: +44 1926 314755
Email: intras@intras.co.uk
Website: www.wire-ukraine.com

23-26: **9th China (Guangzhou) International Metal and Metallurgy Exhibition** – trade exhibition – Guangzhou, China
Organisers: Julang Exhibition Co Ltd
Fax: +86 20 386 20790
Email: meiwen@julang.com.cn
Website: www.julang.com.cn

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

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

Spooling line for New Zealand

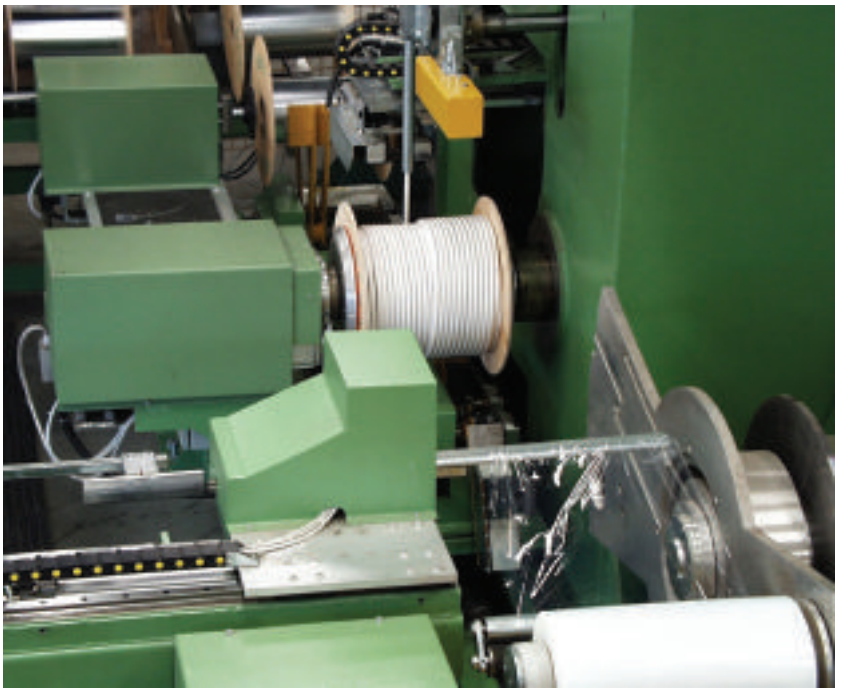
PS Costruzioni Meccaniche Srl has recently installed a fully automatic spooling line at General Cables Company, New Zealand.

The line can work both in tandem with the extruder and off line, as an independent unit, together with two Portal Pay Off systems, which avoid stopping the line during the reel change. When working in tandem with the extruder, the machine can reach a linear speed of 300 metres per minute.

Through its post-sales customer assistance centres in Australia, located in Sydney and Melbourne, PS Costruzioni Meccaniche has become a steady presence in the Australian and New Zealand markets, and ten automatic spooling lines have already been sold and installed in the area.

Two assistance centres can supply customers with spare parts and can also provide specialised technicians, who follow all the start-up operations at the customer's premises.

PS Costruzioni Meccaniche Srl – Italy
Fax: +39 03968 98769
Email: ps@pscostruzioni.com
Website: www.pscostruzioni.com



▲ *Spooling line installed in New Zealand*

"the international meeting point for specialists" – wire 2008 show report

Spirits were high at the end of wire 2008, after five days of lively activity across all halls. "Every two years, Düsseldorf becomes the international meeting point for specialists from the wire, cable and tube industry. Here, they can meet face to face and fill their order books," commented Werner M Dornscheidt, chairman of the management board of Messe Düsseldorf.

Around 2,200 exhibitors at wire (1,129 companies) and Tube (1,028 companies) occupied a display area of over 95,000 square metres, receiving 73,600 trade visitors from more than 90 countries.

Joachim Schäfer, managing director of Messe Düsseldorf, is delighted with the feedback he has received, "The exhibiting companies and visiting trade fair guests were truly enthusiastic with the results of the fair. Many large and medium-sized businesses have told me of new, promising business contacts."

Of the two shows, wire attracted the most visitors from France, India, Great Britain and Northern Ireland, Italy, the USA, Poland, Brazil and Belgium. Tube visitors travelled from Italy, France, the Netherlands, Great Britain, India, Czech Republic, Switzerland, Belgium and Spain.

Visitor surveys indicate that most wire visitors were interested in machines and systems for wire production and processing, materials, speciality wire and cables, testing technology, measuring and control technology as well as process engineering tools. The visitors were mainly from the industry (80%), retail (8%) and the trades sector (4%). New areas premiered at wire, environmental technology and energy efficiency and logistics were a success, assessed as important by 10% of visitors.

As we go to press the dates for wire and Tube 2010 have yet to be confirmed, pending the further results of exhibitor and visitor surveys.

Messe Düsseldorf GmbH – Germany
Fax: +49 211 4560 87 541
Email: hartmannp@messe-duesseldorf.de
Website: www.wire.de

Ocean's spectrometer gets the approval

Huge Winners CNC System (Shenzhen) Co Ltd has chosen Ocean Optics miniature fibre optic spectrometers to use in its LED (light emitting diode) sorting systems.

Ocean Optics Asia, based in Shanghai, worked together with the Chinese company to develop a workable solution to improve the reliability of its LED sorting system.

With bulbs moving through its sorters at a rate of approximately 8,000 pieces per hour, speed was another important factor for Huge Winners in selecting a spectrometer. Ocean Optics' USB4000 measures and processes individual LED spectral data within 10 to 50 milliseconds.

Spectral data is quickly digitised and processed by computer for dominant and peak value wavelength, CIE colour and irradiance (lumens).

Based on these results, the sorter then transports each individual bulb to the appropriate collection bin for storage.

Even under rigorous 18 hour work days, the USB4000 maintains consistent speed and accuracy.

▲ *Ocean's spectrometer is the real winner in China*

The USB4000 Spectrometer selected by Huge Winners is distinguished by enhanced electronics: 16-bit A/D resolution for auto nulling (an enhanced electrical dark-signal correction); EEPROM storage of calibration coefficients for simple spectrometer start-up; 8 programmable GPIO signals for controlling peripheral devices; and an electronic shutter for spectrometer integration times as fast as 3.8 microseconds – a feature that prevents detector saturation. In addition, the USB4000 has signal-to-noise of 300:1, sensitivity of 130 photons/count at 400nm, and optical resolution (FWHM) ranging from 0.3-10.0nm.

Ocean Optics – USA
Fax: +1 727 733 3962
Email: info@oceanoptics.com
Website: www.oceanoptics.com

Latest "NIEHOFF-News" – hot off the press

The latest Maschinenfabrik Niehoff newspaper includes a two page illustrated article about the exhibits presented at the wire 2008 trade fair in Düsseldorf.

One of these is the new opto-electronic traversing system NBAT, said to enable a faultless strand take-up for further processing at high speeds without the potential for damage.

Other features include a description of the application of NBM's RI series induction annealers, contactless annealers that give improved physical properties to wires made from copper alloys, and an interview with Wolfgang Hentschel from Auto-Kabel Managementgesellschaft, who talks about the application of aluminum conductors in car manufacturing.

Short news articles and summaries in Chinese and Russian are included in the newspaper, available from any Niehoff service centre or from the website.

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

Positive signs for Interwire 2009

The Wire Association International (WAI) Inc and the International Fastener Machinery and Suppliers Association (IFMSA) have announced plans to co-locate their respective trade events – the Interwire Trade Exhibition and the International Fastener Exposition – at the IX Center, Cleveland, Ohio, USA, between 27th and 30th April 2009.

With WAI's educational and annual convention functions the complete Interwire event, which ranks among the top 200 trade shows in the US, will run from 25th-30th April 2009.

"Many factors contributed to the Interwire 2007 success story and the co-location with IFE was clearly among them," said WAI President Ron Reed. "Our decision to co-locate again in 2009 was based on the 14% boost in attendance in Cleveland in 2007 and on the interest in a combined event – both of which were positive signs. We're pleased to reconnect with the IFMSA group and intend to focus our efforts over the next year toward refining an already well received programme for even better visitor appeal," he said.

Wire Association International – USA
Fax: +1 203 453 8384
Email: info@wirenet.org
Website: www.wirenet.org

Wire connects the world

As the cars move you through the day, as an elevator connects you to the building, as a bridge connects you to the road and as a ship connects you to the ocean...
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Certification for Gem Gravure

Gem Gravure Co Inc, Hanover, Massachusetts, USA, has recently earned its ISO 9001:2000 certification.

This internationally recognised standard for quality management requires a commitment to product quality and continuous improvement. Certified companies use the ISO 9001:2000 standard as a tool in pursuit of improved customer satisfaction.

"The requirements of the ISO specification work well with the processes we use at GEM," said quality manager Jean Patton.

"Formal certification assures our customers of what they have known for years, GEM continues to strive for the highest quality in our products and processes." In addition to quality systems, GEM continues to pursue products that fulfil customer environmental and regulatory requirements.

GEM is known for its wire and cable identification applications. All GEM fluids comply with Restriction of Hazardous Substances (RoHS) requirements. The company offers ink jet fluids registered as Clean Air Solvents in Southern California.

▲ *Jean Patton, quality manager; Ramona Krogman, marketing manager; Sharon Hall, administration manager; Brian Leopold, technical support manager; JJ Jenness, customer service manager; James Grey, chemical engineering; Peter Cook, environmental, health and safety manager after receiving the ISO certification*

VOC exempt and low VOC eco-friendly fluids are available for ink jet, and water-based inks are available for band marking and high temperature printing systems.

All GEM inks are tested and available for use in all major ink jet printer types. Customers are welcome to submit product samples for test printing.

Gem Gravure Co Inc – USA
Fax: +1 781 878 5753
Email: info@gemgravure.com
Website: www.gemgravure.com

Make a date for Kiev

KyivExpoPlaza will see the first Ukrainian Wires and Fasteners show, part of the Kiev Technical Show taking place from 17th to 20th June.

This is a significant event for the industry, which views the Ukraine as more accessible than its neighbour Russia but with huge potential as its economic growth continues. Ukraine is the world's third largest steel producer and the exhibition is anticipated with enthusiasm in the market.

Exhibition space is selling very well, particularly for a first show, and continues to attract lively interest from potential exhibitors.

Wires and Fasteners – organised by TDS-Expo and sponsored by EuroWire and Wire & Cable ASIA – has received considerable support from the Ministry of the Industrial Policy of Ukraine, Ukrainian Manufacturers and Employers Association, and Machine-Building Engineers and Technologists Association of Ukraine.

Organisers: **TDS Expo – Ukraine**
Fax: +380 44 526 93 76
Email: olga@welding.kiev.ua
Website: www.weldexpo.com.ua

International Exhibit Sales: **INTRAS Ltd – UK**
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SIF MDC is a company ISO 9001:2000 certified. Market leadership by SIF MDC is backed by continuous improvements to QUALITY processes implementing the most modern development technologies and effective management strategies. At SIF MDC, customer service is the basis for company growth.

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SIF MDC pivots on consultancy, on-time deliveries and customised pre-sales and after-sales services its corporate mission regulations and development. At SIF MDC, excellent service is key to customer satisfaction.

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Stezzano (BERGAMO) - Italy
Tel. + 39 035 592931
Fax + 39 035 4559358
Email info@sifmdc.com
Web www.sifmdc.com

Boosting power in Africa

Nexans and INEO Energie Export (part of Suez Group) have just completed a major project to install Nexans AERO-Z® high voltage overhead conductors in record time.

This project is part of a contract to upgrade the capacity of the 264km power line between Birnin-Kebbi (Nigeria) and Niamey (Niger). The €7m contract was awarded by Société Nigérienne d'Electricité (NIGELEC).

At NIGELEC's request, the INEO-Nexans consortium completed the project in just 29 days.

"The deadline imposed by NIGELEC was a real challenge for Nexans because the cable had to be installed in winter – a low demand period – so as to minimise service interruptions.

"The experience and flexibility of all INEO installation staff allowed us to meet this challenge", said Thierry Capelle, Nexans overhead lines business group managing director.

Installing the AERO-Z® cable on the power link between Birnin-Kebbi in Nigeria and Niamey, the capital of Niger, has two important benefits.

▲ *Nexans – helping keep power on line in Africa*

It will increase the power transmission capacity by at least 75% – to 70 MW in the worst summertime conditions and up to 80 MW in winter. It will also reduce the need for costly local generation alternatives such as gas, diesel or kerosene powered generators.

The new higher performance high voltage link, that significantly reduces energy losses, will enable NIGELEC to import more power from Nigeria, its main supplier, and thus benefit from a dramatic decrease in cogeneration costs.

The contract awarded by NIGELEC involved a total length of 820 km of AERO-Z® conductors. The Nexans Dour plant in Belgium manufactured most of the cable (740 km). The Nexans plants in Bourg-en-Bresse (France) and Mohammedia (Morocco) also each produced 40 km of cables.

Nexans – France
Fax: +33 1 56 698484
Email: info@nexans.com
Website: www.nexans.com

Help is at hand for the end users

Based on the premise that all members of the wire and cable industry should collaborate to improve power, communications and data products and processes, Dow Wire & Cable has expanded its corporate initiatives to further benefit end users.

"Strong working relationships amongst suppliers, cable manufacturers and utilities will continue to drive success in both emerging and established wire and cable markets," said Tim Laughlin, general manager, Dow Wire & Cable.

"Business presence, regional manufacturing, high quality standards and the understanding of regional requirements are also important components, but the best results will come from solid partnerships."

To achieve and support these important partnerships, Dow Wire & Cable has added a global End Use Marketing Team, which consists of experienced executives who will focus on the regional needs of end users, including utilities, co-ops, manufacturers and others who establish and maintain industry specifications.

Led by Ram Ramachandran, director of End Use Marketing, the new team will promote Dow Wire & Cable technologies and solutions for the transmission, distribution and consumption of power, voice and data.

Team members will participate in key country/regional industry organisations, committees and testing agencies to help develop high-performance solutions.

Their individual expertise, combined with Dow Wire & Cable's global reach and involvement, will continue to provide strong support for the cable industry across the entire value chain.

Regional leaders of the Dow Wire & Cable End Use Marketing Team include: Marcio Alves, South Latin America (mtalves@dow.com); Simon Leung, China & Asia Pacific (leungs@dow.com); Marcello Mori, North Latin America (mmori@dow.com); Brent Richardson, (brichardson@dow.com) North America; Simon Sutton, Europe and Russia (sjsutton@dow.com).

"Our goal is to enable customers and end users to achieve the longest possible lifespan in finished wire and cable goods by combining their processes with our technology and advanced materials," Mr Ramachandran said. "While this requires extensive up-front planning and collaboration, the benefits are significant: improved reliability, longevity and efficiency; lower total system costs; and environmental improvements."

Dow Wire & Cable
– USA
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From Russia . . . with a new order!

A new order has been received by Tenova LOI Italimpianti from Siemens VAI Metals Technologies Srl in Russia.

This order is for the overall revamping of the existing rolling mill of Izhstal OAO plant, located in Ishvesk, Udmur Republic (Russia).

The order is relevant to the installation of a new 90t/h walking hearth furnace. The furnace will be operated to reheat billets of different steel grades such as structural steel, tool steel, high speed tool, martensitic and ferritic steel grades.

The furnace will be equipped with latest generation Tenova flameless burners. The plant is owned by Mechel, one of Russia's leading mining and metals companies, producer of coal, iron ore, nickel, steel, rolled products and hardware.

This order confirms the strong presence of Tenova LOI Italimpianti in the Russian market and strengthens the relationship established with Mechel Group.

Tenova has recently received orders from Mechel in Romania for the revamping of a walking hearth furnace and for the supply of an EAF in Ishvesk (Russia).

Tenova LOI Italimpianti – Italy
Fax: +39 02 4693026
Email: info@tenovagroup.com
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Interest booming

Interest is booming in euroLITE – the meeting point for the lightweight construction industry – being staged from 24th-26th June in Salzburg, Austria.

As the only specialist trade fair in Europe, euroLITE focuses on the entire spectrum of development and simulation tools, materials and production technologies for lightweight construction.

It's a concept which has aroused great interest among the suppliers of these products and solutions. The second euroLITE has attracted numerous renowned companies which were not represented at the first event. In the 'Joints and Connections' and 'Surface Technology' theme parks, euroLITE concentrates on areas which represent major challenges in lightweight construction.

The three-day lightweight construction forum by the Landshut Lightweight Construction Cluster, with contributions from the fields of construction, materials and manufacturing technologies, will be held in German and English with simultaneous translation.

H & K Messe GmbH & Co KG – Germany
Fax: +49 711 7223 1020
Email: info@hundkmesse.de
Website: www.hundkmesse.de

Corporate website for Sikora

Sikora has launched a new website, placing special emphasis on corporate design and brand recognition.

The website takes up a new and dynamic design to convey a company strategy of future orientation.

"Our new website design offers specific issues, adapted to customer demands and diverse interests. From corporate information to product news and topics such as environment and corporate social responsibility, visitors can quickly enter the fascinating world of Sikora and gain an interactive experience on the potential of our company," says Harry Prunk, chairman. The website provides continually updated information and news about upcoming events to keep visitors informed on time.

"The rotating globe and dynamic cable lines correspond to our corporate philosophy: we are manufacturing our high-quality products in Bremen and guarantee, with the support of several offices and representatives worldwide, individual sales and services on site. We are constantly advancing on developing new technologies to enthuse our customers and to be always one decisive step ahead in the world markets," Mr Prunk added.

Apart from the design and content of the website, the functionality for the user has been improved. With the new website visitors receive a stronger multimedia brand experience, and can quickly and easily learn about products and company news.

▲ *Sikora's new website*

Additional features such as product videos, interviews, a newsletter and the Return on Investment Calculator (ROI) round off the digital channel of information.

Sikora AG – Germany
Fax: +49 421 48900 90
Email: sales@sikora.net
Website: www.sikora.com

EFSOP system gets the seal of approval

Industrie Riunite Odolesi (IRO) has chosen to install Tenova Goodellow Inc's EFSOP® Holistic Optimization™ system as their preferred process control tool for the EAF meltshop in Odolo, Italy.

Optimisation of the 75/tls electric arc furnace will be based on standard parameters which include reducing electrical energy, oxygen and natural gas consumption along with increasing yield and productivity.

Tenova's scope of supply also includes post-combustion optimisation and TGI's off-gas water detection technology for increased safety within the furnace environment. EFSOP® will also tune at the finest levels the KT Oxygen Lances and PC-burners already on site at the facility to provide EAF optimal continuous improvement. The sale of EFSOP® to IRO SpA is the tenth Tenova Goodfellow sale in the Italian steel market.

The EFSOP® system is part of a wider project handled by Tenova Meltshops BU which will also supply new bimetallic power conductive arms and a new regulation system for the TDR-H.

Tenova is proud to highlight that, with this order, IRO decided to equip its furnaces with a complete Tenova Technological Package including the KT Injection System, the TDR-H Electrode Regulation, the Power Conductive Arms and the EFSOP® System.

Tenova Goodfellow – Canada
Fax: +1 905 567 3899
Email: info@tgti.ca
Website: www.techinct-technologies.com

Making sure the link is 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.

The alloy steel chain welding is completed in medium frequency (1,000 Hz) which enables the perfect control of all welding phases.

▲ *Machines for making all types of chains*

All welding parameters for each specific diameter and material can be stored in the PLC of the machine

Vitari SpA – Italy
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Oil industry VIPs visit Q8Oils' Leeds facility

As part of their tour of Kuwait Petroleum International's (KPI) worldwide operations, the Q8Oils Leeds manufacturing and operations facility received a visit in January from two distinguished guests from Kuwait – KPI president Hussain El Esmaiel, and vice president Esam Al-Marzouq.

Kuwait Petroleum International Lubricants Europe managing director Giuliano Franzi escorted the guests. UK director Stuart Dron and operations manager David Wright met the visitors and presented information on the Leeds team's successful financial and growth results, health and safety performance and long-term strategy.

During the visit the guests made an extensive safety walk and tour of the facility's offices, laboratories and plant guided by production manager Andy Barker.

▲ *Pictured, from left, Andy Barker, production manager; David Wright, operations manager; Stuart Dron, director UK; Hussain El Esmaiel, president; Esam Al-Marzouq, vice-president; Giuliano Franzi, MD; John Briggs, SHE manager*

The three VIPs spent time discussing how the Leeds team is working on developing sustainable metalworking fluids as well as providing lubricants for alternative energy sources such as wind turbines and gas engines. As well as being a major centre of lubricant production, the Leeds facility is also Q8Oils' European Centre of Excellence for metalworking fluids development.

Q8Oils – UK
Fax: +44 113 235 0705
Email: info@q8oils.com
Website: www.q8oils.com

New managers at SPI

SPI Lasers, a leading designer and manufacturer of fibre lasers has appointed Jack Gabzdyl and Andrew Appleyard to the positions of product line manager for pulsed lasers and high power laser systems respectively, following the successful launch of both G3 pulsed lasers and the R4 system platform.

The product line managers will drive the rapid uptake of the new lasers by the customer base and spearhead the new product introduction for 2008.

SPI Lasers – USA
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Email: info@spilasers.com
Website: www.spilasers.com

B3 starts talks over Spanish business

B3 Cable Solutions has entered into exclusive negotiations with Nexans to purchase its telecommunications and railway signalling cable business in Santander, Spain.

The deal was expected to complete at the end of the first quarter of 2008, subject to due diligence and finalisation of the necessary agreements and approvals. On completion B3 will become the third largest manufacturer of metallic telecommunication cables in the world and the largest outside the USA market.

This deal would represent the fourth acquisition by the group since the beginning of 2006 and makes B3 the fastest growing cable manufacturer in the world.

This acquisition follows hard on the heels of B3's announcement in November 2007 that it had agreed to purchase UM Cables Ltd, one of India's leading manufacturers of optical fibre and copper telecom cables, employing 140 people and with a turnover of $60m.

The Manchester and Ireland acquisitions carried out in 2006 were the first milestones in B3's strategy of building a successful company through a combination of organic growth and acquisition.

The modern and well equipped operation in Santander serves high profile telecommunications companies across mainland Europe. It employs approximately 340 people for €75m of turnover and €29m of capital employed. The business also has an impressive rail company client list, and the acquisition of the business will enable B3 to further grow its market share in the rail cabling sector.

B3 Cable Solutions – UK
Email: info@b3cables.com
Fax: +44 161 795 8393
Website: www.b3cables.com

Executive vice president appointed for Polyolefins

Borealis has appointed Lorenzo Delorenzi as executive vice president for its Polyolefins business group and member of the executive board.

Delorenzi vacates the position of vice president for the business unit pipe, where he led a successful turnaround of the business.

Prior to joining Borealis, he held senior commercial and management positions within Tetrapak, one of the world's leading packaging organisations.

Delorenzi has a degree in Applied Business Economics from the University of Louvain in Belgium.

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

An addition to Nexans' board

▲ *Dr Wolfgang Bedorf*

Dr Wolfgang Bedorf has been appointed as a member of the executive committee of Nexans, and executive vice president, rest of the world area, with effect from 1st February.

The area includes the Middle-East, Morocco, Turkey, South America, Africa, Russia and the former Soviet Socialist Republics. Dr Bedorf, who will be based in Nexans' headquarters in Paris, is moving from his current position as Nexans country manager of Germany.

Dr Bedorf was born in Cologne, Germany, and graduated as a doctor of engineering from the technical university of Aachen. He started his career in engineering management with AEG AG (later Daimler Benz AG) progressing to the position of manager of the electrical machines and transformers division.

He joined Alcatel Cable in 1995 as manager of the Energy Network Cable Business Group. When the company split from the Alcatel Group in 2000 to form Nexans, he became chairman of the management board for Nexans in Germany and country manager. From 2000 to 2004, he was also manager of the Nexans Energy Networks Business Group. Since 2005, he has supervised both Nexans' business in the Central Europe Area and the Harnesses Business Group.

Outside of Nexans, Dr Bedorf is a board member of the Association of the German Electro-Technics and Electronic Industry.

Nexans – France
Email: info@nexans.com
Fax: +33 1 56 698484
Website: www.nexans.com

Federation's new president

Tim Jessop, TWI's associate director, professional affairs and certification, has been elected as the next president of the European Welding Federation.

He succeeded Mr German Hernandex at the last EWF general assembly in Dubrovnik, Croatia, and his three-year term of office began in January 2008.

Established in 1974, the European Welding Federation acts as the representative of the welding and joining community in Europe.

At present, 27 national welding societies are members of the federation.

European Federation for Welding, Joining and Cutting – Belgium
Fax: +32 2260 1179
Email: ewf-iab@isq.pt
Website: www.ewf.be

Keeping the trains on the right track!

ClearFill 'Line', part of an innovative suite of end-to-end wireless indoor solutions (WINS) from leading wireless technology group, Radio Frequency Systems (RFS), has been successfully installed in the stage two development of the UK end of the channel tunnel rail link (CTRL Section 2).

RFS Radiaflex radiating cables, Cellflex coaxial feeder cables and accessories form a key component of the wireless communications system for the high-speed rail upgrade.

The new link runs between the centre of London and Southfleet Junction, approximately 40km to the south-east.

Courtesy of the upgrade, trains can now travel at 230km/h from Folkstone, on England's coast, right through to London's St Pancras station.

The entire journey from Paris to London now takes only 2 hours and 15 minutes.

The RFS ClearFill Line solution was selected by infrastructure specialist Thales UK, the company with responsibility for the entire communications system of CTRL Section 2.

Senior principal design engineer with Thales UK, Kevin Moxsom, said that the low longitudinal and coupling losses of RFS's RADIAFLEX radiating cable – an important element of the ClearFill suite – was a key consideration.

The new link includes three tunnels with a combined length of 21km.

The RFS Radiaflex radiating cable was installed in close proximity to the tunnels' high-voltage catenary cables.

To prevent power surges in the communications cables, RFS's 'DC blocks' – which protect both the inner and outer conductors – were installed every 500 metres.

An important system requirement was to concurrently support all four tunnel communications systems.

At the heart of the system is the 900MHz Global System for Mobile communications-Railway (GSM-R). Emergency services use a separate terrestrial trunked radio (TETRA) system operating at 380MHz, with the London Fire Brigade operating an additional 462MHz system.

▲ *Courtesy of a channel tunnel rail link upgrade incorporating RFS's ClearFill 'Line' solution, trains can now travel at 230km/h from England's coast right through to London*

Communication to the locomotive is presently via cab-secure radio (CSR) operating at 448MHz.

According to Moxsom, the GSM-R system will ultimately replace the CSR and also the trackside signalling.

All signal and control information will be transmitted directly to the locomotive, and the familiar sight of railway signals alongside the track will be a thing of the past.

In such systems, a fail-safe mechanism stops the train if the GSM-R communications are lost for more than three seconds.

For built-in system redundancy, every component of the CTRL Section 2 communications system has been duplicated. The RFS Radiaflex cable was the only exception, as in single-cable format it exceeded the 'mean-time-between-failure' (MTBF) reliability specifications.

This was achieved, not only because of the quality of the cable, but also by careful system design: the dual-redundant communications signals are fed simultaneously into the cable, from opposite ends of the tunnel.

In the event of accidental cable damage, communications can continue on both sides of the break.

The emerging use of GSM-R for train control in CTRL Section 2 and other links opens the way for harmonised communications systems throughout the entire pan-European rail network.

Radio Frequency Systems – Germany
Fax: +49 511 676 3750
Email: rfs.germany@rfsworld.com
Website www.rfsworld.com

A helping hand...

▲ *Free guide gives advice on avoiding errors*

Cropico has published a new illustrative guide providing an overview of low resistance measurement techniques, common causes of errors and advice on how to avoid them.

The free, 34-page full colour 'Guide to Low Resistance Measurement' features tables of wire and cable characteristics, temperature coefficients and formulae to enable the user to select the appropriate measuring instrument and measurement technique.

The guide includes a useful section explaining the role and importance of resistance measurement in the manufacture of electronic components, switches, relays, connectors, cabling, electric motors, generators and fuses.

Information on resistance measurement requirements in the automotive and railway utilities industries has also been featured. There's a handy glossary of terms at the end of the guide, providing an easy-to-follow explanation of terms relating to both bonding and earth resistance, as well as common industry acronyms such as DMM (digital multimeter), DUT (device under test) and AWG (American wire gauge).

Cropico – UK
Fax: +44 191 586 0227
Email: sales@cropico.com
Website: www.cropico.com

DSM strengthens its US market

Royal DSM has bought US-based Soluol, a developer, producer and marketer of high performance urethane resins which are used in a wide range of applications, with annual sales of US $20 million.

Both parties have agreed not to disclose financial details.

The acquisition of Soluol enhances DSM's speciality-resins presence in North America and adds new technology, as well as a state-of-the-art production facility in Rhode Island.

The acquired company will be grouped under the DSM NeoResins+ business unit, part of the DSM Resins business group.

Royal DSM – Netherlands
Fax: +31 1747 5639
Email: info@dsm.com
Website: www.dsm.com

No more lead after July – Teknor Apex

In the first initiative of its kind in the wire and cable industry, Teknor Apex has advised customers that it will supply only non-lead stabilised (NLS) PVC compounds after 31st July this year.

In the case of NLS compounds that have already been fully developed and established as compliant with requisite codes and standards, the company will cease producing lead-stabilised versions effective immediately.

Also included in the changeover are pre-coloured compounds, for which the Vinyl Division's sister business, Teknor Color Company, has developed colour concentrates that comply with the European Union's Reduction of Hazardous Substances (RoHS) regulations, including restrictions against the use of lead.

Underscoring the significance of this initiative is the pioneering role of Teknor Apex in developing PVC as a workhorse compound for insulation and jacketing, as well as the sheer number of such compounds – more than 3,000 – now offered by the company, according to Mike Patel, industry manager.

"For decades after Teknor Apex began manufacturing PVC wire and cable compounds in the 1940s, lead-containing additives were the most effective means of making PVC thermally stable while maintaining its outstanding electrical properties," said Mike Patel, industry manager.

"All that has now changed. New non-lead stabilisers plus advanced compounding technology have enabled us to manufacture NLS compounds whose performance and cost are comparable to lead-stabilised materials."

Customers that have not already initiated a changeover to NLS compounds are urged to do so as soon as possible.

Teknor Apex representatives will contact those companies to provide NLS-compound recommendations and other advice.

Teknor Apex Company – USA
Fax: +1 401 729 0166
Email: vinyl@teknorapex.com
Website: www.teknorapex.com

Latest furnace contract for Tenova

GTS Industries, France, has awarded Techint Italimpianti Deutschland, the contract for engineering, supply, erection and commissioning of one Pusher Type Furnace for a plate mill in Dunkerque, France.

The furnace is designed for a capacity of 200t/h to heat up slabs with different qualities up to 1,250°C.

The furnace fulfils the highest conditions about homogeneity of temperature, scale losses, efficiency and emitted values.

The new furnace will be connected in series to the existing furnaces with the purpose to increase the mill load capacity.

The order includes a turnkey plant of a bilateral heated Pusher Type Furnace equipped with Tenova LOI Italimpianti FlexyTech®–LO-NOx high speed and roof radiant burners firing natural gas.

The complete equipment will be started up in June 2009.

Tenova LOI Italimpianti – Italy
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Second FastenerTech

The second FastenerTech gets underway in Rosemont, Illinois, USA, between 8th-10th June 2009.

This biennial event includes exhibits, seminars and networking opportunities and is being held at the Donald E Stephens Convention Center.

FastenerTech 09 – USA
Fax: +1 330 864 5298
Email: info@fastenertech.com
Website: www.fastenertech.com

Rozmas buys out Japanese partner

Rözmaş group is continuing as a 100% Turkish organisation in the automotive industry after buying all of the shares from its Japanese partner.

Mr Durmuş Özcan, general manager, said that, as of 20th February 2008, the 50%-50% joint venture, which was established with Chuo Co Ltd in April of 2002, was terminated.

▲ *Rözmaş' base in Gebze, Turkey*

Mr Ozcan stated he could not satisfy his expectations out of his Japanese partner in terms of R&D studies which was the main reason for the termination of the joint venture.

Rözmaş produces hot and cold suspension springs and hot and cold (tube) stabiliser bars. In 2007, Rözmaş had a turnover of $30m.

Based in Gebze, Turkey, the company employs 200 people.

Rozmas Group – Turkey
Fax: +90 262 751 1314
Email: info@rozmas.com.tr
Website: www.rcstr.com

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team meccanica spa

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Wire rod mill heading for Brazil

Morgan Construction Company has won the contract to supply a single strand wire rod mill for Votorantim Metais in Resende, Rio de Janeiro, Brazil.

The project design allows for future expansion to two strands for rod production of up to one million tons per year.

The mill will roll plain rod from 5.5mm to 24mm and HYQST rebar from 6.35mm to 16mm. Rolling speed for the 5.5mm rod will be guaranteed at 105m per second.

Initial furnace capacity should produce 120 tons per hour, rising to 180 tons per hour when the second strand is built.

"This mill incorporates the highest level of technology to achieve the greatest mill efficiency," says Ricardo Cruz, project manager. "It will enable Votorantim Metais to grow and maintain a competitive position in the marketplace." Morgan's scope of supply includes hot and cold billet charging equipment, a 28-stand mill comprised of a roughing, and intermediate mill, a pre-finishing mill of three 'vee' style mini blocks, a 10 stand No Twist® Mill, side shifting water boxes, four intelligent pinch rolls, a laying head, Stelmor® conveyor, a reforming station with ring distributor, vertical pallet system with a transfer car onto horizontal hook system, compactor and unloading station.

Morgan will supervise the mill commissioning, expected to be in the second quarter of 2009.

Morgan Construction Company – USA
Fax: +1 508 755 6140
Email: sales@morganco.com
Website: www.morganco.com

Website for German market

SPI Lasers, designer and manufacturer of fibre lasers, has launched a new website for the German speaking market – www.spilasers.de

The new website provides information on the company's range of lasers, as well as the giving the capability to book evaluations, download datasheets and application notes, book samples into the applications laboratory, find contact details of the relevant sales and customer support teams and more.

This new website comes at a time of increased sales in the region.

SPI Lasers – UK
Fax: +44 1489 779698
Email: info@spilasers.com
Website: www.spilasers.com

Chinese subsidiary

▲ *New base in Shanghai for Team Meccanica*

With more than 15 years' exploring and cultivating the Chinese market, Team Meccanica has set up a wholly foreign-owned enterprise – Shanghai Team Meccanica Machinery Corp in NanXiang (Shanghai) Economic Developing Zone.

Team Meccanica's products will be mainly supplied in the Chinese market, as well as exported to those surrounding countries.

As a part of the Eurolls Group, Team Meccanica China also will offer relevant services to group members such as Eurolls, Vitari, Cortinovis Machinery and Teurema.

Team Meccanica SpA – Italy
Fax: +39 035 0779 728
Email: sales.office@teammeccanica.it
Website: www.teammeccanica.it

New machines from a new company!

A new name on the block – Zachar Machinery. Based in Graz, Austria, the company provides machines for copper and aluminium wire and cable production.

The portfolio includes:

- Stand-alone drawing machines – for aluminium and copper from rod-break-down to ultra-fine wire drawing machines
- Konform continuous extrusion lines – for aluminium and copper solid and hollow profiles, multi-profile-tubes, (flat) wire and cable sheathing,
- Enamelling machines – for aluminium and copper, round and flat wire, single and multi-line ovens, horizontal and vertical design, all dimensions, self bond ovens
- CTC lines/paper-wrapping machines/ wire strander – eg CTC lines for continuously transposed conductor production for example for power transformers
- Complete copper rod upcast lines – complete line (including cathode feeding and take-ups) for continuous production of copper rod by continuous upward casting process

Zachar Machinery Int – Austria
Fax: +43 31646 82110

June 18 - 20, 2008, Kyiv, Ukraine

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Tel: +44 1926 334137 Fax: +44 1926 314755 E-mail : intras@intras.co.uk

Organizer: LLC "TDS-EXPO", Tel.: +380 44 596 93 76, Fax: +380 44 596 93 74, E-mail: olga@welding.kiev.ua, Web-Site: http://www.weldexpo.com.ua

New MD at Rofin

▲ *Stephan Geiger*

Stephan Geiger took over as managing director of Rofin/Baasel Lasertech in Starnberg, Germany. Stephan joined Rofin's micro division as manager of the new technologies business unit in 2006 where he was responsible for the development of new laser sources and systems.

Until 2005 Mr Geiger was managing partner of Bavarian Photonics GmbH – a subsidiary company of TuiLaser AG – which he co-founded in 2002.

He started his career in 1985 at Rofin's marking division, rising to the level of R&D manager. He holds a German diploma in Physical Engineering from the University of Applied Sciences in Munich.

Rofin/Baasel Lasertech – Germany
Fax: +49 8151 776 159
Email: info@baasel.de
Website: www.rofin.com

Joining forces to produce bio-based performance materials

Royal DSM, the global Life Sciences and Materials Sciences company headquartered in the Netherlands, and the French starch and starch-derivatives company Roquette have joined forces to implement and commercialise the fermentative production of biorenewable succinic acid, which – among other applications – opens the possibility to produce bio-based performance materials.

Succinic acid is a chemical currently produced as a derivative from crude oil and natural gas. It is commonly used directly in a variety of industry applications, such as pharmaceuticals, food and automotive and also as an intermediate for the production of several (high-performance) polymers.

The bio-based succinic acid will be produced in a fermentative way with the use of renewable resources.

The novel production process developed by DSM and Roquette is expected to stimulate further market development of bio-based and bio-degradable polymers that use succinic acid as an intermediate.

The current target of the cooperation is to have a demonstration plant in Lestrem (France) operational at the end of 2009.

The capacity of this plant will amount to several hundred metric tons per year. It is expected that after a successful trial the technology will be transferred to large-scale production within two years.

Royal DSM NV – Netherlands
Fax: +31 1747 5639
Email: info@dsm.com
Website: www.dsm.com

What's in a name?

Femutec Engineering GmbH has changed its name to Simufact Engineering GmbH.

The new name takes the international character of the company into account and will contribute to a higher recognition of the Simufact brand.

"For us, renaming Femutec into Simufact, it has been a logical step," said Michael Wohlmuth, managing director of Simufact Engineering GmbH. "Now we can communicate our philosophy with our company name and increase the value of our product brand Simufact as well. With the new branding we enforce our main focus on 'Simulating Manufacturing' within all of business divisions and underline this internationally."

Simufact Engineering GmbH – Germany
Fax: +49 40 790 16222
Email: office@simufact.de
Website: www.simufact.com

Ending the year on a high!

Maillefer SA ended the year on a high note – with the second management buy-out, with backing from the Alpha Group.

Prior to the deal, Maillefer management was financed through private equity from Argos Soditic. Neither the increased level of management participation nor the acquisition price has been disclosed.

The timing for the buy-out was opportune. Maillefer activities have been steadily developing. Total sales in 2006, as announced in early 2007, reached a record well exceeding €100 million. Though the figures for 2007 are not yet published, they are clearly topping those of 2006. The opportunity exists for further development.

Maillefer is a leading provider for manufacturing solutions to the world's wire and cable and tube and pipe industries.

Maillefer SA – Switzerland
Fax: +41 21 691 2143
Email: info@mailleferextrusion.com
Website: www.mailleferextrusion.com

Boosting Midwest sales team

DeWAL Industries Inc, a manufacturer of PTFE and UHMW-PE film and tape, has added Michael B McBain to its sales team in the Midwest.

Michael has years of experience designing, developing and implementing the use of self-lubricating polymer-based components for major Fortune 500 companies.

Based outside of Chicago, he will handle sales for DeWAL in Illinois, Wisconsin, Michigan and Indiana.

He will be responsible for all products supplied by DeWAL Industries to existing and new customers.

He will assist them with selection and application of PTFE & UHMW-PE films and tapes, including unsintered and low density PTFE films and speciality laminations.

A former University of Illinois football player, Michael lives with his wife and children in Naperville, IL.

DeWAL Inc – USA
Fax: +1 401 783 6780
Email: info@dewal.com
Website: www.dewal.com

Conference heads for Spain

Following the success of the inaugural conference last year, CRU's 2nd World Wire and Cable Conference will this year be held in Barcelona, Spain, from 1st-3rd June.

The conference is being co-hosted by Superior Essex and El Sewedy Cables and will address and discuss the essential topics affecting the global wire and cable industry.

Day one of the conference will cover: routes to market, the contribution of suppliers to cablemakers, and copper and fibre issues.

Day two of the conference will consist of parallel tracks. Delegates have the option to attend different sessions from each track, giving a broader industry perspective. This conference also introduces a new track covering structured cabling.

With an expected international delegation of more than 300 senior level representatives, this conference presents all attendees with a unique opportunity to meet other industry decision makers from around the world who are involved in the wire and cable industry.

CRU Events – UK
Fax: +44 20 7837 0976
Email: cruevents@crugroup.com
Website: www.cruevents.com

€15m site investment

Royal DSM NV is to invest nearly €15m in the construction of a new plant for the production of wet polyesters and other speciality resins in Meppen, Germany.

The new production line will be built at the existing site of DSM NeoResins+ in Meppen. The plant will be completed in the first half of 2009 and will allow for further expansions in the future.

Wet polyesters represent an important and promising product line. With this expansion DSM NeoResins+ will reinforce its strong position in the fast growing (more than 8% per annum) and strategically important markets such as can, coil and niches in the decorative segments.

Royal DSM NV – Netherlands
Fax: +31 1747 5639
Email: info@dsm.com
Website: www.dsm.com

New president at Wardwell

John Tomaz, a veteran of 30 years at the Wardwell Braiding Machine Company, has been named president of the company, succeeding Jonathan Farnum who has held the position for the past 34 years.

The change in leadership became effective 1st March 2008.

Mr Tomaz has been vice president sales and marketing since 1999 with responsibility for combined worldwide marketing, sales, and service activities.

He succeeds Jonathan Farnum, under whose tenure Wardwell experienced steady growth through a series of mergers and acquisitions in North and South America, Europe, and the Pacific Rim.

Mr Farnum will retain his position as Chairman of the Board and will remain involved in the company's activities.

Wardwell Braiding Machine Co – USA
Fax: +1 401 723 2690
Email: sales@wardwell.com
Website: www.wardwell.com

Changes at the top

There is a new management structure in place at plastic solutions giant, Borealis.

Mark Garrett officially took over as chief executive and chairman of the executive board on 1st January.

He is joined by two long-time Borealis executives, Herbert Willerth, who will continue as executive vice president (EVP) of operations, and Henry Sperle, who, after many years running the hydrocarbons business, takes on the new EVP position for the Middle East and Asia.

Two new members who have recently joined the board are Martin Kuzaj, EVP of the newly formed Base Chemicals business group and Daniel J Shook, chief financial officer.

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Transatlantic Cable

The economy

Until recently, the Iraq war seemed to exert a strikingly small short-run impact on the US economy. No more

"There is no such thing as a free lunch, and there is no such thing as a free war. The Iraq adventure has seriously weakened the US economy, whose woes now go far beyond loose mortgage lending. You can't spend $3 trillion – yes, $3 trillion – on a failed war abroad and not feel the pain at home."

Thus did Linda J Bilmes and Joseph E Stiglitz mark the approach of the fifth anniversary, on 19th March, of the war in Iraq – the second-longest in US history (after Vietnam) and the second most costly (after World War II).

Asserting the impossibility of separating the war from the economy, Mr Stiglitz, the Columbia University economist and Nobel Prize winner, and Ms Bilmes, an expert in public finance, claim that the US will be paying the price of Iraq for decades to come. (*Washington Post*, 9th March)

A review of the Stiglitz and Bilmes book *The Three Trillion Dollar War: the True Cost of the Iraq Conflict* in fact notes that the co-authors' $3 trillion price tag reflects a choice to risk erring on the conservative side.

The final tally in their "realistic-moderate" scenario reaches $5 trillion. Moreover their figures do not count the costs of the war to Iraqis and US allies, nor to the rest of the world.

To make matters worse, the US economy is facing a recession. But *The Three Trillion Dollar War* observes that the country's ability to implement an effective economic-stimulus package is hampered by expenditures of close to $200 billion on the wars in Iraq and Afghanistan this year alone, and by a "skyrocketing" national debt.

Filling in the bleak picture, Mr Stiglitz and Ms Bilmes observe that the total loss from the economic downturn now facing the US (as measured by the disparity between the actual output of the economy and its potential output) is likely to be the greatest since the Great Depression of the 1920s and 1930s. The current total, itself well in excess of $1 trillion, is not included in their estimate of the cost of the war.

Excerpts from *The Three Trillion Dollar War* have appeared in American and international publications, and the book is due to be translated into Dutch, French, German, Italian, Spanish, and Japanese. In his review in the *Post*, Carlos Lozada wrote that the White House – "to no one's surprise" – has dismissed the book's conclusions. Also true to form was its shift away from the topic into a fuzzier area.

"People like Joe Stiglitz lack the courage to consider the cost of doing nothing and the cost of failure," White House spokesman Tony Fratto told reporters. "What price does Joe Stiglitz put on attacks on the homeland that have already been prevented? Or doesn't his slide rule work that way?"

❉ Reviewing *The Three Trillion Dollar War* ("What's the Tab?", 16th March), Mr Lozada noted that the co-authors address the economic realities of the Iraq war far more fully than did the Bush administration before the invasion. The deputy defence secretary at the time told Congress that Iraqi oil revenues would fully finance any postwar reconstruction, while an economic adviser to Mr Bush lost his job for suggesting that the conflict could cost $200 billion (a fraction of the funds appropriated to this point in 2008). Mr Stiglitz and Ms Bilmes write, "The tone of the entire administration was cavalier, as if the sums involved were minimal."

The US dollar tumbles, and Europe feels the jolt

While the Iraq war and the US economy are inextricably intertwined, in this presidential election year the economy looms larger in the minds of voters; and their concern is exacerbated by the fall of the US dollar to record lows against other major currencies. On 14th March, a day on which the euro traded for an all-time high of $1.5687, the dollar hit its lowest point against the Japanese yen in 12 years and fell below the Swiss franc for the first time ever.

Considering the number and seriousness of the other threats to their serenity – big job losses, troubled mortgages, soaring fuel costs, a credit crisis, turmoil on Wall Street – Americans may perhaps be forgiven some self-centredness just now. But those who can spare a thought for their European counterparts might consider the broader implications of the steadily weakening US currency.

European regional editor Jack Ewing of *Business Week* notes that, as the greenback nears lows last seen in 1995, it is forcing a radical rewrite of business plans all over Europe. While some companies do benefit from lower import costs, those that manufacture in the euro zone and sell in the US or Asia are finding themselves at a serious competitive disadvantage. ("The Power of the Falling Dollar," 10th March)

The increase in the value of the euro (80% *plus* since October 2000) is making it difficult if not impossible for European goods to compete on price with products made in the US.

Charles Edelstenne, chief executive of French aircraft maker Dassault Aviation and head of the French aerospace manufacturers association, told *Business Week* that the pain in his sector is the worst he has seen in nearly 40 years.

Mr Ewing observed that the big disappointment for Europe is that it has worked so hard in the last decade to protect itself from just this kind of currency market oppression: "After the last dollar-induced crisis in the mid-1990s, many [European] companies set up operations in the US and Asia so that shifts in currency values would tend to balance each other out. They also protect against currency swings with sophisticated hedging techniques."

Moreover the euro itself, introduced in 1999, eliminated currency risk for trade among the 15 nations using it. Most European countries are still one another's largest trading partners.

Transatlantic Cable

But Mr Ewing notes that such measures go only so far, particularly for countries and companies that depend on exports. He cited Ireland, which uses the euro and "has been hit by a double whammy because the currency has risen against the British pound as well as the dollar, making Irish exports more costly for its two largest trading partners."

❉ As an example of shared transatlantic pain, Mr Ewing offered Volkswagen's redesigned Scirocco, one of the hits of the Geneva auto show in early March. The sporty car, he noted, might be just the thing to revive the image of the Volkswagen brand in the United States. But Americans should not expect to see the Scirocco, built in euro territory, cruising down their highways any time soon, even though German engineers designed it to meet US requirements. "At the current exchange rate there's no point," Detlef Wittig, VW executive vice president for group sales and marketing, told *Business Week*. "There's no profitability there."

Of related interest . . .

❉ According to New York's tourism operation, the weak US currency helped draw 8.5 million foreign visitors to New York in 2007, more than ever before. And a small but growing group of merchants in such popular Manhattan neighbourhoods as Times Square, Greenwich Village, and SoHo has begun to accept the euro and other foreign currencies. A visiting *Washington Post* reporter even spotted a hand-lettered sign reading "Euros Only" in a store window on East Houston Street, near the offices of *EuroWire*. But the proprietor of the antiques-and-props establishment confessed this was only an attention-getter. He is prepared to accept Canadian dollars and British pounds – US dollars, too.

Can the next president restore America's image overseas?

Speaking in Paris on 11th March, Bernard Kouchner, the foreign minister of France, said that the successor to US President George W Bush may be able to restore something of the United States' battered image and standing overseas. But, Mr Kouchner added, "I think the magic is over." The setting was a meeting of the Forum for New Diplomacy, co-sponsored by the Académie Diplomatique Internationale and the *International Herald Tribune*. In the course of a wide-ranging conversation afterward with Roger Cohen of that newspaper, Mr Kouchner was asked whether the US could repair the damage it has suffered to its reputation during the current Bush presidency and especially since the US-led invasion of Iraq in 2003.

In the sober assessment of this longtime diplomat – who, as noted by the *Tribune*'s Alison Smale, is one of the strongest supporters in France of the United States – "It will never be as it was before." ("The US 'Magic' is over, Says French Foreign Minister," 12th March)

US military supremacy endures, observed Mr Kouchner, who is also co-founder of Médecins Sans Frontières and a noted humanitarian; and "there are many means for [the new president] to re-establish the image." But that, he said, "will take time."

The Air Force surprise

The US military chooses Airbus over Boeing for one of its largest contracts

Boeing Co on 11th March protested the award by the US Air Force of a $40 billion contract to replace 179 Eisenhower-era aerial refuelling tankers to a group that includes Airbus, the European commercial airline company. The Boeing protest, made to the Government Accountability Office, followed several days over which company officials issued a series of complaints about unfairness. Chicago-based Boeing was widely expected to win the contract.

Indeed, it was that expectation that some industry observers say led to a complacency that may have lost Boeing the deal. The winners, Northrop Grumman Corp and its European partner, Airbus parent EADS, "clearly provided the best value to the [US] government," Sue Payton, the Air Force's chief weapons buyer, told reporters at a briefing following the 29th February announcement. EADS (European Aeronautic Defense and Space) is based in Paris and Munich.

Boeing and its lawmaker-allies in Washington contended that too many American jobs are moving offshore, and that sensitive military contracts should not be in the hands of a foreign company. That argument was also pressed from the campaign trail by the Democratic candidates for president, Senators Hillary Rodham Clinton and Barack Obama.

The Northrop Grumman-EADS team had quietly gone about polishing its product rather than its rhetoric, proposing a tanker made from a refitted Airbus A330 passenger jetliner that could hold more fuel, troops, and supplies than the rival entry, a modified Boeing 767. Most notably, the winning team built a $100 million state-of-the-art refuelling boom on spec.

Writing in the *New York Times*, David Herszenhorn and Jeff Bailey described the apparatus in action in the skies above Spain, where at 27,000ft an Airbus plane rendezvoused with a Portuguese F-16 fighter. South of Madrid, the two aircraft edged closer until they were connected by a 50ft boom hanging off the back of the big Airbus plane. The boom pumped fuel from one plane to the other, 2,000 gallons in all during several connections. ("In Tanker Bid, It Was Boeing vs Bold Ideas," 10th March)

The *Times* writers noted, "The technology to pass fuel from one plane to another may not be rocket science – in fact, aerial fuel booms have been in use for more than 50 years – but it helped Airbus's parent and its partner, Northrop Grumman, establish their technical bona fides."

❉ Whatever turned the trick, if Boeing and its very vocal protectionist-minded cheering section do not force a reconsideration of the award, Northrop Grumman (Los Angeles) and EADS expect to create nearly 2,000 jobs in Mobile, Alabama, where the new tanker will be assembled from parts made in Europe. The team told the *Washington Post* (10th March) that the number of American jobs supported nationwide could reach 48,000.

As noted by the *Post*: "[The deal] gives EADS a bigger foothold in the US military aircraft business and an opportunity to expand its commercial business. It leaves Boeing, which built the KC-135 tankers that the Air Force has used for nearly 50 years, with the strong likelihood that it will have to shut down its 767 line on which its tanker is based because commercial sales of the aircraft are down."

The Airbus coup from a European perspective

If the rivalry between Airbus and Boeing is a tiresome old story, an article translated from the German and published in the Europe edition of *Business Week* offers some new interest.

In it, Dinah Deckstein, Cordula Meyer, and Gabor Steingart make the point that, for all the hot clamour pumped out by American lawmakers over Airbus as a threat to American workers, the company's contract with the Pentagon for in-flight refuelling aircraft may lead to an accelerated exodus of jobs *from Europe* to Asia and the US ("Air Force Deal Could Cost European Jobs," 10th March)

Harking back to a traditional New Year's address given by the chief of Airbus parent EADS (European Aeronautic Defence and Space Company) at its Eurocopter subsidiary, the three German writers identify a move away from Europe "[getting] underway in earnest."

First, EADS CEO Louis Gallois expressed his gratitude to the workers in the Bavarian town of Donauwörth. Then he told them that the group planned to shift significant portions of its production to the dollar zone.

Mr Gallois said that at least 20% of the group's workforce would be posted in the medium term to factories far from Europe, mainly in Asia and the United States.

As noted by *Business Week*, "Such a shift would represent a major change for the company. Until now, an impressive 97% of employees at EADS and its key subsidiary, Airbus, have held European passports."

The EADS head also said that the group plans to procure both parts and complete subassemblies outside Europe, thereby protecting itself against further decline of the American dollar. Whatever the current woes of the US currency, it remains the principal medium of exchange in the aviation industry.

When the dollar falls, Europeans' profits fall along with it. Meanwhile, *Business Week* notes, EADS pays 70% of its costs in euros.

The article observes: "Until recently, it seemed as though the Gallois speech at Eurocopter was one intended to indicate what the future might hold [rather] than impending reality for German, French, and Spanish workers [at Airbus].

"Now his plans, grandiosely dubbed 'Vision 2020' within the company, will become reality sooner than expected."

- The first outpost of the transatlantic shift is, of course, the EADS research and development centre in Mobile, Alabama, where some 90 American engineers are engaged in research for the European plane maker.

  Plans call for the tanker version of the Airbus A330 to be assembled there, where the company's US partner Northrop Grumman will install the electronic systems.

  But the Airbus plans go beyond the R&D centre. In late January, a month before the US Department of Defense awarded the Air Force contract to EADS, Airbus CEO Thomas Enders visited Alabama.

  If the Airbus/Northrop Grumman joint venture were to win the Air Force contract, he said, Airbus would also be assembling cargo versions of the A330 in Mobile.

  "But this doesn't necessarily mean that Airbus will stop there," notes *Business Week*.

  "Once production has successfully begun in Mobile, this provincial city could conceivably become the fourth-largest Airbus assembly site for passenger aircraft, after Hamburg, Toulouse, and Tianjin, China.

  "There are no such plans at present," an EADS spokesman said.

  Not yet, that is, mused his interviewers.

In brief . . .

- Canada has signed a free trade agreement with the four-nation European Free Trade Association designed to improve access and fuel their $8.7 billion trade relationship. Norway, Iceland, Switzerland and Liechtenstein agreed to remove duties on goods with Canada, the EFTA countries' fifth-largest trading partner in 2006.

Transatlantic Cable

- Canada exports nickel, machinery, and mechanical appliances to EFTA, which together with the European Union forms the European Economic Area.

  As measured by gross domestic product per capita, Canada's four EFTA trading partners are among the 10 richest countries in the world. The accord was signed on 28th January during the World Economic Forum at Davos, Switzerland.

- The city of Chicago has launched a public-private partnership – the Chicago China Development Corporation, with an office in Shanghai – to stimulate Chinese investment in Chicago and aid Chicago-based companies in China.

  Run by former diplomat John C Thomson, it is only one of a number of civic initiatives prompted by Mayor Richard M Daley's conviction that "[in] such a global economy, any city that stands still, loses."

  The burst of civic activity includes a Chicago ambassador to China; Chinese and Arabic – and, soon, Russian – language classes in the public schools; and a public art project on climate change that saturated downtown with globe sculptures. As reported in the *Washington Post* (4th February), the Chicago Chamber of Commerce and city leaders invoked the need for global-city status as a reason for a nearly $300 million increase in taxes and fees proposed by Mr Daley last October.

- Microsoft chairman Bill Gates on 12th March visited Washington yet again to deliver a scolding about America's outdated restrictions on immigration. He told the House Committee on Science and Technology that the failure of Congress to pass high-skilled immigration reform has forced many US firms, Microsoft among them, to locate staff "in countries that welcome skilled foreign workers to do work that could otherwise have been done in the United States."

  Mr Gates is particularly interested in getting Congress to raise the cap of 65,000 H-1B visas – nonimmigrant visas that allow employers to hire foreigners with specific skills. The current limits, he said, have led to a "serious disruption" in the flow of science, technology, and engineering graduates to American companies.

  The Microsoft founder told the lawmakers that, if they were to increase the number of H-1B visas available to American companies, employment of US nationals would likely grow, as well. He said, "Microsoft has found that, for every H-1B hire we make, we add on average four additional employees to support [that job] in various capacities."

Automotive

General Motors has inventory enough to withstand parts-maker strike

A strike at American Axle and Manufacturing that began on 26th February had, two weeks later, slowed or stopped production at 29 General Motors plants; but a GM executive said on 10th March that the auto maker did not plan to intervene in the dispute between the parts supplier and the United Automobile Workers, its labour union.

Nearly 42,000 GM employees, about half the manufacturing work force, had been affected by the strike, the company said on its website 10th March.

By that point, 11 GM plants in Michigan, Indiana, Ohio, Missouri, and Ontario (Canada) had been idled; an assembly plant in Wisconsin was running on shortened shifts; and 17 factories had stopped making some transmissions, engines, sheet metal, and other parts.

The strike had not yet affected sales because GM had a three- to five-month supply of pickup trucks and large sport utility vehicles for sale at the end of February. Analysts had expected GM, over the course of this year, to temporarily shut the factories that build those products.

The strike offered a variation on the usual theme. American Axle, which was spun off from GM in 1994, said it needed the UAW to *accept* steep concessions on wages and benefits – to keep production in the United States.

Struggling Chrysler sets a two-week shutdown for July

The 71,000 employees of Chrysler Corp will be on "mandatory vacation" for two weeks in July when all operations across the country are shut down, the company said 13th March.

As noted by Ken Bensinger of the *Los Angeles Times*, the forced break "is drastic, though for Chrysler perhaps not surprising considering its financial straits."

After losing $1.6 billion last year, the Auburn Hills, Michigan auto maker announced a number of cost-cutting measures. But these may not be enough.

Mr Bensinger wrote, "Unless Chrysler figures out how to increase sales and build cars and trucks that people want, the 83-year-old company's prospects will be dim."

Dennis Virag, president of the Automotive Consulting Group in Ann Arbor, Michigan, went further, telling the *Times*: "Chrysler is in a tailspin.

"In two or three years, there may not be a stand-alone Chrysler company any more."

Chrysler is No 4 in US sales volume, behind General Motors, Toyota, and Ford. After nine years under the direction of Daimler, the German maker of luxury vehicles, Chrysler was acquired in August 2007 by Cerberus Capital Management in a highly leveraged, $7.5-billion deal.

Hopes rose for a turnaround. But slumping credit markets, together with continuing problems of overproduction, excess inventory, and a dealer network far too large for Chrysler's market share, blighted those hopes.

Helped by the sale of its Chrysler division in the US, Daimler on 15th February reported a profit for fourth-quarter 2007. Net income in the quarter was $2.5 billion, in contrast to a loss of $18.4 million in the equivalent period a year earlier, Daimler said. Revenue fell 1.9%, to $39.9 billion.

Dieter Zetsche, the chief executive, predicted further earnings growth in 2008 as demand for vehicles in emerging economies outweighs a looming recession in the United States, Daimler's biggest market.

Its disposal of Chrysler last year will let Stuttgart-based Daimler focus on improving profitability at remaining divisions, Mr Zetsche said.

Elsewhere in automotive . . .

- The German auto maker BMW said on 10th March that it would spend $750 million to expand its Greer plant in western South Carolina, adding 1.2 million ft² of manufacturing space.

  BMW intends to produce a new generation of its X3 sport utility vehicle at the site, and to make the plant the exclusive source for the X3 and X5 sport utilities as well as for the X6 sports coupe introduced at the North American International Auto Show held in January in Detroit.

  The announcement about the expansion in the US, which will create 500 jobs, came two weeks after BMW said it planned to cut 5,600 jobs over two years (5,000 of them in Germany), representing 7.5% of its global work force.

- Porsche Cars North America had sales of 36,680 cars in the US and Canada in 2007, and accounts for nearly 40% of Porsche's global sales volume. From now on that unit of the German auto maker will be focusing entirely on the US market under the leadership of a new president and chief executive who formerly headed up the French operation.

  To oversee Canadian sales, in mid-February the auto maker set up Porsche Cars Canada, a subsidiary based in Mississauga, Ontario. Both companies import Porsche sports cars and are wholly owned subsidiaries of Porsche AG, with headquarters in Stuttgart.

- Ford Motor Co said on 4th March that it is developing a new business plan for Volvo that will set the unit, which it acquired in 1999, to operating on more of a stand-alone basis.

  The Detroit auto maker indicated on its website that a "top priority is to return Volvo to sustainable profitability." Ford in November 2007 took the Swedish luxury brand off the auction block and said it would integrate Volvo more fully into purchasing and development efforts. Analysts consider Volvo the most valuable of Ford's three European luxury brands.

Dorothy Fabian
USA Editor

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Habia extends cable range

Global cable manufacturer, Habia Cable, has further enhanced its market leading range of Flexiform coaxial cables with the introduction of Flexiform L versions that offer a reduced insertion loss over the standard Flexiform range.

Flexiform is a re-formable alternative to traditional semi-rigid cable that can be stripped and formed by hand.

Without the need for special, and often expensive, tooling associated with traditional semi-rigid cable Flexiform also provides a cost effective alternative.

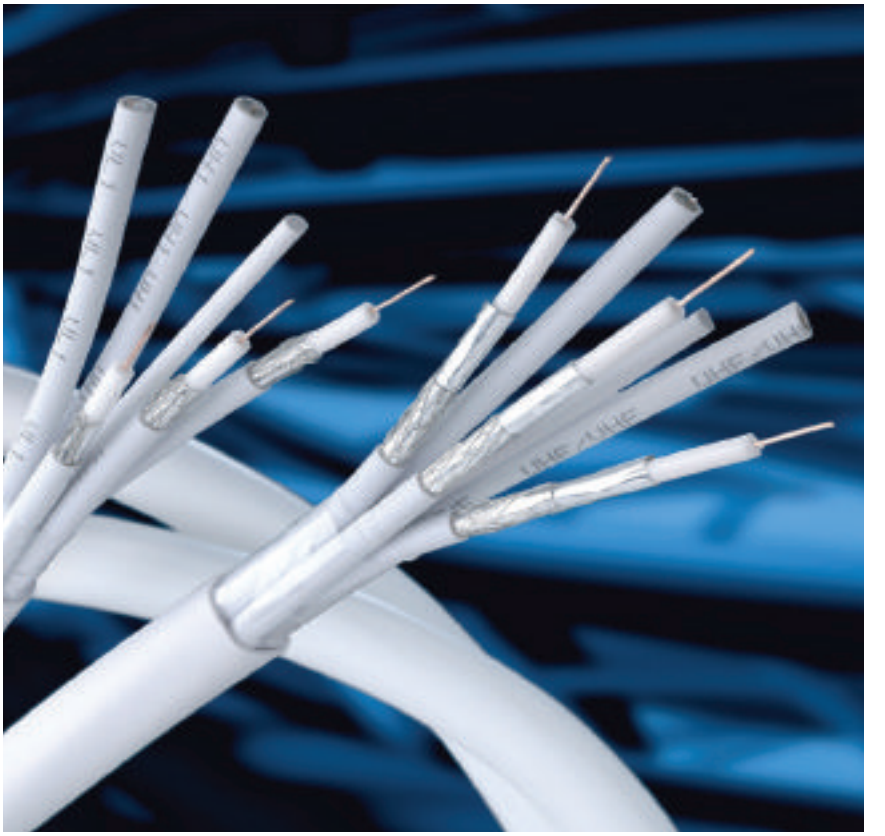
Handling is similar to any standard coaxial cable, so allowing existing cut and strip machines to be used.

Frequently used within cellular base station antennas, the new 'L' versions give the opportunity for antenna manufacturers to incorporate the cable into cellular base station designs and offer antennas providing enhanced call quality.

By introducing a profiled low loss dielectric, Flexiform 401 L and Flexiform 402 L coaxial cables give a 7% reduction in attenuation over the standard Flexiform range whilst maintaining the outstanding shielding qualities.

A range of impedance options are available together with non-magnetic conductor types, various screening options and jacket colours as well as a wide range of material alternatives.

Flexiform 401 L and Flexiform 402 L offer a phase stable product with little dimensional trade-off and no additional cost implication.



▲ *Extending range of cables from Habia*

As with the standard product, a range of different impedances can be provided if required.

Designed to operate from -65 to 180°C the cables are manufactured with a silver plated copper conductor, profile extruded PTFE jacket, tin soaked tin plated copper braid and the option of Fluoropolymer (FJ) or Halogen free Jackets (HFJ).

Flexiform L is also available in a range of alternative colours.

Habia Cable – Sweden
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Email: info@habia.com
Website: www.habia.com

technology at a glance

Sikora's new measuring device contains the latest LEDs combined with high resolution CCD-lines. The integration of state-of-the-art SMD technology ensures the gauge head is very small.

Full story inside

Cometo has been involved in the wire drawing industry for 25 years. The company has a range of high speed electronic traverse units for the spooling process which can be mounted onto existing machinery.

Full story inside

Multi-mode eddy current tester

Magnetic Analysis Corp (MAC) has introduced MultiMac™, a new Windows-based, multi-mode eddy current tester that operates with encircling/sector test coils (to detect short-surface defects) and/or rotary test probes (to identify long, seam-type surface defects).

The new multi-mode capability incorporates all of the best features of MAC's individual encircling coil and rotary probe instruments into one unit.

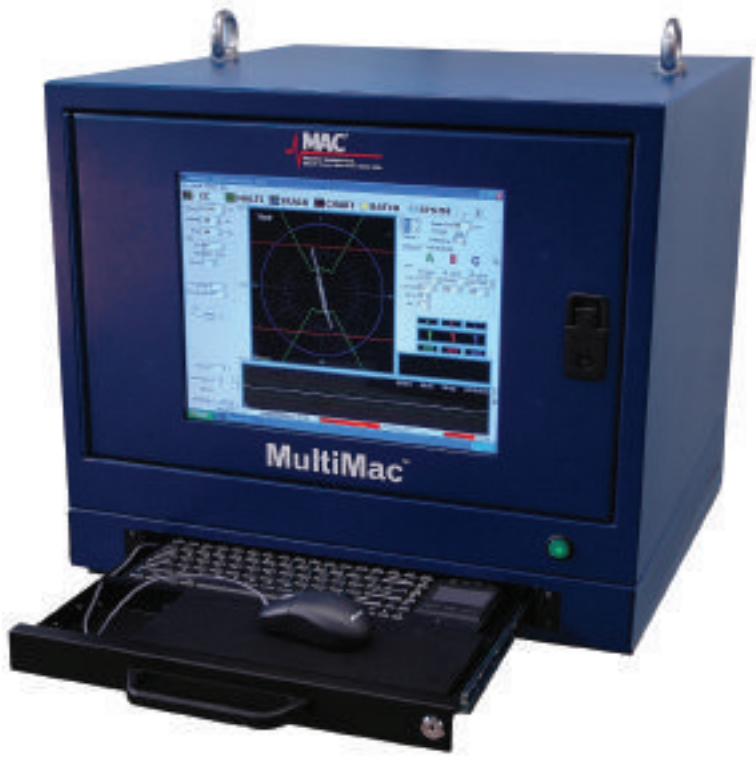
The MultiMac includes up to eight test channels, and a wide selection of test parameters and special circuits to enhance signal-to-noise ratio.

Building on the successful Echohunter® software graphics, the instrument's test screen displays a single channel, and the multi-screen provides a simultaneous display of 1 to 8 channels.

The test screen provides all the information needed to set up and operate MultiMac.

Both screens display simultaneous polar and linear modes and all test parameters, including thresholds.

Each channel on the MultiMac can be individually configured with different frequencies and different channel modes.



▲ *The MultiMac from Magnetic Analysis Corp*

For example, 'differential' mode is used to detect short weld-line defects, while 'absolute' mode is appropriate for long, continuous surface flaws and open welds.

A choice of three thresholds per channel – All Phase, Sector, or Chord – can be mapped to any of eight outputs, independently configurable for time or distance delay and normal reject or latched mode.

With these features, MultiMac can be used to test a wide variety of non-magnetic products, or inspect magnetic material by using Direct Current saturation systems.

A special configuration of channels, based on flux leakage phenomenon, provides detection of very small subsurface steel inclusions in copper or aluminium rod.

Test speeds for the MultiMac can range from one fpm up to several thousand fpm. MultiMac offers end-suppression circuitry with optional optical sensor to prevent false signals from leading and trailing ends.

The MultiMac offers enhanced recording capability and remote access through in-plant networks or the Internet.

Featuring user-configurable reports, data output can include customer and product information, defect location, time, amplitude, and phase. Reports can be stored locally on a network server or on a flash memory device using the USB port.

Operator interface for the Windows-based system is by use of a keyboard and mouse. The all-inclusive model, designed for demanding plant environments, consists of a sealed, heavy-duty cabinet with a built-in 17" monitor, air conditioner and pull-out keyboard. Other smaller models can be supplied with pull-out keyboard, air conditioner and separate, optional monitor.

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Wire cleaning for plating quality

Decalub's new in-line Pressure Wet Cleaning (PWC) system is used to clean drawn wire of lubricant residue to obtain a smooth and glossy finish to 'plating' quality, at a rate of 6 to 14 m/s (1,200 to 2,800 ft/min) dependent on the wire size.

The system simultaneously performs surface cleaning and polishing, in-line with the wire drawing machine and is used for the most demanding wire cleaning and polishing applications using standard cleaning medium including cold water, water emulsions and oil.

The wire leaves the cleaning unit completely dry, ultra-clean, with a highly reflective appearance.

The PWC system is particularly recommended for cleaning applications in which a traditional process is inappropriate, especially with wire drawn in severe conditions resulting in increased heat and burnt lubricant tightly bound to the wire surface and embedded in micro-cracks and longitudinal scratches.

Exceptional cleanliness obtained in smooth and glossy finish in 'plating' quality permits wire direct brass coating, zinc coating, copper coating or painting, and wire cleaning prior to heat treatment applications including patenting, annealing, welding and cladding.

▲ *Wire cleaning and polishing by PWC system*

In demanding applications, including production of highly 'reflective' wire, the PWC system revolutionises the wire cleaning, enabling considerably higher surface quality of the end product. The new Decalub wire intermediate dry re-coating process, permits a smooth and 'frictionless' drawing with completely water soluble sodium lubricants in all drafts, easy to clean in-line at high speed with 'rust preventive' additives.

As a consequence, the PWC offers significant downstream benefits and process savings with the potential to replace acid and ultrasonic methods.

Decalub – France
Fax: +33 1 60 20 20 21
Email: info@decalub.com
Website: www.decalub.com

Programming made easy ...

Simply programmed via touch-screen with animated icons and using CAD coordinate input, Pave Automation believes Panther X3 to be the easiest to programme machine the company has produced.

Simple, but not basic – this latest 13-axis wire bending machine is designed for sequential forming of three-dimensional components of 1.5mm to 6.35mm in diameter and up to 3m long.

Six bending shafts offer the forming of multi radii – up to 12 differing selections can be programmed – and 13 programmable axes allow sequenced operations to be performed that were never previously possible. These include the use of a single forming mandrel to produce up to three different radii.

Panther X3 offers carriage speeds up to 80m per minute, and ten bending speeds up to 0.05 seconds for 180°.

▲ *Panther X3*

Three bending shafts per bending head ensure repeatability on angles of ±0.05°. For ease and reliability, Panther X3 is coil fed with a twist-free wire straightening system to maintain efficient throughput. X3's clamp unit allows 360° rotation with ten programmable speeds up to 0.02 seconds for 90°.

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Faultless strand take up

Maschinenfabrik Niehoff has developed an automatic opto-electronic traversing system, NBAT (Niehoff Bunching Automatic Traverse), for its bunching machines.

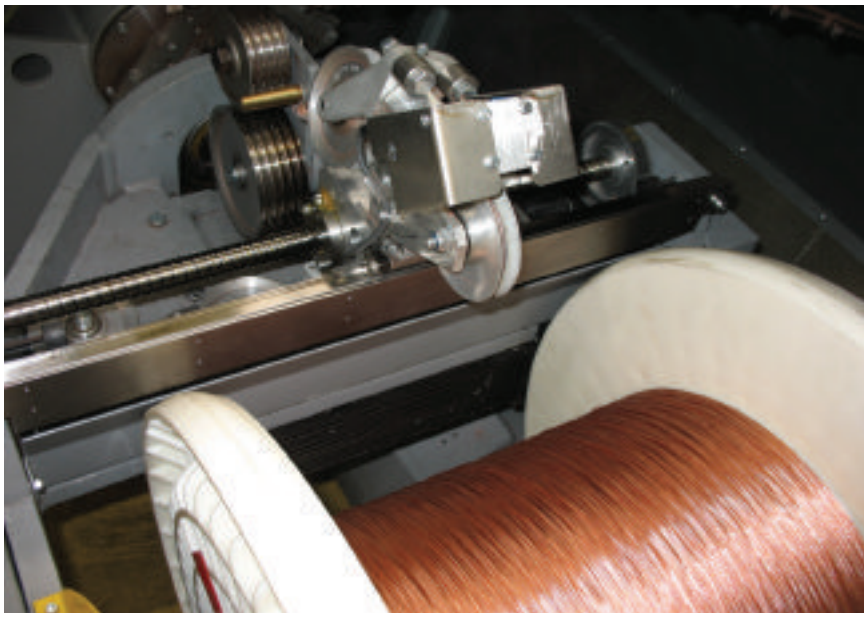
When strands are being taken up on spools, the area close to the flange of the spool, where the traversing direction changes, is critical.

If the turning points on the traversing unit are not precisely set, there is a potential of strand loops overlaying each other or of voids being created between them, causing them to slide onto each other and tangle.

This erratic lay results in poor and rough payout strand during the next operation, causing wire overstretching and possible wire breaks.

The new traversing system, which has already been successfully tested in the field, ensures that the strands are wound in a uniform pattern.

The NBAT consists of a separate electronic unit and two laser sensors located at the traversing shaft.



▲ *The new NBAT automatic opto-electronic traversing system for Niehoff bunching machines*

The system performs two essential functions, and eliminates the need for the machine operator to set up the machine whenever a new spool is loaded or whenever the traversing settings are readjusted during spool filling.

The system automatically detects the flanges of the spool at the first traversing stroke and continuously adjusts the traversing turning points during the spool filling operation. The system also continuously scans the winding surface. Whenever it detects any 'hills' and 'valleys', it sends control commands to the step motor of the traversing unit to ensure that they are corrected immediately for a uniform and smooth lay.

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Wire coating solutions

▲ *Bekaert is a wire coating technology specialist*

Bekaert, Belgium, is a specialist in wire coating technology and an expert in flat and shaped wires.

The company has launched new coatings to support new applications.

Solutions offered by Bekaert include: shaped wires with a PVC coating; high corrosion resistance combined with special chemical compositions; special colours for design projects; and complex forms in steel or stainless steel.

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Software suite removes the guesswork from building large scale FTTH networks

Draka has announced that its proven software network management suite will be an integral part of the Draka XS.Net package of services and products for next generation broadband implementation.

The Draka Software Management Suite comprises four integrated software tools which cover network design, project management, identification and registration and installation planning. The result of a substantial investment over a period of 20 years, the tools have been developed from Draka's turnkey project experience of building traditional telecom networks in Saudi Arabia, Ghana, Indonesia, Turkey and other dense urban conglomerations around the world. Typically, the software allows an engineer to handle and manage all of the functional tasks necessary to control a major FTTH project.

The software has proven itself in FTTH projects such as Amsterdam's CityNet with claimed savings of over €2 million. In building the first phase of the Amsterdam FTTH network, the Draka software system accelerated customer connection time and cost by automating the project flow for approvals, permits, logistics and contractor participation.

As each FTTH project varies in size, shape and environment, intelligent, self-learning software tools are essential to standardise and automate the process of building and managing the entire construction supply chain. The Draka software suite was originally developed to plan and manage copper cable networks in overseas environments involving as many as 1,500 components. As the average FTTH project, each of which is unique, comprises some 500 components, the software has proven to easily accommodate FTTH environments, helping standardise the entire process while giving fine control of the supply chain, from product inventory through to the end consumer registration identification.

The four fully integrated component modules that make up the Draka XS.Net software suite include: Net.DesignXS, which guides the designer in mapping a network, together with all materials and labour resources required; Net.ProjectXS for project, product and materials management covering supplier details, pricing, technical information, store inventory management, and contractor definitions and job control; Net.IDXS, dedicated to network registration and allows viewing of all of the route connections in the entire network in GIS form, giving visibility over all customer connections; and Net.PlanXS custom-tailored planning software which details project addresses, house registration, installation planning and registration of digging and installation permits, as well as an automatic messaging service between the various partners involved in the project.

As of February 2008, independent contracting and engineering companies will be able to be certified to use Draka XS.Net modelling tools, logistics and planning software.

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ZW-R heavy drum trailers for slow traffic

▲ *ZW-R series drum trailer*

After the major success of last year's LTV-R drum trailer for speedway traffic, Venrooy Cable Equipment has now introduced a series of six drum trailers for slow traffic: the ZW-R series. This new series has the following product features that enable cablers to work much more efficiently, safely and simply:

- an upside opening rear bridge (much easier insertion of the drum)
- broadening the trailer later is easy and cheap, simply by using a broader in-between piece (lowers investment, therefore more efficient)
- advanced quicklocks for axle insertion block (securing faster and easier)
- a new drum-drive concept, with direct drive on the axle (more precise, no slippage)
- broad tyres for perfect grip on soft terrain (safer)
- extensive lighting in the rearbridge (safer)

The ZW-R is protected by European registration.

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ERP software for cable manufacturers

InnoVites BV, a Dutch software development company, has announced the development of 'InnoVites for Cable' enterprise resource planning (ERP) software for cable manufacturers, based on Microsoft technology.

The innovative ERP product combines the power and the user-friendliness of the Microsoft Dynamics AX platform with best practices from lean thinking applied in the cable industry.

InnoVites for Cable is designed to help cable manufacturers improve their business performance.

Albert Groothedde, CEO and co-owner of InnoVites, commented, "This is a unique opportunity for our team to create value for cable manufacturers. We combine our knowledge about best (lean) practices in the cable industry and our experience with the development of cable-specific enterprise applications. This is now leveraged with the powerful, user-friendly Microsoft Dynamics AX platform. We are really well-positioned to pursue our mission: to help cable manufacturers around the globe to improve their business performance through our enterprise applications."

Herman van der Weerd, VP operations and services of InnoVites, was the co-founder of the company Proloq, which extended the Baan software to make it fit for cable manufacturers more than 15 years ago. The software has been installed and used successfully by many cable companies around the world.

Dick de Jong, VP products and technology, was product architect at Proloq, and has worked with cable companies to understand their business needs.

Mr de Jong commented, "Cable manufacturers, no matter the size of the business, have to compete in a global competitive arena. Today's cable manufacturers do not just deliver cables; they deliver telecom or power solutions, tailored to their customers' needs, at the right location, at the lowest costs and just in time. They need modern, innovative technology to be able to support complex logistical operations and interact seamlessly with their business partners to meet the customers' expectations. We are excited to fulfil this need by merging modern IT concepts with our in-depth knowledge and experience in the cable industry."

Microsoft Dynamics AX (formerly Microsoft Axapta) is an adaptable business-management solution that enables users to make business decisions with confidence.

The familiar working environment helps lower learning curves so users can focus less on technology and more on their business goals.

Users can define links to favourite forms and applications, and gain easy access to them from individual screens.

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Eddychek advanced eddy current equipment

The touch-screen operated Eddychek® 5 advanced tester from Prüftechnik NDT GmbH, Germany, offers fast and accurate detection of defects in wire, welded tube, seamless tube, bar and non-round profiles in all kinds of ferrous and non-ferrous metals.

In combination with this tester, Prüftechnik NDT provides sensors and transducers in a wide range of shapes and sizes, magnetisation and demagnetisation units, encoders and markers, and also offers entire turnkey testing tables. For the detection of longitudinal defects on wire, bar and seamless tubing, the company offers rotating systems in three different sizes.

Eddychek® 5 advanced features two testing channels with a large selection of parameters for close adaptation to the testing situation, and precise defect evaluation using sector and circular masks. It enables automatic marking of defects and sorting of faulty parts. User-friendly menu-guided software with online help in a large number of languages makes operation of the tester easy. It can be readily integrated into existing company networks and incorporated in central production control systems. Test results can be archived either on Eddychek 5 itself, or on a PC or server.

Additional statistics and recording software includes the Eddychek 5 Viewer for visualising statistics and defect location reports, and Data Logger for recording test signals and viewing previous test signals. As a specialist in eddy current inspection systems for the semi-finished products industry, Prüftechnik provides the industry with a wide portfolio of testing equipment for reliable quality control.

▲ *Prüftechnik's Eddychek 5 advanced*

Eddychek and Novaflux systems are used to test and document all types of semi-finished tube, bar and wire during the production process or final inspection.

Applications include the testing of tube, weld seams, bar, wire, thick-walled tubes and cold heading. Eddychek 5 meets an extensive range of international standards, including ASTM, API, BS, JIS, ETTC, ENEL, DIN and SEP.

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Zwick builds flexible robotic testing systems

The 'roboTest F' robotic testing system is designed for flexible specimens, such as films, textiles and fleece materials, but even metals and wires can be tested using the corresponding grips and tooling.

The main benefit of this sophisticated testing system is its ease of use. It allows testing to be carried out overnight and at weekends thereby reducing the need for shift working and saving costs for many organisations. In addition it is possible to carry out testing using unsupervised or relatively unskilled operators. The variance which often occurs with traditional testing systems is eliminated resulting in much better accuracy and reproducibility over time.

The sequence starts by entering specimen data into a database, either locally or in an external database or host computer. The operator simply loads the specimen into a special magazine.

Once tested, the specimens are either blown out of the grips using compressed air or are mechanically removed by the robot system. The magazine is adjustable over a range from 100 to 300mm to accommodate different specimen lengths and shapes.

Zwick's product manager for automation, Robert Kaifler, explains how it is possible for robotic testing systems to achieve more accurate and consistent results: "The positioning accuracy of robotic systems means that they are able to handle and place the specimen into the testing machine in perfect alignment every time. With different operators and shifts this is not always possible, and in addition extensometry used to measure strain during the test can be applied and removed automatically without any human contact. The complete test sequence is controlled by software and results can be automatically logged into databases or spreadsheets avoiding typing errors. With the whole process being very easy to administer it ensures that the testing system follows precisely the same procedure every time."

Robotic testing systems simplify the processes required for quality management systems such as ISO 9001 because the testing sequence is pre-programmed, and not subject to human error. Results and long term statistics are also available in real-time helping to minimise communication inefficiencies between production processes.

▲ *The 'roboTest F' robotic testing system*

Zwick has used a modular design concept which allows testing sequences to be changed or adapted to customer specific requirements. These systems can even be retro-fitted to existing Zwick testers.

By using Zwick's testXpert® software platform host computer systems can be interrogated to find out the test specification which then allows the specimen remains to be handled differently after the test depending on whether they pass or fail.

The test system illustrated shows a tensile tester and a roboTest F system.

The system has two axes of movement including a rotating clip carrier which can hold up to 200 test specimens. Depending on which specimen types or shapes are to be handled, the carrier uses metal clamps, braces or magnets in any combination, so it is feasible to test strip metal, wires, or films and textiles using the same system. Manual testing can also be performed whenever necessary by simply disconnecting the robot.

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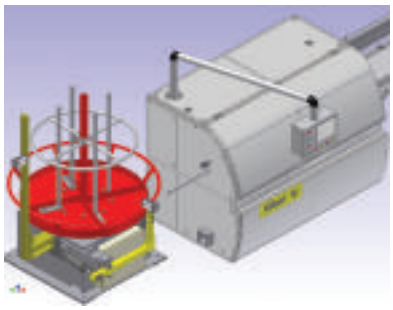
New automatic wire straightening and cutting-off machine



▲ *Vitari manufactures wire processing machines*

Vitari, Italy, has launched the NR222 automatic wire straightening and cutting-off machine, which can process wires from ø2 to 10mm, with feeding speed electronically variable from 30 to 200m/min.

Main characteristics include bar length measuring made by an encoder and wire cutting realised by brushless servomotor. The collecting bench of the machine is modular, composed of cutting bench of 3, 6, 9 or 12 metres. The machine is equipped with a movable stopping device: a display shows the operator the required bar length size, and the stopping device can be moved manually to the correct position in order to obtain a more exact bar length.

Vitari has over 80 years' experience in the manufacture of wire processing machines, including nail, chain, gabion, chain-link fencing, high-tensile barbed wire and dress hanger machines.

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Hydraulic crimping pliers for connecting two wire ends

Petig has developed a new solution to the problem of joining a wire end with the start of the wire of a new coil.

The new method allows the connection of two wires with the help of a short length of tubing, which must meet the requirements as the wire is pickled or annealed.

Petig's Hydrocut steel cutters are well-suited to this application.

Instead of a shearing blade, crimping tools are employed, that are provided with a tooth-shaped crimping edge.

Prior to the crimping, the connection tubing is pushed over the end of one coil and the start of the second coil.

The Hydrocut, in this case model HC 530-3W, is then used to apply two crimping actions, and the connection is ready.

A tension test has shown that 25-30 kN can be achieved.

▲ *Petig's Hydrocut used to join wire ends by crimping*

The value depends on the strength of the wire and the penetration depth reached in the crimping action. The crimping pliers and the hydraulics can be supplied as a mobile unit that is easily transported.

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Sikora's first gauge with LED light source

Sikora has launched the newly developed LED 8025 XY, for the measurement of several cable types, including those with a transparent insulation layer.

The latest LEDs, combined with high resolution CCD-lines, create the foundations of the measuring device.

With the help of powerful software, the shadow width of the measuring object is calculated and the outer diameter precisely defined.

▲ *Sikora's LED 8025 XY provides precise measuring values for transparent products*

For the measurement of cables which have a transparent insulation layer, the LED 8025 XY provides optimum reliability. The integration of state-of-the-art SMD technology ensures the gauge head is very small and can easily be installed into any production line. The LED 8025 XY is designed for product diameters from 0.25 to 25mm.

The gauge head is equipped with vertically arranged glass windows, which offer protection against dirt. Additionally, the LED 8025 XY is open at the bottom, which prevents both dirt and water contaminating the measuring area. The device is equipped with an RS 485 serial interface and RS 232 diagnostic interface for direct connection of a line control system or Sikora's Remote 2000 or Ecocontrol 600, 1000 and 2000 control devices. Optional Ethernet RJ45, Profibus interface or analogue outputs are also available.

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Italian control cables

▲ *KC Industrie is a specialist in control cable production*

KC Industrie, established in 1996, is a successful company in the field of control cable production. The company houses a fully automated plant using the latest manufacturing technology. It benefits from the IEMMEQU HAR, VDE, UL, CSA and SEV quality labels, and ISO 9001-2000 certification, guaranteeing the quality level of the production process.

KC Industrie's manufacturing capabilities and expertise ensure that finished products meet or exceed agreed standards, and its internal quality assurance department monitors the process through every step, from order to delivery.

The production range includes cables from 0.14mm^2 to 70mm^2, and from 2 to 61 cores, screened and unscreened. The company uses first quality thermoplastic compounds to manufacture its cables, including PVC, halogen free, PE and PUR.

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Sonobond Ultrasonics' spot welding technology

Ultrasonic welding and bonding technology specialist Sonobond Ultrasonics has announced that increasing numbers of companies are relying on its microprocessor-controlled spot welding technology.

According to Janet Devine, the company's president, manufacturers are reporting that the SonoWeld® 1600 digital metal spot welder series is proving to be dependable, efficient, and easy-to-operate, citing Lake Cable, LLC as an example of a company that is obtaining impressive results from the technology.

The company encapsulates cables in metal sheathing and extrudes overall jackets over its control, instrumentation, and power cable product line.

Lake Cable needed to update its spot welding machine at its 100,000ft^2 Prairie Cable facility in Valparaiso, Indiana. According to that facility's maintenance manager, Chris McLaughlin, they were already familiar with many of the advantages of Sonobond technology.

"We had been using a 20 year old Sonobond machine and were very pleased. We knew there were other assembly methods but, unlike ultrasonics, these other methods were less efficient and used consumables. We didn't want that. When we contacted Sonobond to replace a manual we'd lost, they recognised that a newer, customised unit could help us improve our existing processes."

Sonobond responded promptly by providing free sample welds and a recommendation that Lake Cable, LLC replace the current unit with a specially modified version of the 2,500-watt SonoWeld 1600 digital metal spot welder.

This new unit featured a custom anvil slide assembly, as well as a modified frame to accommodate material up to 4.5" in width. It also enabled the unit to weld on an angle so that the stress would be spread out to make a stronger joint. As a result, it was found that the weld strengths of the new joint equalled 90% of parent material strength, and a ¾" weld took only ½ second.

Other features that make the SonoWeld 1600 popular with manufacturers include a power supply with built-in microprocessor to permit storage and recall of over 250 weld protocols.

The easy-to-operate unit also features automatic frequency control, overload protection and automatic quality monitoring.

The efficient metal spot welder has heat-treated, tool steel taper lock tips that can perform up to 300,000 welds before being replaced. A digital display allows selection of welding modes by time, energy or final weld thickness.

In ultrasonic welding, high frequency ultrasonic energy is directed via a welding tip to the surfaces for the metals to be welded.

The energy disperses the oxides and surface films between the work pieces to create a true metallurgical bond without melting the materials. Ultrasonic welding is environmentally friendly, produces no waste, and is economical.

The patented Wedge-Reed coupling system assures precise, dependable welds and can be mounted in a variety of orientations for special applications.

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▲ *Spot welding technology from Sonobond Ultrasonics*

Electronic traverse unit for automatic spooling process

Cometo's continued interest in electronic research has led to the manufacture of the STR-E traverse unit which is available in three models: STR-E 10, STR-E 25 and STR-E40 with an axial force of 13, 30 and 50, respectively.

Developed by the company in order to improve the quality of the spooling process and reduce the operator's work time, the STR-E electronic traverse unit automatically winds the wire over the width of the spool, so that there are no overlaps or missing contact with it and hence a consequent improvement in the production quality.

As technological developments have allowed machines to work automatically and at faster rates, the spooling process must be perfect. This is achieved by the STR-E traverse unit.

The unit can be mounted on new or old machines (even 30 or 40 years old), which increases their value, thanks to its enhanced performance. The STR-E traverse unit adapts to the speed of the machine it is mounted on: when the machine slows down or speeds up, the traverse unit movement automatically slows down or speeds up and when the machine stops, the equipment stops as well. The unit is equipped with a grooved base for a rapid mounting on any kind of machine, sliding bars made in hardened and ground steel, and a traversing block made in aluminium alloy with ball bearings. It is driven by a step motor and a toothed belt which provide for the highest precision and speed in the reversing process. Models with a brake for special applications are available with the option of a rotary or linear position transducer.

▲ *The STR-E traverse unit*

The equipment allows for a high energy conservation thanks to a consumption of only 25 Watts. The equipment allows for the storage of up to 99 programs which are always ready to be reused and it is equipped with a standard monitor of 4 rows with 20 characters, PC connections, CanBus network, programming terminal and I/O interface to connect other machines.

The STR-E traverse unit has been manufactured in different models in order to meet the client's needs and increase their productivity.

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Category 7a cable with a model's measurements

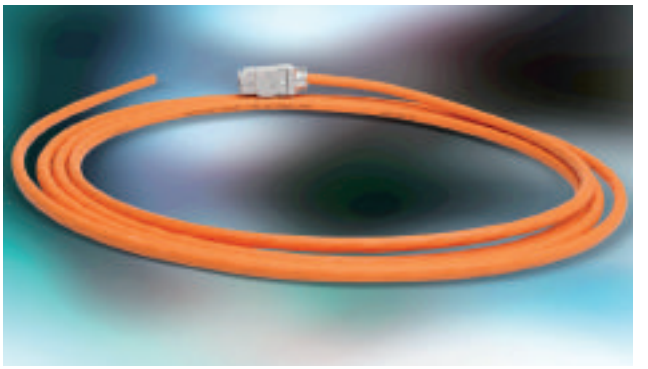
With its twisted-pair Uninet 7120 data cable, Dätwyler Cables has extended its range of Class FA systems by a very thin, high-quality PiMF cable (Pair in Metal Foil), meeting all the requirements for Category 7a (augmented).

The Uninet 7120 has a copper wire diameter of only 0.58mm, corresponding to AWG 23. In combination with high-performance connectors, these comparatively economical high-speed cables can be used for up to 1,000 Megahertz (MHz), thus enabling them to transmit even applications such as 10Gbase-T (10 Gigabit Ethernet) without problems.

"With our current innovation, we have succeeded in raising the Cat.7a quality to AWG 23 diameters for the first time", explains Markus Grüter, head of market region 1 of Dätwyler Cables.

"The high reserves of the Uninet 7120 provide long-term investment security with regard to future applications and upcoming data transmission rates, but with far smaller space requirements and at an excellent cost/benefit ratio."

When installing a Local Area Network (LAN) that must meet the requirements of Class EA (up to 500 MHz), AWG 23 data cables – and particularly those in Category 7 (up to 600 MHz) – are a popular choice.



▲ *Dätwyler Cables' very thin (AWG23) twisted-pair data cable Uninet 7120 meets all the requirements for Category 7A (1,000 Megahertz)*

At 1,000 MHz, the Uninet 7120 offers even higher reserves for the transmission of digital and analogue voice, image, multimedia and data signals in this range.

In addition, its Cat.7a quality makes this an ideal cable for economical, space-saving, high-speed connections in computer centres. The new data cable has a FRNC/LSOH sheath, is 7.4mm thick and weighs only 63 kg/km, with a copper count of 32.3 kg per km. At 1,000 MHz, its attenuation is less than 60 decibels (dB) and NEXT-value (near end crosstalk) is 90 dB.

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Borealis boosts competitiveness of low voltage cable producers

Borealis, a leading provider of innovative, value-creating plastics solutions, has launched a unique high productivity, low voltage cable insulation material that will boost the competitiveness of cable manufacturers.

Making its début at wire 2008, new Visico™ FX LE8823 delivers 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 an innovative base material for low voltage moisture cured XLPE cables which enables faster production of consistently high quality cables. Its outstanding crosslinking speed is twice that of 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 the leading industry advances in curing speed, Visico FX improves productivity by delivering a consistent, high quality product with less down time required for cleaning. Suitable for running on standard extruder equipment, the new material shares the unique scorch retarder technology of standard Visico material. This creates a smooth production process with minimum change required, higher output and less scrap.

Moreover, Visico FX offers time and cost saving benefits to grid owners and cable installers.

The material gives cables greater flexibility, thus improving ease of installation and helping to significantly reduce time and cost.

Hans Christian Ambjerg, vice president 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 has over 40 years' experience in developing solutions for the wire and cable industry and is a world leader in this market segment.'

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NDT equipment from CMS

▲ *NDT equipment from CMS*

Contrôle Mesure Systemes is a leading manufacturer of NDT equipment, specialising in eddy currents, flux leakage and ultrasound testing.

The company focuses its activity in the field of equipment for the inspection of tube, bars, wires and special profiles for the detection of surface defects by eddy current and sub-surface defects by ultrasound.

CMS has the ability to supply complete system re-vamping, or just few accessories. A sister company gives CMS the knowledge to provide drawing or full mechanical systems, for EC, MFL and UT.

All CMS equipment is in compliance with the strictest standards such as API, DIN, ASMT and GOST.

The company has a worldwide network of agents that assure the distribution of CMS equipment in more than 25 countries.

CMS is also able to offer fully customised systems, multi-channels, multi-frequencies with heavy specifications.

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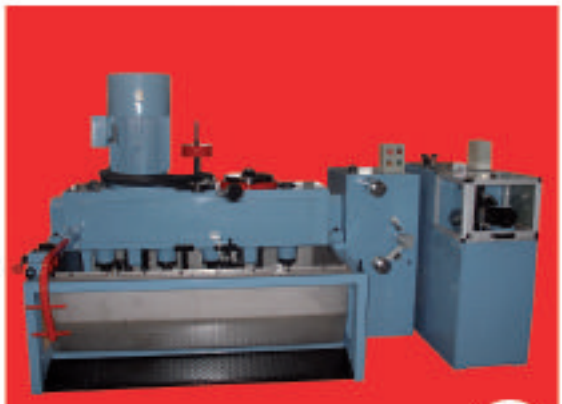
JIANGSU JINTAILONG

JIANGSU JINTAILONG is the largest equipment manufacturer in China for the steel cord making industry. Over the years we have made high-quality, cost-effective machinery for some of the best-known steel cord producers in the global tyre market. Long-term relationships with our customers have been built upon our proven innovation and our ability to take designs through development and into real-time production. Come to JIANGSU JINTAILONG for high-quality, cost-effective steel cord equipment.



1. plating line
2. dry drawing machine
3. 23 Wet drawing machine
4. double twisting strander
5. wet drawing machine
6. wrapping machine

JIANGSU JINTAILONG MECHANICAL AND ELECTRICAL EQUIPMENT MANUFACTURER

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Image credit Messe Düsseldorf®

Expect plenty to see, learn and do at the Wire Association International (WAI) Inc Wire Expo 2008, June 7th to 11th.

WAI's Wire Expo event began in 1990, and has visited a new US venue every other year since then. The event schedule coincides with WAI's Annual Convention (2008 will be the 78th) and features exhibits, technical paper presentations, plant or area tours, networking, and social activities offering visitors and exhibitors fresh insights to the wire and cable industry in a convenient and relevant location.

Wire Expo 2008 will take place in Pittsburgh, Pennsylvania, a city situated at the convergence of three rivers, accommodating 944 bridges, and recognised for its important industrial history. Pittsburgh today is home to over 170 research laboratories and can claim more doctoral scientists and engineers per capita than Boston, Los Angeles or San Francisco.

For more information about visiting Pittsburgh, see www.visitpittsburgh.org

Presentations and exhibitions will be held in the award-winning David L Lawrence Convention Center – the only meeting venue of its type to be awarded the Gold LEED (Leadership in Energy and Environmental Design) by the US Green Building Council.

Wire Expo 2008

Wire Expo 2008 is an opportunity to make contacts, sharpen up on best manufacturing practice and learn from in-depth technical presentations from acknowledged experts in the field. Technical information will suit all levels of expertise and the event begins with a back-to-basics two-day workshop for students and newcomers to the industry.

Social and networking functions will include a baseball outing to PNC Park, and the 'see and be seen' Opening Reception to be held on the rooftop of the convention centre to a backdrop of exceptional city views. Before the presentations begin, Sunday offers the chance to explore Pittsburgh's industrial heritage with the Carrie Furnace Hard Hat tour, a renovation project based around the Monongahela Valley's oldest blast furnace.

Full details for both attendees and exhibitors, can be found at:

www.wirenet.org/events/wireexpo

Technical Information
Short course – the fundamentals of wire manufacturing
Technical Paper Presentations
Production Solutions - demonstrations on the exhibit floor
LeanSigma® Luncheon & Plant Operations Roundtable
Practical Extrusion Workshop

Convention Activities
Carrie Furnace Hard Hat Tour – June 8th
Keynote presentations – June 9th
Exhibits – June 9th to June 11th
WAI's 4th Annual 5K Road Race – June 8th

Networking & Social Functions
WAI Annual Meeting, breakfast and awards ceremony
Opening Reception – June 9th
WAI's Baseball Outing: PNC Park – June 10th

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Wire **Expo 2008**

WIREexpo 2008

7-11 June

Wire bending & forming

When the "new" AT&T began its first day on 21st November, 2005, the company celebrated its transformation with a new logo: actually the familiar old one, but revitalised by ribbons of blue circling a spinning three-dimensional globe. It was a shrewd choice, with its suggestion of telephone wire girdling the earth, binding together nations and peoples, working the magic of communications in the far corners.

With all respect to the AT&T design team and their refurbished symbol, reaching and turning those corners was made possible by a speciality that supports not only telephony but also a host of other high-tech applications – automotive, aeronautic, refrigeration – in which connectivity is vital and space is limited. Bending narrow strands of wire without compromising their integrity is a kind of magic of its own, made available to millions around the world by means of the products and services reviewed in this section. A good connection has no static. Bending and forming are not static – but processes on a continuum of improvement. A case in point is the current generation of CNC-based spring formers from Itaya Engineering, of Japan.

These units offer numerical control of wire feed and tool movement to produce complex springs to ever more accurate dimensions, in one continuous operation. A graphical user interface now permits shortened set-up of the forming program with the entry of dimensions as-is. Many generic designs are contained in the control system's memory. The company asserts, confidently and accurately, that these advantages were unimaginable just a few years ago. Even more important – to its clients and to those clients' customers – Itaya is at work on the new functions that it will make available in the next generation of its spring formers. AT&T claims that its new corporate logo "symbolises innovation, integrity, quality, reliability, and unsurpassed customer care." It might have been referring to attributes of the companies represented in the pages of this section.

New Bihler punch-bending machine

The compact RM 40K from Bihler will open up new and promising prospects to all manufacturers who already use an RM 35, RM 40 or RM 40E.

This is due to the RM 40K's compatibility with the tools of these existing machines and an increased performance due to optimised work processes.

The machine's open and accessible layout for radial and linear manufacture offers increased scope for various manufacturing processes (18 drive positions) and allows all Bihler key technologies such as welding, tapping, bolting and assembly to be integrated easily into the manufacturing concept. It therefore makes it possible to manufacture a great variety of parts on this machine.

▲ *RM 40K punch-bending machine*

The larger centre aperture (diameter 125mm, width 200mm and height 84mm) in the work-plate for more flexible central mandrel movements also affords additional integration possibilities from the rear of the machine.

The 90 kN two-point eccentric press is characterised by a larger space for die sets. Dies up to 320mm in length and 170mm wide are easily accommodated here.

To achieve faster tool-exchange and thus increase the machine's availability, all slide units (maximum nominal force 60 kN) are equipped with an innovative rapid tool-clamping system.

The punch-holder interlock is quickly and easily released by a pin.

After the new tool is inserted it must only be fixed using the clamping pin. The old tool mounting-system is also retained so that the RM 35, RM 40 and RM 40E tools can be fitted without any difficulty to the new machine's slides.

In addition, the innovative cam system consisting of a cam carrier and driving disk ensure that the cams are rapidly exchanged.

The cutting-edge, user-friendly VariControl VC1-E, which is fully integrated into the machine housing, enables highest process security. Operation is via a colour 15" TFT touch screen in the right sliding door of the operator protection enclosure.

This new Bihler control generation uses a Human Machine Interface with intelligent operator guidance, comfortable error support and deletion as well as an integrated possibility for remote maintenance.

As an extra bonus, the VC1-E can also be upgraded for multi-axis applications.

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CNC wire bending machines from Pave

Pave Automation manufactures CNC bending machines for bending wire from 2mm to 25mm diameter.

The company's range includes machines for manufacturing automotive car seat wires, making point of sale components and for general 3D wire bending.

Pave estimates that over 1,000 machines have been manufactured over their 30 years in business.

Pave Automation is a family owned business, and brothers Silvio Perna and Antonio Perna are dedicated to the development of new machines.

The company launched its latest addition, the Panther X3 twin head CNC bender, at the wire 2008 exhibition in Düsseldorf.

▲ *Silvio Perna of Pave Automation*

Pave Automation's aim is to develop and supply CNC bending machines that, together with the latest in software technology, will increase the user's productivity by working faster, and more economically.

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Automatic wire and strip forming machine

The main strength of the Bend 50 CNC machine from Nova-S comes from the separate drives of each of the main sections of the machine – feeding, stamping and forming. The cooperation between all three of the servo motors is controlled by its CNC system.

The machine consists of the forming unit, stamping unit, feeding unit with straightener and distribution box with control panel.

The machine's modular construction enables adjustment of the position (distance) of the stamping unit against the forming unit centre.

The control panel displays the production data, operating speed and the reasons for the machine stopping, should it break down.

The machine's control system can be set in either production mode or operating mode which enables die adjustment at low adjusting speeds.

▲ *Bend-50 CNC – automatic wire and strip forming machine*

The Bend 50 CNC machine is designed for the precise and high-speed production of the complex parts of spring wire (maximum 4mm diameter) or steel strip (maximum 50mm width). Brass, copper or aluminium materials can also be processed on this machine.

NOVA-S as – Slovakia
Fax: +421 34 6242 468
Email: novas@novas.sk
Website: www.novas.sk

Electronic straightener from Cometo

The electronic straightener from Cometo enables maximum wire straightening process automation.

The device provides a rapid straightening process using percentage parameters provided by Cometo itself.

▲ *STRE- electronic traverse unit*

The wire straightener can store up to 100 programs to suit specific needs.

The device is equipped with step by step motors and an epicycloidal redactor and is driven by an electronic installation supplied with a display, end switch and a sensor for the positioning of the rollers to make scheduling quicker.

Cometo Snc – Italy
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Website: www.cometo.eu

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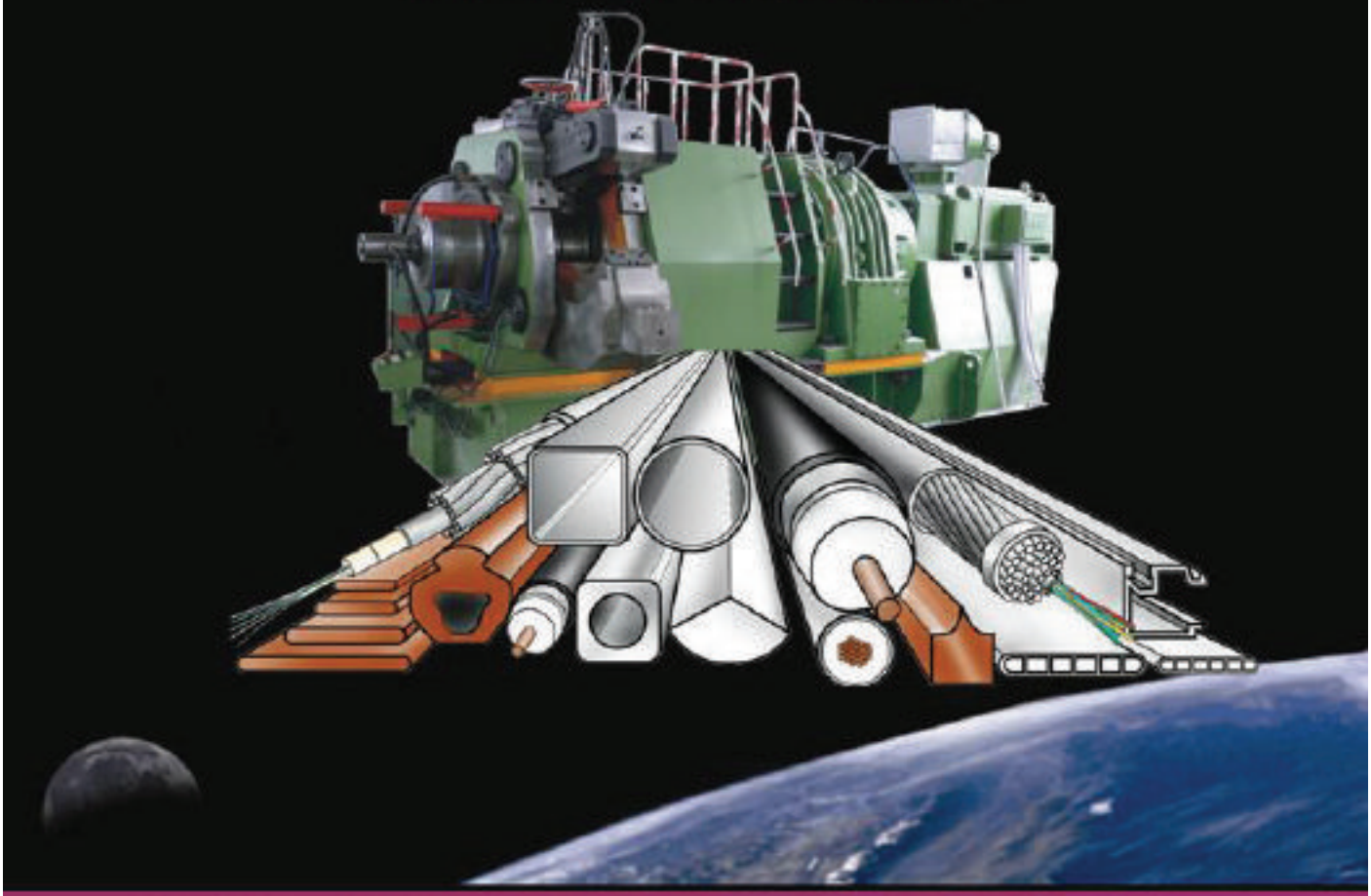
For Copper & Aluminum



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Agent For East Europe
PIP Machinery, Austria
Email: info.pip-machinery.com

Agent For India
Beijing Holland Tech. Co., Ltd
+86 10 68032755/56/57

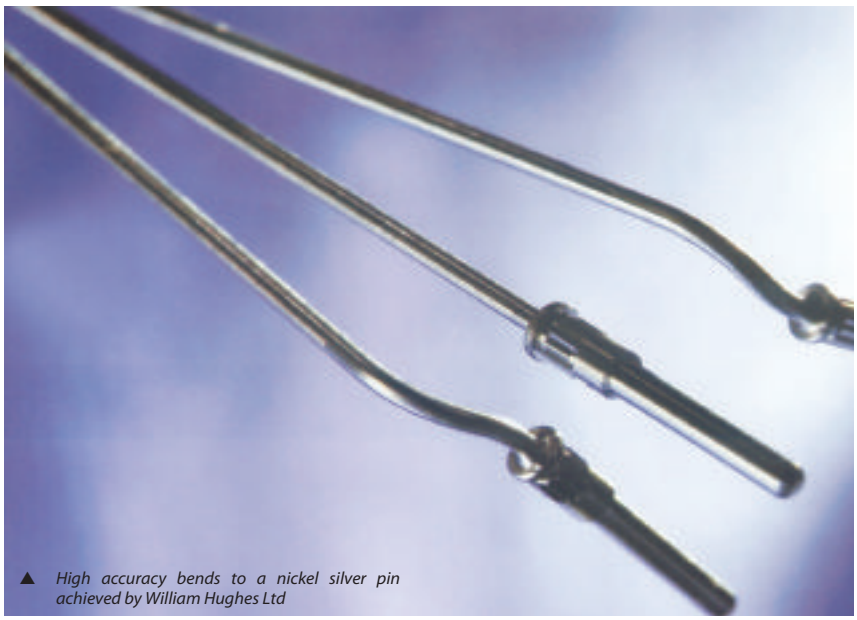
The right bends for perfectly aligned pins

William Hughes Ltd is well known for its specialist skills in the design and manufacture of bent wire parts. When a leading supplier of moulded electrical components for diesel engines needed to manufacture a precision plug assembly using wire pins, it turned to the design and application engineers at William Hughes to provide an accurate and cost effective solution.

The special plug is used in the engine management system and the components needed to be resistant to vibration and high temperatures, whilst providing a reliable electrical contact.

The design of the plug is based on four nickel silver pins approximately 75mm long which need to be positioned very accurately in the moulding. Each of the four pins is supplied to William Hughes as a straight turned part and it is the company's role to apply two high accuracy bends to each pin to ensure that the tails of the pins are perfectly aligned when they are inserted in the moulding.

The plug manufacturer had tried various methods of bending the pins but none gave reliable and accurate results. Variations in the pin material, and the bending process itself, meant that instead of the pin tails being parallel, they were out of alignment by several degrees making them unusable.



▲ *High accuracy bends to a nickel silver pin achieved by William Hughes Ltd*

To achieve the desired result, each of the four pins, left, right, upper and lower have to be bent in a different way. Slight variations in the material used to make up the different batches of pins require the bending process to be easily adjustable to accommodate different 'springback' characteristics.

The design and application engineers at William Hughes used their specialist knowledge of spring materials and production processes to provide an adaptable and accurate solution. This involved the design of a special machine that can work with the wire pins allowing adjustments to cater for the varying characteristics. Four interlinked machines are used to produce the pins in sets. The machine, specially designed by William Hughes, ensures that each pin is positioned correctly before it is bent. As a further check for quality, each movement of the four pins is checked electronically to ensure accuracy and consistency.

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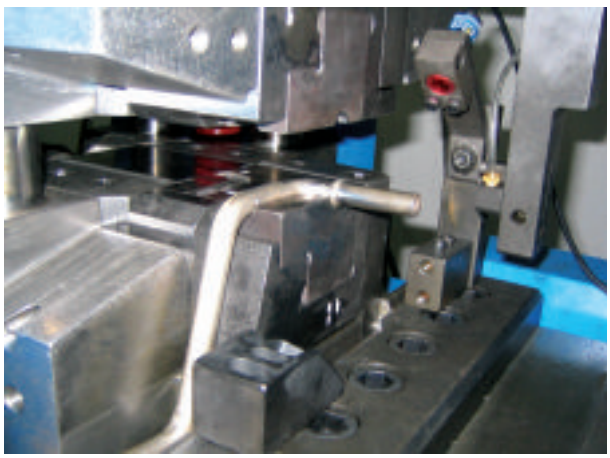
Website: www.wmhughes.co.uk

Hand feed cold formers from Israel

Videx is offering a new line of single or multiple die hand feed cold formers. The machines are designed for production of small and medium size batches of long headed, shouldered or extruded parts which can be either straight or bent.



▲ *New line in single or multiple die hand feed cold formers*

The Videx cold formers are available with 1, 2 or 3 heading stations and in tonnage rating from 50 tons to 300 tons. A threading station is optional on all models.

The feed of the parts is done either from the front (for straight parts) or from the side (for bent parts that need to be collated or headed close to the bend).

Machines are designed for a very quick and simple change-over. The whole gripper die block lifts up pneumatically and die change can be performed outside the machine. The heading tools are reachable from the side and can be changed in a couple of minutes.

The position of the blank is precise due to the retractable positive stop and the stroke is fully adjustable by turning a big wheel at the back of the machine. When supplied as a fully automatic machine, the machine will also straighten, cut to length and optionally thread the parts and bend them.

Videx Ltd – Israel
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Email: videx@videx.co.il
Website: www.videx.co.il

www.niehoff.de

The worldwide partner for the wire & cable industry

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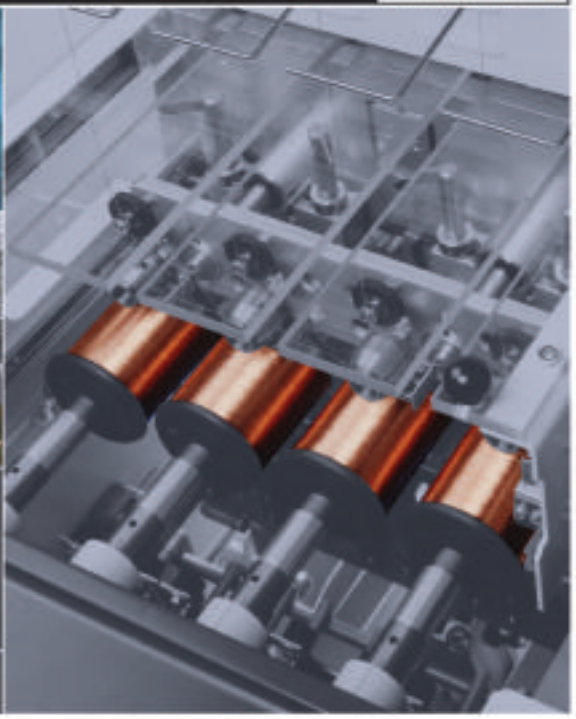

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New machines from Eurobend

Eurobend SA has developed two new distinctive series of automatic wire bending machines, the G-STAR F series, which is a single head (line) machine and the G-MULTI series, which can have from two up to six bending heads (lines) working simultaneously, adapting the machine to any production capacity. Both the G-STAR and the G-MULTI series are available in four diameter ranges, (from 2mm to 12mm, 0.078"- ½") and offer:

- combination of multi-slide production output and CNC wire bender versatility
- unlimited flexibility and increased productivity
- reliability, consistency, minimum changeovers and maintenance requirements

The company's automatic wire bending machines have a combination of features that offer numerous advantages:

- an adjustable counter-torsion (anti-twist) mechanism, ensuring control of wire twist regardless of wire quality, bending direction (patented)
- diameter changes can be completed in less than two minutes, thanks to a carefully designed presetting system
- the two available types of wire bending heads, single and bi-directional, combined with one or both available versions of 3-D bending options cover all wire forming applications achieving high production speeds and product accuracies
- the 3-D wire twisting unit ensures fast production of small and mid-sized wire forms, whereas the 3-D rotating bending unit achieves high accuracies on large 3-D wire forms.

The G-STAR F and G-MULTI range of wire benders are available with the following optional items:

- bending table extension with inclination mechanism
- external hook and spring bending unit
- ring forming attachment
- automatic butt welding device
- chamfering unit
- automatic collection unit
- various types of de-coiling stations

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Website: www.eurobend.com

▲ *Machinery from Oscam*

Pioneers in automatic bending machines

Formed in 1938, Oscam was among the first companies to produce and patent automatic bending machines worldwide, and many of the advancements in cut and bend technology have arisen from the efforts of Oscam's R&D department.

Today, the Oscam production range covers every kind of cut and bend machinery including: combined machines, benders, hoop-spiral machines, shears, portable cutters, mesh benders and cutters, straightening machines, stirrup machines, pulling machines, shearlines, robotic benders, pile caging machines, super automated preshaping centres, loading and storing devices, logistics and advanced interfaces using a remote computer for programming and controlling production.

The company not only supplies the machines but offers a full consultancy on equipping a factory, based on its experience with thousands of customers worldwide, many with extraordinary needs or special environmental conditions.

Oscam sells all over the world, and is a market leader in many of the key countries, with an important presence in the Middle East dating back almost 40 years. Starting from large jobs with contractors such as Makka Road and Jeddah Desalinizator, over the years the company has supplied a large number of fixed installations throughout the region, including the biggest names in the cut and bend business, companies like Cicon (that will soon reach a capacity of 70,000 tons a month with Oscam machines), Union Rebar, Madar Holdings, Extra Co, Emirates Rebar, Corporate Technology, Erf, Bin Al Sheikh, Al Watania, QRC, Dawood Rebar, Yousuf Steel, Al Ansari, Al Fozan, Fulath Factory, Attieh Steel and National Steel Technology Co.

Many of the largest contracts in the region were made with Oscam machines. Cut and bend companies and big contractors choose Oscam machines for their reputation for reliability, sturdiness, extremely high output, ease of use and advanced ergonomics.

Oscam will not only advise the most efficient solution for users, and supply and install the machines, but also provide professional training for the factory's staff as well as provide an efficient after sales service. Oscam holds a comprehensive stock of spares, including parts for machines that have been out of production for many years.

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Website: www.oscam.com

Forming and welding machines

Since 1991, Ultimation Machines has been designing and manufacturing innovative CNC wire forming and welding machines, used for the manufacture of a wide range of wire products from POP displays to automotive components.

The range includes the well established ULTIMAT UMW series of 2D wire forming and welding machines, which feature a robust, modern, modular design, and user friendly Windows® based software.

Comprising six standard models for processing wire ranging from 2.00mm to 16.00mm, all ULTIMAT models use a closed die forming and cutting system, which produces high-quality bends with square, burr-free cuts.

The UMW can be combined with the innovative UCW series of machines, to create a fully integrated forming and welding cell, with rectangular butt-welded frames being produced directly from coil, on the UMW-65 wire forming and welding machine, and then the completed frame being transferred into the UCW-65 whereupon the frame's support/brace wire is fed direct from coil, straightened, cut to length and welded into the butt welded frame.

The versatile ULTIMAT design negates the need for special tooling to produce high-quality parts and components. Options include versions for use with flat strip or profiled wire, press and chamfering stations, and secondary bend heads for intricate forms with a tilting table to accommodate large components or for forming spirals.

▲ *Ultimat UMW-65 wire forming and welding machine*

From the established design of the UMW series the new URW series of automatic ring forming and welding machines has evolved for manufacturers of filter cage rings and automotive rings.

Combined with new developments in welding technology these machines produce a strong burr free weld in stainless and mild steel wire.

Ultimation Machines also takes on projects to suit customers' specific requirements which have recently included the development of the USW Sign Frame forming and welding machine, specifically designed for the manufacture of political sign frames for the US market.

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Website: www.ultimat.com

Experience counts at Essebi

Essebi, with more than 30 years' experience, has developed its own technology in cold forming machines. The machines are customised to include all modifications requested by the customer. This is what Essebi calls the 'easy innovation philosophy'. This philosophy is of continuous development during any time of the customer's order.

Essebi machines are designed to be 'easy' and 'friendly' for operators, with special care taken to the simplified regulations and the ergonomics of the machine.

The same philosophy has been applied to the latest models with fully automatic set up.

A computer controls all the set up and the operation of the machine: the motorised set up of the punches, of the ejection cams and of the die ejection pins, the pre-assembly of the tools on a second die holder and punch holder made on the separate table, on line with the main computer, to which the new set up is immediately transmitted.

▲ *'Easy innovation philosophy' from Essebi*

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Furnaces & heat treatment

It is general knowledge that the induction furnace offers a clean, energy-efficient, easily controlled melting process. If flexibility and economy are the main considerations, the electric arc furnace will be the candidate of choice. We are on terms of easy familiarity with heat treatment, too. Annealing, case hardening, precipitation strengthening, tempering, and quenching; austempering, cyaniding, nicarbing, and nitrocarburising – are well understood, proficiently induced – and have secured the properties and integrity of the materials.

The fact that heat treatment can include chilling, to extreme cryogenic temperatures, is testament to its variety and comprehensiveness: qualities that put it in the good company of the furnace.

Pioneering innovations from Rad-Con

Celebrating more than 40 years of innovative bell-type batch annealing furnace designs, Rad-Con Inc, USA, engineers, manufactures, installs, and supports high-capacity, robust systems to the wire and wire-rod industry.

Rad-Con established itself as the technology leader by pioneering innovations in convection design, atmosphere analysis and temperature control of bell annealing equipment.

Efficient performance of the system's convection flow is critically important to the end-quality of the annealed material.

Rad-Con's 100% hydrogen super-high convection (H2SHC)™ system utilises the most advanced fan designs combined with a 100% hydrogen atmosphere, resulting in greater temperature uniformity throughout the charge, low utility costs, and clean, decarb-free product every cycle.

Today's control technology allows for ease of operation and maintenance of required advanced safety systems for 100% hydrogen, with redundant safety elements to eliminate operator error.

Rad-Con continues to change the industry with its development of the AC/APEx™ atmosphere control system. Coupling gas stream analysis with closed-loop process control improves the surface quality of the charge while minimising the amount of atmosphere gas required. Specialising in annealing systems that produce spheroidised cold heading quality (CHQ) wire for the fastener industry, the company's experience also encompasses ferrous and non-ferrous applications in the agricultural, electrical, construction, spring, industrial, and communications industries.

▲ *Efficient performance from Rad-Con*

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Skako Comessa's important role

Skako Comessa furnace feeding systems are an important part of many industrial processes.

As an example, for the automatic and weight guaranteed:

- feeding of belt, annealing and tempering furnaces
- discharge of industrial washing and drying machines
- feeding and discharge of industrial electroplating and surface treatment lines

Controlled, automatic and weight guaranteed feeding of bulk material ensures steady product quality, optimised efficiency of the downstream equipment to be fed, as well as reproduceable and traceable production parameters.

◀ *Controlled, automatic and weight guaranteed feeding of bulk material*

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▲ *Example of a furnace from QED*

New combustion control system

QED specialises in furnaces for heat treating and coating steel wire. All the company's furnace designs are for multiple strands of wire traveling through the equipment at relatively high speeds. With a view to improve efficiency and to minimise environmental concerns, QED has developed the dual loop pressure control system. This is a new system of burner control that maintains a close air to gas ratio while allowing for stopping and starting burners without changing these ratios. This has proven to be so successful that the company has received a US patent for the technology.

QED are now using this combustion control system on all their multiple burner furnaces, such as oil temper lines, patenting and autenitising furnaces as well as galvanising and Galfan coating furnaces. Another area that the company has concentrated on is the Fluidbed heat-treating furnace. This technology has been around for some time and is well proven for in line annealing, stress relieving, tempering and quenching. QED are finding that more and more customers are running seven days a week, twenty four hours a day (7/24) and can't afford any down time. Even small maintenance items are a problem.

Having studied these maintenance areas QED has now all but eliminated them. Its new furnaces have a fuel injection system that has done away with the need for distribution plenums and porous bases. The previous heat loss problems with poor sealing of the threading openings have been eliminated with their new labyrinth seal system. One example of continuous technological improvement is in QED's sand return design. With improved design the company has minimised sand drag out and greatly improved the sand handling technology.

QED Wire Lines Inc – Canada
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▲ *Can-Eng can deliver any or all components of an integrated and automated system*

Proven mesh belt furnace systems

Can-Eng Furnaces is a leading designer and manufacturer of industrial heat treating equipment. The company's designs have served commercial and captive heat-treaters, stamping and fastener companies, automotive component producers, the iron and steel industries, aluminium foundries, agricultural, construction and appliance manufacturers.

The company's mesh belt furnace systems are field-proven for reliability, fuel-efficiency and production uptime. Standard capacities range from 100kg/hr to 3,000kg/hr.

Processes available include clean hardening, light case carburising and carbonitriding, austempering, and martempering.

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Induction heating technology

▲ *Induction heating system from ATE*

ATE Applicazioni TermoElettroniche was founded in 1987 by combining in-depth experience in the fields of industrial electronics, static energy conversion and electric heating for various industrial applications.

The company has now become renowned in Italy and abroad as a qualified manufacturer of induction heating systems.

Specialisation, innovation, continuous investments in research and state-of-the-art technology are the underlying and guiding principles of ATE's business.

The company also carefully monitors the whole process from internal organisation to customer service.

ATE's philosophy is based on new challenges to develop new applications which satisfy the most demanding customers, working together with them from the initial research right through to commissioning, and throughout the entire useful life of the system.

The main types of ATE induction heating systems are:

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

ATE Applicazioni TermoElettroniche Srl – Italy
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Tenova Goodfellow installation

Industrie Riunite Odolesi (IRO) has chosen to install Tenova Goodellow Inc's (TGI) EFSOP® Holistic Optimization™ system as their preferred process control tool for the EAF meltshop in Odolo, Italy.

Optimisation of the 75/tls electric arc furnace will be based on standard parameters which include reducing electrical energy, oxygen and natural gas consumption along with increasing yield and productivity.

Tenova scope of supply will also include post-combustion optimisation and TGI's off-gas water detection technology for increased safety within the furnace environment.

EFSOP® will also tune at the finest levels the KT Oxygen Lances and PC-burners already on site at the facility to provide EAF optimal continuous improvement. The sale of EFSOP® to IRO SpA is the tenth Tenova Goodfellow sale in the Italian steel market.

The EFSOP® System is part of a wider project handled by Tenova Meltshops BU which will also supply new bimetallic power conductive arms and a new regulation system for the TDR-H.

Tenova is proud to highlight that, with this order, IRO decided to equip its furnaces with a complete Tenova Technological Package including the KT Injection System, the TDR-H Electrode Regulation, the Power Conductive Arms and the EFSOP® System.

Tenova Goodfellow Inc – Canada
Fax: +1 905 567 3899 **Email**: goodfellow@ca.tenovagroup.com

Energy saving from Nuova Tecno

Nuova Tecno's new horizontal enamelling machine energy saving line has been designed to drastically reduce the electrical consumption cost.

The energy saving line is a multi-line enamelling system where, with the same thermal electrical energy, it is possible to produce four independent lines. The enamelling chamber is divided physically with four sections, one for each line, avoiding in case of the line breaks, any interference to the nearest line.

In addition, the machine is equipped with a new steam generator, which uses the hot air exhausted from the enamelling oven, to produce the necessary steam for the annealing oven. This characteristic allows the energy saving machine to claim the lowest electrical energy consumption obtainable at this time.

During the design phase, technicians are facilitating the simplest accessibility to the various machine areas, to allow ease of operation and the maintenance of the machine. For this reason the enamel applicator can easily be removed for thorough cleaning. The transmission belts and motors are also assembled in such a way that makes them easily accessible to the operator.

The use of safety devices in accordance with European norms (CE) ensures an automatic operation of the machine in all its functions. This new energy saving enamelling machine has a great versatility, suitable for large and small enamelled wire producers.

Nuova Tecno Tau Srl – Italy
Fax: +39 0161 423 920
Email: scaringella@ntecnotau.com
Website: www.ntecnotau.com

▲ *Great versatility from new machine*

Preheater system that fits your needs

Thanks to its expert know-how and flexible research, SIF MDC has launched an innovative preheater system into the market that was produced to order for the company Rosendahl.

The machine was produced with the aim of solving the heating problem of a rigid copper conductor with Ø 6.7mm, 120°C, 200m/min.

The system has been designed to solve specific client requirements, with the purpose of improving production performance and product quality.

This is a preheater system and not just a simple preheater as the company's systematic approach has helped them design a product where all the components combine together to create a high performance piece of equipment.

Some examples of SIF's implemented solutions are:

- Use of the colour RAL9006 to allow the application of the Kaizen method, now adopted as a strategy of continuous incremental improvements by the most up-to-date companies.

▲ *Preheater system from SIF*

- Use of an isolated pulley Ø 600mm made of conductive alloy and other pulleys Ø 600mm made of aluminium with a ceramic cover for two reasons: in order to reduce heat loss and consequently increase the system performance and in order to increase the system lifetime, but mostly to avoid excessive stress on the rigid conductor. The return pulleys can be adjusted for an easy alignment to the line inlet and outlet heights.
- System operation at industrial frequency 50Hz for a good penetration of the heating current into the conductor

Particular attention has been paid to safety measures with the introduction of:

- emergency button with safety module coordinated with the safety system of the line
- doors with transparent safety glass (Visarm) for product inspection
- safety switches on the doors for system turn-off in case of opening
- system protection automatic switch
- system remote control through an analogue/digital interface so that the operator only needs to check on tables and databases already present in the line control, thus minimising intervention and maximising results.

The company has also introduced a new motorised temperature measurement system with an analogue/digital interface.

Through a remote control, the temperature meter can be put in contact with the conductor, obtaining a reliable measure from the interface to check that the set temperature is correct.

In case of any difference, due for example to a lower or higher initial temperature of the conductor, it is possible to adjust the temperature modifying the preheater system control offset according to the corresponding variations.

At this point it is possible to deactivate the temperature measurement system.

This is a very functional and reliable choice also because the adjustment and control system of the preheating current, which allows attainment of the desired temperature, is very stable and can reach excellent repeated and reliable performances thanks to this improvement.

Since the recent wire 2008 exhibtion in Düsseldorf, the new range of preheaters has been presented with the new system of smart control.

This new system allows the client an easy set up of the heating curves, offering a great flexibility of use.

SIF sas di Claudio Formenti e C – Italy
Fax: +39 035 4559358
Email: marco.bedussi@sifmdc.com
Website: www.sifmdc.com

Horizontal chamber furnaces in two series

Horizontal chamber furnaces are produced in two distinct series for a maximum working temperature between 500 and 700°C and used for stress-relieving, tempering, structural hardening, ageing, annealing of non-ferrous materials and for various applications for the chemical-glass manufacture.

The main characteristic of these plants is the high thermal efficiency, achieved by using ceramic fibres in several layers at differentiated density without thermal links, for the insulation; mass-less wire heating elements with a special form, placed directly in the air circuit.

A patented vitrifying system together with the special design of the internal deflector and of the high-revolutions fan for the air circulation, allow a temperature uniformity of ± 5°C inside the treatment chamber.

▲ *Furnaces can be supplied with a variety of options*

These furnaces can be supplied with several options, such as:

- protective atmosphere
- timer
- safety equipment against over-temperatures
- device for product's certification
- moveable external roller plane with rapid clutch device on the furnace
- fix external roller plane
- double external roller plane with motorised movement
- thermal cycles automation (no operator is required)
- 4/6/8/12 posts external storage units, with loading system and thermal cycles automation (no operator is required)

The standard equipment for all the models includes a PLC operator panel, microprocessor temperature controllers and an arrangement for EDP network connection.

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Olefinic Elastomers for Wire and Cable Applications

By Day-Chyuan Lee, Ray Laakso, Larry Gross and Jack Muskopf, the Dow Chemical Company

Abstract

Polymeric insulations and jacketing materials provide a reliable, cost-effective means of protecting cables, wires, and fibres used in today's power and data transmission applications. The choice of polymeric coating for a particular application is dictated by numerous factors, including the electrical, environmental, and physical property requirements of the cable. Plastic and elastomeric compounds are two of the most common classes of materials used in the majority of wire and cable constructions. Polyethylene, one of the most popular plastics being used in the wire and cable industry due to its good performance and relatively low cost, maintains a large market share. Complementary to plastics, cables made using elastomeric compounds have their own distinct performance attributes due to their particular polymeric architecture.

Elastomers are polymers that exhibit extreme elastic extensibility and flexibility when subjected to relatively low mechanical stress. Comparison of the polymeric architecture of polyethylene with three common commercially available elastomers (ethylene-octene (EO) (or–butene (EB)), chlorinated polyethylene (CM), and EPDM (ethylene propylene diene terpolymer) reveals the similarities and differences of these various classes of materials and provides an insight into their performance characteristics. All of these polymers have a saturated backbone structure, but the flexibility, tactile nature, and performance of the compounds are very different. The more amorphous elastomeric EO/EB, CM, or EPDM materials tend to produce compounds that are more flexible than polyethylene compounds.

This paper will provide an overview of the role of these elastomeric polymers in wire and cable applications and discuss the similarities and differences of the materials due to their polymer architecture. Emphasis will be on the elastomer resins. Structure-property relationships will be highlighted to help explain the major benefits and deficiencies that each polymer type offers for the wire and cable industry. Elastomers can participate in a broad range of applications, including thermoplastic or thermoset systems, such as jacketing, insulation, bedding, low-smoke zero halogen, and low-voltage insulation.

Technical data on the use of these polymers in typical wire and cable applications will be presented for illustrative purposes.

1. Elastomer structure

Commercial polyolefin elastomers are co-polymers of ethylene with one or more higher α-olefins such as ethylene-octene (EO), ethylene-hexene (EH), or ethylene-butene (EB) as illustrated in *Figure 1*.

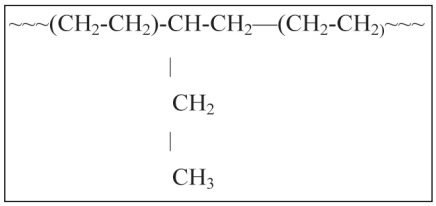
Ethylene-propylene rubbers (EPR) are co-polymers of ethylene and propylene arranged in a random manner to produce rubbery and stable polymers. A third, non-conjugated diene monomer can be terpolymerised in a controlled manner to maintain a saturated backbone and place the reactive unsaturation in a side chain available for vulcanisation or polymer modification chemistry. The ASTM designation for EPR is EPM for the co-polymers and EPDM for the terpolymers where 'E' denotes 'ethylene', 'P' denotes 'propylene', D denotes 'diene' and 'M' denotes a saturated chain of the polymethylene type. An EPDM polymer structure with ethylidene norbornene (ENB) as the diene monomer is illustrated in *Figure 2*.

Chlorinated polyethylene (CPE) is a synthetic elastomer produced by the controlled chlorination of polyethylene feedstock[1] with chlorine atoms randomly distributed on the polymer backbone. A generalised chemical structure for CPE is shown in *Figure 3*.

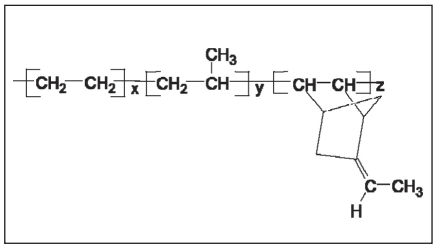
The ASTM designation for CPE is CM or chloro-polyethylene where 'C' denotes 'chloro' and 'M' denotes a saturated chain of the polymethylene type. Due to their stable, saturated polymer backbone structure, compounds made from ethylene containing elastomers are valuable for their excellent combination of heat and oil resistance as indicated and classified by the ASTM D2000/SAE J200 specification[2,3] as shown in *Figure 4*. In addition to their durability in harsh environments, their flexibility enables ease of cable installation and helps provide reliable splices and terminations, especially in cold weather. This makes them attractive candidates for cable insulation and jacketing. The flexibility ranges of ethylene containing elastomers relative to other common plastics are shown in *Figure 5*.

2. Structure-property relationship

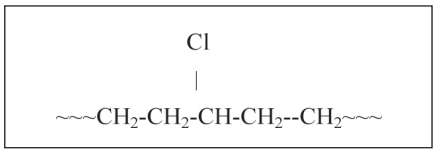
Crystallinity, molecular weight (MW), molecular weight distribution (MWD), branching, copolymer/diene type/level, and chlorine contents are some of the major chain architecture variables that can be engineered to optimise the performance of the variety of commercial ethylene containing elastomers.



▲ **Figure 1**: *Structure of ethylene-butene elastomer*



▲ **Figure 2**: *Structure of EPDM containing ENB*



▲ **Figure 3**: *Structure of CPE*

2.1 Crystallinity and molecular weight

Ordered and regularly repeating arrangements of atoms or groups of atoms can result in crystallinity. Crystallinity and crystalline melting point are functions of the ethylene segment block length and crystal imperfections of ethylene containing elastomers. Compared to ethylene-higher α-olefins copolymers, ethylene propylene co-polymer typically has shorter ethylene blocks with more defects in the crystalline phases. The crystallinity of CPE can be adjusted by the chlorination process to yield amorphous or semi-crystalline product. The level of residual polyethylene crystallinity also plays a role in controlling the overall physical properties of CPE. Ethylene blocks are too short in a random co-polymer to give significant crystallinity and an amorphous polymer results.

Amorphous ethylene co-polymer is soft and easy to process and generally has lower physical properties than a higher crystallinity elastomer. At around 60 wt% ethylene, an olefin elastomer has sufficient crystallinity and is hard enough to be pelletised.

Due to the chlorination process, CPE is always in the powder form independent of the crystallinity. Crystallinity has a strong influence on the physical properties. For example, with increasing crystallinity, modulus and tensile strength along with hardness and tear strength increase, but low temperatures set, elastic recovery, and flex resistance decreases. With increasing crystallinity, cold green strength also improves. Higher molecular weight polymers can accept more filler and have better physical properties including increased tensile and tear strength, but need to be optimised for processability.

2.2 Molecular weight distribution

MWD of ethylene containing elastomers affects processing characteristics. A broad MWD shows improved mill mixing, higher hot green strength, extrusion characteristics, and generally better surface appearance on extrusion. However, cure rate, and cure state can be lower for broad MWD elastomers. In general, broader MWD polymers have better processing but poorer cure characteristics than their narrow MWD counterparts.

2.3 Diene

Similar to crosslinked polyethylene, polyolefin elastomers, EPDM and CM can be crosslinked by peroxide. For EPDM, the incorporation of the diene provides the capability for curing with sulphur.

However, peroxide cure is preferred for power cable insulation because better electrical properties can typically be achieved through peroxide cure than sulphur cure. The most widely used diene termonomers includes ethylidene norbornene (ENB) and dicyclopentadiene (DCPD). For these dienes, ENB has the fastest curing rate, and DCPD has the slowest curing rate. The presence of diene enhances the probability for EPDM to branch and results in repeating CH2 units from a side chain from the main polymer backbone. Branching lowers polymer viscosity at higher shear rates to provide improved extrusion characteristics, and it increases polymer viscosity at lower shear rates to improve sag resistance. In general, DCPD has the most probability to create more long chain branching vs ENB.

2.4 Chlorine content

Similar to the addition of halogen containing additives to polymer for the improvement of ignition resistance, the presence of chlorine on the backbone of CM improves the ignition and combustion resistance characteristics of the polymer. As demonstrated in *Figure 7*, resistance to ignition (as indicated by higher limiting oxygen index (LOI) values, increases as the chlorine content of the CPE increases.

The presence of chlorine enhances the resistance to hydrocarbon oils and fuels for CPE based compounds, therefore, higher chlorine containing CPE is typically selected when resistance to oil and fuels is a critical performance attribute of cable applications.

Figure 4: *Heat and oil resistance of various elastomers*

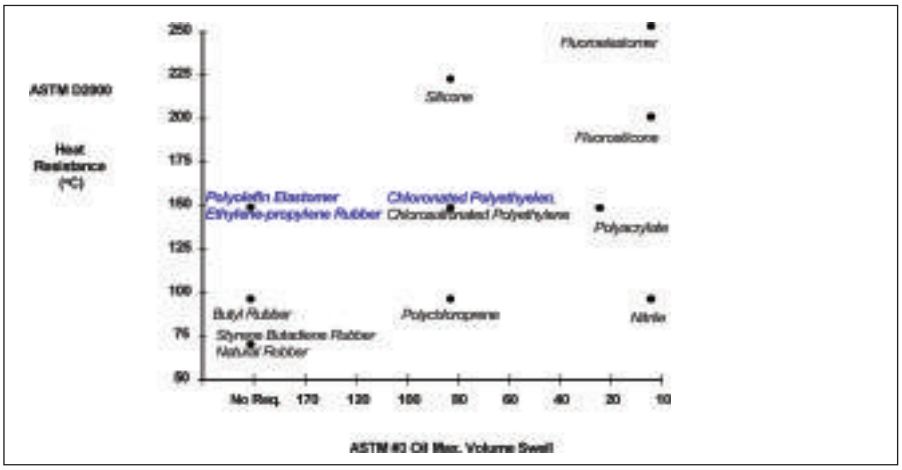
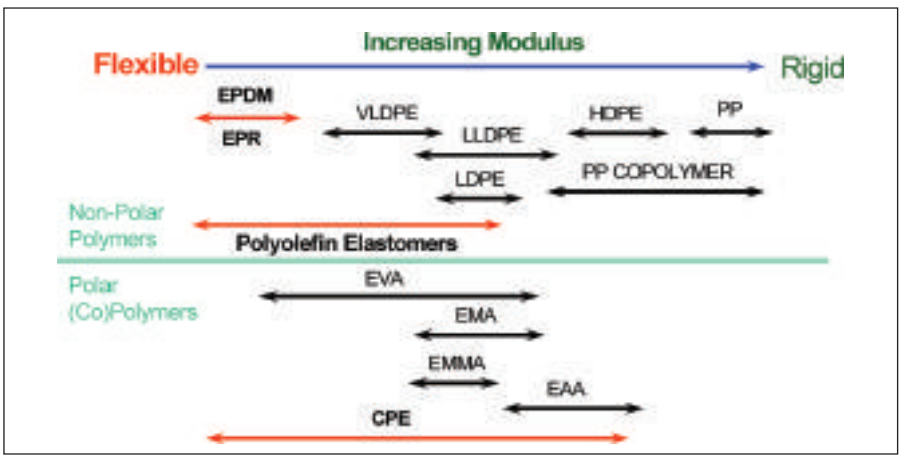


Figure 5: *Flexibility range of olefinic ethylene elastomers*



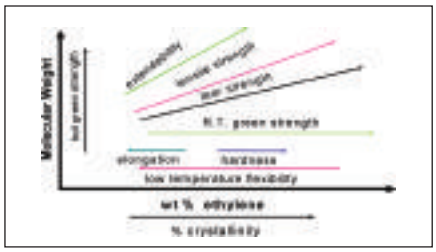
3. Compounding

Extrusion of high molecular weight ethylene containing elastomer alone usually results in a rough extrudate surface due to melt fracture. Filler addition improves the surface smoothness of the extrudate as well as the mechanical strength of the compound. Other ingredients such as plasticisers, lubricants, antioxidants, crosslinking agents, UV absorbers, and flame retardants are frequently used to enhance the functionality of the compound. The composition of the elastomer compound determines the end use performance of the product, but the properties of the elastomer matrix determine the type and quantity of the various ingredients that can be or should be used in the compound.

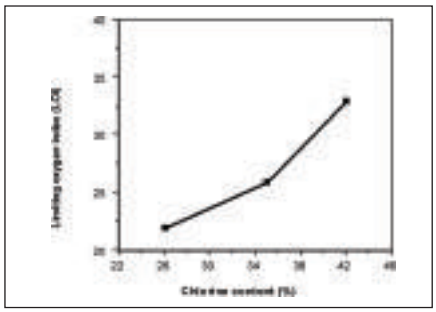
Continuous screw mixers offer excellent rates and reasonable dispersion for effective plastic compound production. However, compound ingredients must be in the form of pellets or powder for proper feeding of continuous mixers. Internal batch mixers such as Banbury® (Farrel Corporation) or two-roll mills are typically used to prepare elastomer compounds. Amorphous low viscosity polymers with broad MWD are best for mill mixing. Compounds based on high viscosity and highly crystalline elastomers are very difficult to mix on two-roll mills and are best suited for Banbury mixer for high mixing efficiency and reasonable cycle time. Elastomers in pellet or friable bale form can be easily mixed in the batch mixer, because friable bales are loosely compacted and can break apart easily in the Banbury under the shearing action. Depending on the application, elastomer compounds produced from roll mill or batch mixer could either go through strainer-extruders or directly feed into the extruder as shown in *Figure 8*.

4. Wire extrusion

For wire and cable production, compounds based on amorphous elastomers are best extruded with a rubber-type screw, while semi-crystalline elastomers run best with a polyethylene-type screw. Amorphous elastomer compounds are normally strip fed while semi-crystalline elastomers are typically fed as pellets or in diced form. Ethylene containing elastomer compounds can be extruded using either cold or warm feed equipment. Cold feed, long barrel extruders take compounded strips at ambient temperatures and usually require a compound with high green strength at room temperature. Elastomers with sufficient crystallinity should be used in cold feed compound or the extruder screw will bite off the strip causing irregular feeding. Warm feed, short barrel extruders are fed strips of stock previously warmed on a mill. These stocks should contain broad molecular weight elastomer to give green strength at elevated



▲ **Figure 6**: *Structure-property of olefinic elastomers*



▲ **Figure 7**: *Limiting oxygen index versus chlorine content of CM*

temperatures. The feed strips should be as cool as possible to minimise balling of the feed at the hopper. Minimisation of the use of process aids with the proper selection of aromatic oils can improve the contact of the strip at the screw surface and feeding. Some high viscosity or crystalline polymers may be needed to improve collapse resistance of the extrudate.

With proper feeding either by strip or pellets, elastomer compounds then extrude rapidly and smoothly onto conductors with either rubber-type or plastic type screws or crosshead pressure dies as shown in *Figure 9*. Crosshead temperatures are typically set high enough to soften the polymer to allow good flow but below the peroxide decomposition temperature so that scorch is not a problem. Most elastomer-insulated wire is then cured in a continuous vulcanisation (CV) tube. The reeled wire is either sold or used in subsequent cabling operations.

5. Chain architecture optimisation for wire and cable application

The performance of wire and cable compounds is dependent upon the combinations of the performance attributes of the ingredients involved and the choice of polymer. The elastomeric matrix and its compatibility with the ingredients being incorporated into the elastomer strongly influence the success of a compound's development. Therefore, the correct chain architecture design represents one of the most critical steps in the design of the compound for wire and cable applications. However, it is the properties of the elastomer matrix which determines the type and quantity of the various ingredients that can or should be used in the compound to control the end use performance of the product.

For example, CM-d is a developmental, amorphous grade of chlorinated polyethylene (CM) that has been designed to accept high loadings of fillers with comparable or better physical properties compared to standard CM products. CM-d has an excellent balance of heat and chemical resistance that makes it suitable for use in specific wire and cable applications. The data in *Tables 1–3* illustrate the potential advantages of CM-d.

5.1 Higher filler loadings

CM-d was designed to accept high filler loadings while maintaining physical properties. To illustrate, CM-d was compared to CM-a in a Flexible Cord Jacket application as per Underwriters Laboratories (UL®) Standard 62. A typical formulation containing CM-a with 'normal' loading of fillers and plasticisers was compared to compounds containing a 'high' loading. The highly loaded compounds contained ~34% higher total phr than the 'Normal' compound (see *Table 1*).

The compounds were extruded as a 0.76mm jacket onto 14 AWG solid aluminium wire (1.63mm diameter) using a 38.1mm single screw extruder with a length to diameter (L/D) ratio of 15. The wire was cured in the continuous vulcanisation (CV) tube for 2 min in 1.72 MPa steam. Slab samples (for low temperature brittleness testing) were cured 2 min at 200°C. Processing and curing data are shown in *Table 2*.

Samples were tested according to appropriate ASTM specifications:

- tensile Strength ASTM D412
- IRM 902 Immersion ASTM D471
- heat ageing ASTM D573
- low temperature brittleness ASTM D746
- physical properties are included in *Table 3*

5.2 Viscosity considerations

CM-d, when substituted directly for a chlorinated polyethylene resin in an existing compound, will typically result in a higher viscosity than the original compound. However, through the addition of increased levels of plasticiser and/or addition of EO-b at 10–15 phr, the viscosity of the compound can be reduced as seen in *Table 2*.

The highly filled compound with EO elastomer has processing characteristics comparable to the normally loaded CM-a compound.

5.3 Physical properties

When filler levels are raised from 'normal' to 'high' in the compound based on CM-a, there is a corresponding loss of physical properties (see *Table 3*). In particular, tensile strength and retention of elongation after ageing show a significant decrease.

However, when the 'high' filler level is used with CM-d (or a blend of CM-d and EO-b), the physical properties are comparable to those seen using 'normal' filler loading in CM-a.

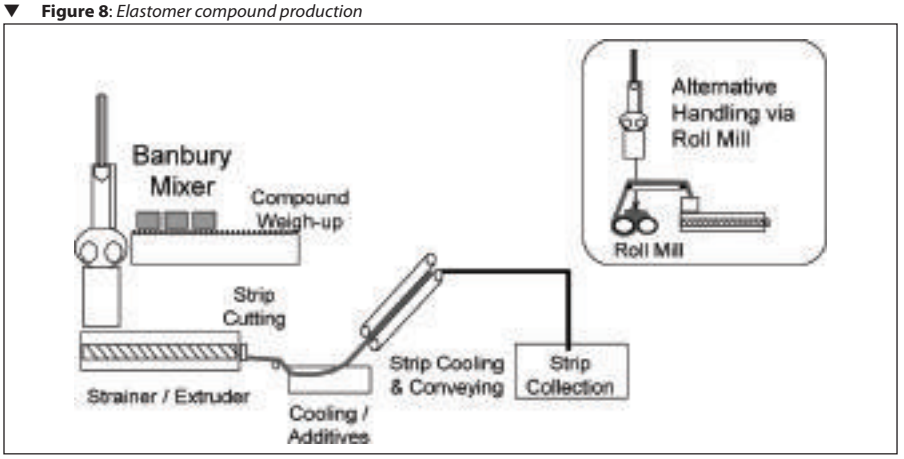
5.4 The importance of elastomer chain architecture design

CM-d enables the compounder to modify a 'normally loaded' recipe by increasing the levels of fillers and oils, while still maintaining physical property performance.

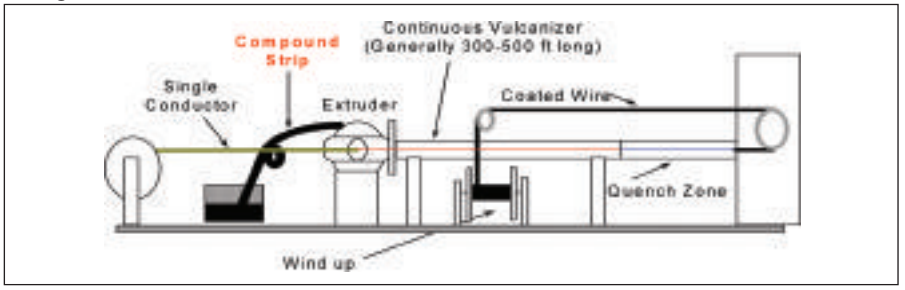
Typical high molecular weight CPE grades such as CM-a do not perform as well as CM-d in highly loaded compounds.

CM-d was designed specifically to help the compounder achieve improved performance at similar or reduced cost (due to higher filler/oil loadings).

▼ **Figure 8**: *Elastomer compound production*



▼ **Figure 9**: *Wire extrusion of elastomers*



	'Normal Loading'	'High Loading'		
	CM-a	CM-a	CM-d	CM-d/EO-b
Density	1.607	1.648	1.648	1.622
CM-a	100	100	--	--
CM-d	--	--	100	85
EO-b	--	--	--	15
Trifunctional acrylic ester (co-agent)	5	5	5	5
a,a'-bis(t-butyl peroxy) diisopropyl benzene, 40% active	5	5	5	6.5
N-550 Carbon black	35	--	--	--
N-774 Carbon black	--	80	80	80
Calcium carbonate	150	200	200	200
DINP	38	60	60	60
Paraffin wax	2	1.5	1.5	1.5
Magnesium oxide	5	5	5	5
Total phr:	340	456.5	456.5	458

▲ **Table 1**: *Flexible cord jacket recipes*

	'Normal Loading'	'High Loading'		
	CM-a	CM-a	CM-d	CM-a/EO-b
Processing Characteristics				
Mooney Scorch at 121°C, Small Rotor				
Minimum, MU	28.5	23.2	39.5	31.5
t3, mins	>25	>25	>25	24.2
t5, mins	>25	>25	>25	24.7
RPA (Rubber Processability Analyzer) at 110°C, 10% Strain				
Viscosity at 150 rad/s, Pa-s	4577	3842	5282	4764
Wire Line Extrusion, 38.1 mm Extruder, 15:1 L:D, ~ 110°C)				
Extruder Pressure, MPa	27	23	29	25
Curing Characteristics				
Oscillating Disk Rheometer at 200°C for 6 mins				
Minimum, dN-m	11.2	6.6	15.2	13.3
Maximum, dN-m	80.7	56.3	75.8	82.1
delta Torque, dN-m	69.5	49.7	60.6	68.8
t90, mins	1.7	1.8	1.9	1.8

▲ **Table 2**: *Processing and curing characteristics*

▼ **Table 3**: *Physical properties*

	'Normal Loading'	'High Loading'		
	CM-a	CM-a	CM-d	CM-d/EO-b
Original Physicals*				
Stress at 100% Elongation, MPa	3.4	3.5	2.6	4.6
Ultimate Tensile, MPa	9.2	7.6	9.8	9.7
Elongation at Break, %	514	518	350	306
IRM 902/18 hr at 121°C*				
Tensile Retention, %	87	90	94	96
Elongation Retention, %	91	58	86	89
Air Oven Aging -- 10 Days at 110°C				
Tensile Retention, %	93	108	98	92
Elongation Retention, %	80	52	79	75
Low Temperature Brittleness, °C**	-27.5	-29.5	-32.5	-35.5

*14 AWG (1.63mm dia) aluminium wire/0.76mm jacket/cured 2 min in 1.72 MPa steam
**Slab/cured 2 min at 200°C

The example in *Tables 1-3* helps demonstrate that improved compound performance, such as improved physical properties and low temperature performance, can be achieved by using the correct elastomer matrix with optimised chain architecture to allow higher loading of the ingredients to further balance the compound performance and potentially positively impact the compound economics.

6. Conclusions

Elastomers can participate in a broad range of applications, including thermoplastic or thermoset systems, such as jacketing, insulation, bedding, low-smoke zero halogen, and low-voltage insulation.

Higher levels of filler can be incorporated into elastomers to broaden their compound performance attributes to make them especially suited for demanding environments. The chain architecture of the elastomer is important to determine how and how much of the various ingredients can be or should be used in the compound to achieve the desired end use performance. Cross-linked elastomer compounds have excellent heat and oil resistance, and the cure rate can be conveniently adjusted by diene levels. Most of the EPRs or EPDMs are suited for applications demanding good mechanical properties due to its high molecular weight, but EB or EO is popular as rheology modifier due to its relative lower viscosity. The presence of chlorine in chlorinated polyethylene further improves its chemical, oil, and flame resistance over that of non-chlorine containing ethylene elastomer. As a result, simple changes in structure architectural parameters in ethylene containing elastomer can greatly extend the typical polyethylene cable performance attributes for broader applications. ■

7. References

[1] Polymeric Materials Encyclopedia, Volume 2/C, CRC Press, 1996, Editor-in-Chief J C Salamone, chapter on "Chlorinated Polyethylene", G R Marchand

[2] Classification System for Rubber Material (SAE J200), Society of Automotive Engineers, Warrendale, Pa, 2000

[3] Standard Test Method for Rubber Property–Effect of Liquids (ASTM D471-79) 1979

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Olefin-Elastomere für Draht- und Kabelanwendungen

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Übersicht

Polymerisolierungs- und Ummantelungsmaterialien sind ein zuverlässiges, kostengünstiges Mittel, um Kabel, Draht und Fasern zu schützen, die bei heutigen Strom- und Datenübertragungsanwendungen eingesetzt werden. Die Auswahl der Polymerbeschichtung für eine besondere Anwendung hängt von verschiedenen Faktoren ab, darunter die elektrischen, physikalischen und die Umwelt betreffenden Eigenschaftsanforderungen des Kabels. Kunststoff- und Elastomer-Mischungen sind zwei der gängigsten Klassen von Materialien, die in den meisten Draht- und Kabelaufbauten verwendet werden. Polyethylen, eins der beliebtesten Kunststoffe, die in der Draht- und Kabelindustrie wegen der guten Leistungen und relativen Preisgünstigkeit eingesetzt werden, hält einen großen Marktanteil. Ergänzend zu Kunststoff, verfügen Kabel, bei denen Elastomer-Mischungen verwendet werden, über eigene eindeutige Leistungseigenschaften, die sich aus deren besonderer Polymerarchitektur ergeben.

Elastomere sind Polymere, die eine extrem elastische Dehnbarkeit und Flexibilität aufweisen, wenn sie relativ niedrigen mechanischen Belastungen ausgesetzt werden. Aus einem Vergleich der Polymerarchitektur von Polyethylen mit drei marktüblichen Elastomeren (Ethylen-Okten (EO) (oder –Buten (EB)), chloriertes Polyethylen (CM) und EPDM (Ethylen-Propylen-Dien-Terpolymer) sind die Ähnlichkeiten und Unterschiede dieser verschiedenen Materialklassen ersichtlich und ein Einblick in deren Leistungsmerkmale geboten.

Alle diese Polymere besitzen eine gesättigte Grundstruktur, jedoch sind Flexibilität, taktile Eigenschaft und Leistung der Mischungen sehr unterschiedlich. Die Materialien amorphster Elastomer-EO/EB, CM oder EPDM neigen dazu Mischungen herzustellen, die flexibler sind als Polyethylen-Mischungen.

Dieser Artikel liefert einen Überblick über die Rolle dieser Elastomere-Polymere in Draht- und Kabelanwendungen und berichtet über die Ähnlichkeiten und Unterschiede der Materialien, die sich aus deren Polymerarchitektur ergeben.

Besonderer Wert wird auf die Elastomerharze gelegt. Die Struktur-Eigenschafts-Beziehungen werden unterstrichen, um bei der Erklärung der wichtigsten Vor- und Nachteile zu helfen, die jeder Polymertyp der Draht- und Kabelindustrie bietet. Elastomere können sich an einem breiten Anwendungsbereich beteiligen, einschließlich thermoplastischer oder wärmehärtende Systeme, wie z. B. Ummantelung, Isolierung, Füllmaterial, sowie raucharme, halogenfreie Systeme und Niederspannungsisolierung. Technische Anga- ben über die Anwendung dieser Polymere in typischen Draht- und Kabelanwendungen werden zum Zwecke der Erklärung vorgelegt.

1. Elastomerstruktur

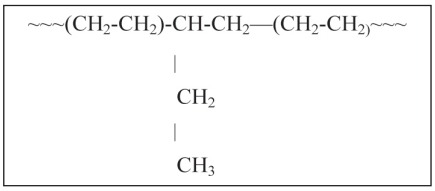
Handelsübliche Polyolefinelastomere sind Copolymere des Ethylens mit einen oder mehreren höheren alpha-Olefinen, z. B. Ethylen-Okten (EO), Ethylen-Hexen (EH) oder Ethylen-Buten (EB), wie im *Bild 1* dargestellt.Ethylen-Propylen-Kautschuk (EPR) sind Copolymere des Ethylens und Propylens, die zufällig angeordnet sind, um gummiartige und stabile Polymere herzustellen. Ein drittes, nichtkonjugiertes Dien-Monomer kann in kontrollierter Weise terpolymiert sein, um eine gesättigte Grundstruktur zu erhalten und den reaktiven ungesättigten Zustand in einer Seitenkette anzuordnen, die für die Chemie der Vulkanisierungs- oder Polymermodifikation verfügbar ist. Die ASTM-Bezeichnung für EPR ist EPM für Copolymere und EPDM für Terpolymere, wobei „E“ für „Ethylen“, „P“ für „Propylen“', „D“ für „Dien“ und „M“ für eine gesättigte Kette des Polymethylentyps steht. Eine EPDM-Polymerstruktur mit Ethylidennorbornen (ENB), wie das Dienmonomer ist im *Bild 2* dargestellt. Chloriertes Polyethylen (CPE) ist ein synthetisches Elastomere, das durch eine kontrollierte Chlorierung von Einsatzmaterial aus Polyethylen[1] mit Chloratomen erzeugt wird, die an der Polymer-Grundstruktur zufälligerweise verteilt sind. Eine verallgemeinerte chemische Struktur für CPE ist in *Bild 3* dargestellt.

Die ASTM-Bezeichnung für CPE ist CM oder Chlorpolyethylen, wobei „C“ für „Chlor“ und „M“ für eine gesättigte Kette des Polymethylentyps steht. Dank der stabilen, gesättigten Grundstruktur des Polymers, sind Mischungen aus ethylenhaltigen Elastomeren wertvoll wegen ihrer exzellenten Kombination von Wärme- und Ölbeständigkeit, wie in der ASTM D2000/SAE J200 Spezifikation[2,3] beschrieben und klassifiziert, und wie in *Bild 4* dargestellt: Neben deren Beständigkeit in rauhen Umgebungen, ermöglicht deren Flexibilität eine einfache Kabelinstallation und bietet eine Unterstützung für zuverlässige Spleißungen und Endverschlüsse, insbesondere bei kaltem Wetter.

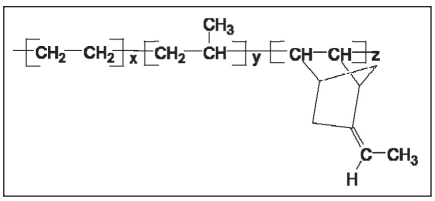
Deswegen sind sie für die Kabelisolierung und -ummantelung attraktiv. Die Flexibilitätsbereiche ethylenhaltiger Elastomere, verglichen mit anderen gängigen Kunststoffen, sind in *Bild 5* dargestellt.

2. Struktur-Eigenschafts-Beziehungen

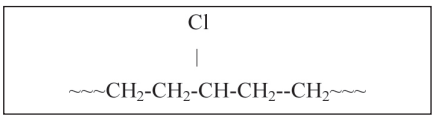
Kristallisation, Molekulargewicht (MW - molecular weight), Molekulargewichtverteil- ung (MWD - molecular weight distribution), Verzweigung, Copolymer/Dien Typ/Niveau, und Chlorgehalt sind einige der wichtigsten Variablen der Kettenarchitektur, die geändert werden können, um die Leistung der vielen unterschiedlichen gängigen ethylenhaltigen Elastomere zu optimieren.



▲ **Bild 1**: *Struktur von Ethylen-Buten-Elastomer*



▲ **Bild 2**: *Struktur von ENB enthaltendes EPDM*



▲ **Bild 3**: *Struktur von CPE*

2.1 Kristallisation und Molekulargewicht

Aus einer geordneten und regelmäßig sich wiederholenden Anordnung der Atome oder Atomengruppen kann sich die Kristallisation ergeben. Die Kristallisation und der kristalline Schmelzpunkt hängen von der Blocklänge des Ethylensegments und von den Kristallmangelhaftigkeiten der ethylenhaltigen Elastomere ab. Im Vergleich zu Copolymere des Ethylens mit höheren alpha-Olefinen, weisen Ethylen-Propylene-Copolymer (CPE) in der Regel kürzere Ethylenblöcke mit mehreren Fehlern in den Kristallphasen auf. Die Kristallisation der CPE kann anhand des Chlorierungsverfahrens eingestellt werden, um ein amorphes oder halbkristallines Produkt zu erzielen. Das Niveau der Restpolyethylen-Kristallisation spielt ebenfalls eine wichtige Rolle, um die gesamten physikalischen Eigenschaften der CPE zu prüfen. Ethylenblöcke sind in einem Random-Copolymer zu kurz um in eine beträchtliche Kristallisation und in ein amorphes Polymer zu resultieren.

Amorphes Ethylen-Copolymer ist weich und kann leicht verarbeitet werden und hat im Allgemeinen niedrigere physikalische Eigenschaften als ein Elastomer mit höherer Kristallisation. Bei zirka 60 wt% Ethylen, verfügt ein Olefinelastomer über ausreichende Kristallisation und ist hart genug um granuliert zu werden. Wegen des Chlorierungsverfahrens ist CPE immer pulverförmig, unabhängig von der Kristallisation. Die Kristallisation hat einen starken Einfluß auf die physikalischen Eigenschaften. So entsteht zum Beispiel bei erhöhter Kristallisation, Zugfestigkeit und gesteigertem Modul, eine Erhöhung der Härte und Reißfestigkeit, jedoch eine Reduzierung beim Verhalten niedriger Temperaturen, elastischer Erholung und Biegebeständigkeit.

Mit gesteigerter Kristallisation verbessert sich auch die kalte Rohfestigkeit. Polymere mit höherem Molekulargewicht können mehr Füllmaterial aufnehmen und weisen höhere physikalische Eigenschaften auf, einschließlich gesteigerter Zug- und Reißfestigkeit, sie müssen allerdings für die Behandlung optimiert werden.

2.2 Molekulargewichtverteilung

Die MWD von ethylenhaltigen Elastomeren beeinflußt die Verarbeitungseigenschaften. Eine größere MWD zeigt eine verbesserte Walzmischung, erhöhte warme Rohfestigkeit, Extrusionseigenschaften und im Allgemeinen ein besseres Oberflächenaussehen bei der Extrusion. Aushärtungsgeschwindigkeit und -zustand können jedoch dabei für größere MWD Elastomere niedriger sein. Im Allgemeinen weisen größere MWD-Polymere eine bessere Verarbeitungsfähigkeit, jedoch niedrigere Aushärtungsmerkmale im Vergleich zu kleineren MWD-Gegenstücken auf.

2.3 Dien

Ähnlich wie bei vernetzten Polyethylen, können Polyolefinelastomere, EPDM und CM mit Peroxid vernetzt werden. Für EPDM wird durch die Einlagerung von Dien die Fähigkeit einer Aushärtung mit Schwefel geboten. Dennoch wird die Aushärtung von Peroxid bei der Stromkabelisolierung bevorzugt, denn höhere elektrische Eigenschaften können in der Regel eher durch die Aushärtung von Peroxid als durch jene aus Schwefel erzielt werden. Die am verbreitesten eingesetzten Diene-Termonomere schließen Ethylidennorbornen (ENB) und Dicyclopentadien (DCPD) ein.

Für diese Dienen, weist ENB die schnellste und DCPD die langsamste Aushärtungsgeschwindigkeit auf. Das Vorhandensein von Diene erhöht die Möglichkeit für EPDM zu verzweigen und führt zu wiederholenden CH2-Einheiten aus einer Seitenkette vom Hauptpolymer-Grundstruktur. Durch die Abzweigung wird die Polymerviskosität bei höheren Scherengeschwindigkeiten verringert, um verbesserte Extrusionsmerkmale zu bieten, während die Polymerviskosität bei niedrigeren Scherengeschwindigkeiten erhöht wird; um die Widerstandfähigkeit beim Durchhang zu bessern. Im Allgemeinen bietet DCPD im Gegensatz zu ENB die beste Möglichkeit mehrere lange Kettenabzweigung zu schaffen.

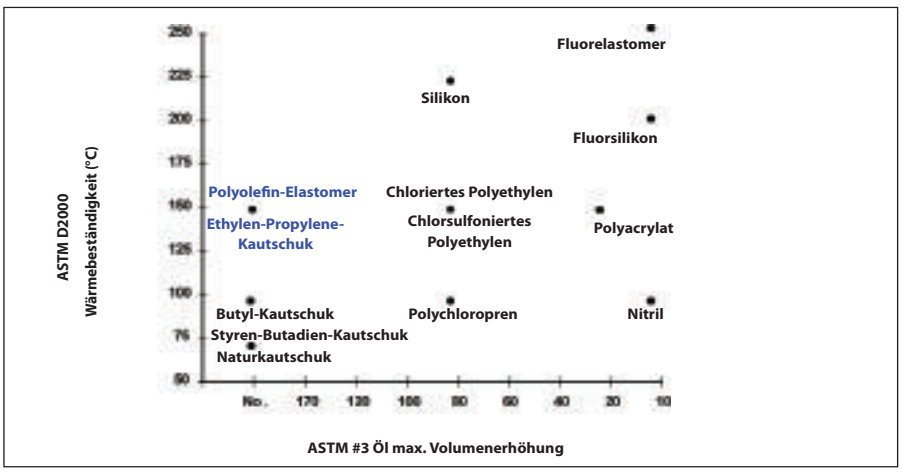
2.4 Chlorgehalt

Ähnlich wie beim Hinzufügen von halogenhaltigen Additiven zu Polymer zur Verbesserung des Zündwiderstands, führt das Vorhandensein von Chlor an der Grundstruktur von CM zu einer Erhöhung der Eigenschaften des Zünd- und Brennwiderstands beim Polymer.

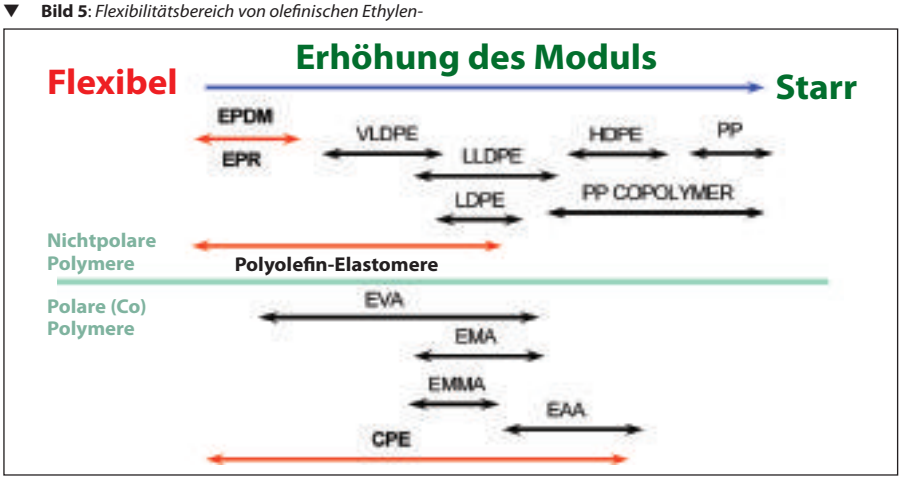
Wie in *Bild 7* dargestellt, steigt der Zündwiderstand (gemäß Angabe der höheren (LOI-) Sauerstoffgrenzwerte) entsprechend der Zunahme des CPE-Chlorgehalts.

Das Vorhandensein von Chlor steigert den Widerstand gegenüber Kohlenwasserstoffölen und -treibstoffen für CPE-basierte Mischungen, deswegen wird in der Regel CPE mit höherem Chlorgehalt dort gewählt, wo der Öl- und Treibstoffwiderstand eine kritische Leistungseigenschaft der Kabelanwendungen darstellt.

▼ **Bild 4**: *Wärme- und Ölbeständigkeit verschiedener Elastomere*



▼ **Bild 5**: *Flexibilitätsbereich von olefinischen Ethylen-*



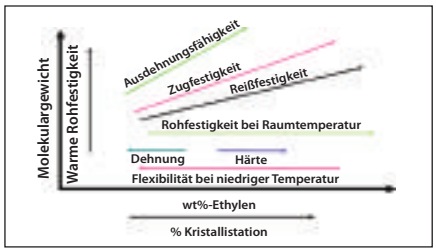
3. Mischungen

Die Extrusion von lediglich ethylenhaltigem Elastomere mit hohem Molekulargewicht führt wegen der Schmelzbrüche in der Regel zu einer groben Extrudatoberfläche. Mit dem Hinzufügen von Füllmaterial wird die Oberflächenglätte des Extrudats sowie die mechanische Festigkeit der Mischung verbessert. Weitere Zusatzstoffe wie z. B. Weichmacher, Schmiermittel, Antioxidante, Vernetzungsmittel, UV-Absorber, flammbeständige Materialien, werden oft eingesetzt, um die Funktionalität der Mischung zu erhöhen. Die Zusammensetzung der Elastomermischung bestimmt zwar die Leistung des Endverbrauchs des Produkts, doch bestimmen die Eigenschaften der Elastomermatrix den Typ und die Qualität der verschiedenen Inhaltsstoffe, die in der Mischung eingesetzt werden oder werden sollten.

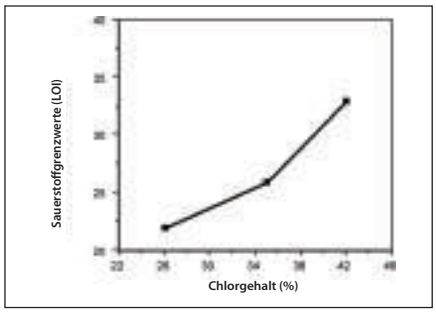
Kontinuierliche Schneckenmischer bieten hervorragende Geschwindigkeiten und eine angemessene Dispersion für eine effektive Produktion von Kunststoffmischungen. Für eine geeignete Zuführung der kontinuierlichen Mischer, müssen die Mischungskomponenten jedoch granulat- oder pulverförmig sein. Chargeninnenmischer, wie z. B. Banbury® (Farrel Corporation) oder Mischwalzwerke mit zwei Walzen werden in der Regel verwendet, um Elastomermischungen vorzubereiten. Amorphe Polymere mit niedriger Viskosität und großer MWD eignen sich am besten für das Walzwerkmischen. Mischungen, die auf hochkristallinen Elastomeren mit hoher Viskosität basieren, lassen sich sehr schwer durch Mischwalzwerke mischen. Dazu eignet sich der Banbury-Kneter am besten, dank des hohen Mischwirkungsgrads und der angemessenen Zykluszeiten. Granulatförmige oder bröcklige agglomerierende Elastomere können leicht im Chargenmischer gemischt werden, weil die bröckligen Agglomerationen locker zusammengepreßt sind und daher leicht im Banbury-Kneter unter der Schertätigkeit auseinanderbrechen können. Je nach Anwendung können die vom Walzwerk- oder Chargenmischer erzeugten Elastomermischungen entweder durch den Strainer-Extruder laufen oder direkt in den Extruder zugeführt werden, wie in *Bild 8* dargestellt.

4. Drahtextrusion

Für die Draht- und Kabelproduktion, werden die auf amorphen Elastomeren basierenden Mischungen am besten mit einer Gummischnecke extrudiert, während halbkristalline Elastomere am bestem mit einer Polyethylenschnecke laufen. Amorphe Elastomermischungen werden in der Regel bandartig zugeführt während halbkristalline Elastomere normalerweise als Granulat oder als Würfel zugeführt werden. Ethylenhaltige Elastomermischungen können mit Einsatz von kalten oder warmen Zuführeinrichtungen extrudiert werden. Extruder mit langen Zylindern und Kaltzuführung entnehmen gemischte Bänder bei Umgebungstemperaturen und erfordern in der Regel eine Mischung mit hoher Rohfestigkeit bei Raumtemperatur. Elastomere mit ausreichender Kristallisation sollten für Mischungen eingesetzt werden, die eine kalte Zuführung vorsehen, oder die Extruderschnecke reißt sonst das Band aus, was wiederum eine unregelmäßige Zuführung bewirkt. Extruder mit kurzen Zylindern und Warmzuführung werden mit Bändern aus dem Lager zugeführt, wo sie zuvor in einem Walzwerk erwärmt wurden.



▲ **Bild 6**: *Struktur-Eigenschaft olefinischer Elastomere*



▲ **Bild 7**: *Vergleich zwischen Sauerstoffgrenzwerten und CM-Chlorgehalt*

Dieses Material sollte Elastomere mit hohem Molekulargewicht enthalten, um Rohfestigkeit bei hohen Temperaturen zu bieten. Die zugeführten Bänder sollten so kalt wie möglich sein, um die Agglomeration der Zuführung am Trichter zu reduzieren. Die Reduzierung des Einsatzes von Verfahrenshilfsmitteln durch die Auswahl geeigneter Aromaöle, kann den Kontakt des Bands mit der Schneckenoberfläche sowie die Zuführung verbessern. Einige Polymere mit hoher Viskosität oder Kristallisation könnten erforderlich sein, um den Widerstand gegen den Zusammenbruch des Extrudats zu verbessern.

Durch eine geeignete Zuführung sowohl mit Band wie mit Granulat, extrudieren sich die Elastomermischungen dann sehr schnell und glatt auf den Leitern, unabhängig davon ob Schnecken bzw. Spritzkopf-Druckziehsteine aus Gummi oder PVC benutzt werden, wie in *Bild 9* dargestellt. Die Temperaturen des Spritzkopfs sind in der Regel hoch genug, um das Polymer zu erweichen, bzw. um ein gutes Gleiten zu ermöglichen, wobei man jedoch unter der Peroxidzersetzungstemperatur bleiben muß, damit die Anvulkanisation kein Problem darstellt. Der meiste mit Elastomeren isolierte Draht wird dann in einem CV-Rohr (kontinuierliche Vulkanisierung) ausgehärtet. Der aufgespulte Draht wird entweder verkauft oder für die darauf folgenden Verseilungsverfahren benutzt.

5. Optimierung der Kettenarchitektur für Draht- und Kabelanwendungen

Die Leistung der Draht- und Kabelmischungen hängt von den Kombinationen der Leistungseigenschaften der damit verbundenen Zusatzstoffe und der Polymerauswahl ab. Die Elastomermatrix und deren Kompatibilität mit den im Elastomere aufgenommenen Zusatzstoffen haben einen hohen Einfluß auf den Erfolg der Entwicklung einer Mischung. Demzufolge stellt ein geeigneter Aufbau der Kettenarchitektur einen der kritischsten Schritte im Entwurf der Mischung für die Draht- und Kabelanwendungen dar. Selbst wenn eigentlich die Eigenschaften der Elastomermatrix, den Typ und die Menge der verschiedenen Zusatzstoffe bestimmen, die in der Mischung eingesetzt werden können oder sollten, um die Gebrauchseigenschaften des Produkts zu prüfen. So ist zum Beispiel CM-d eine entwicklungsgemäße, amorphe Klasse von chloriertem Polyethylen (CM), das dazu bestimmt ist hohe Belastungen von Füllmaterial aufzunehmen mit vergleichbaren oder besseren physikalischen Eigenschaften als dies der Fall bei Standard CM-Produkte ist. CM-d verfügt über ein hervorragendes Gleichgewicht zwischen thermischer und chemischer Beständigkeit. Demzufolge eignet es sich für den Einsatz in spezifischen Draht- und Kabelanwendungen. Die Angaben in den *Tabellen 1–3* zeigen die potentiellen Vorteile von CM-d.

5.1 Höhere Belastungen von Füllmaterial

CM-d ist dazu bestimmt höhere Belastungen von Füllmaterial aufzunehmen, während die physikalischen Eigenschaften erhalten bleiben. Zur Darstellung wurde CM-d mit CM-a in einer Ummantelungsanwendung flexibler Leitungsschnüre, nach der Norm 62 von Underwriters Laboratories (UL®) verglichen. Eine typische Mischung, in der CM-a mit einer „normalen" Belastung von Füllmaterial und Weichmacher enthalten ist, wurde mit Mischungen mit einer „hohen" Belastung verglichen. Im Vergleich zu „normalen" Mischungen, enthielten hochbelastete Mischungen einen um ca. 34% höheren Gesamt-phr-Wert (siehe *Tabelle 1*).

Die Mischungen wurden als eine 0,76mm Umhüllung auf 14 AWG reinem Aluminiumdraht (1,63mm Durchmesser) extrudiert, mit Einsatz eines 38,1mm Einzelschneckenextruders mit einem Längen-Durchmesser-Verhältnis (L/D) von 15. Der Draht wurde im CV-Rohr (kontinuierliche Vulkanisierung) 2 Minuten lang in 1,72 MPa Dampf ausgehärtet. Brammenmuster (für die Brüchigkeitsprüfung bei niedriger Temperatur) wurden 2 Minuten lang bei 200 °C ausgehärtet. Die Verarbeitungs- und Aushärtungsdaten sind in der *Tabelle 2* dargestellt.

Die Muster wurden entsprechend geeigneter ASTM-Spezifikationen geprüft:

- Zugfestigkeit ASTM D412
- IRM 902 Eintauchen ASTM D471
- Wärmealterung ASTM D573
- Brüchigkeit bei niedriger Temperatur ASTM D746
- physikalische Eigenschaften sind in der *Tabelle 3* angegeben

5.2 Überlegungen zur Viskosität

Wenn CM-d direkt durch ein chloriertes Polyethylenharz in einer bestehenden Mischung ersetzt wird, ergibt sich in der Regel eine höhere Viskosität als bei der ursprünglichen Mischung. Jedenfalls kann durch das Hinzufügen von erhöhten Niveaus von Weichmachern und/oder EO-b bei 10–15 phr, die Viskosität der Mischung reduziert werden, wie in der *Tabelle 2* dargestellt. Die mit EO-Elastomer hochgefüllte Mischung hat Verarbeitungseigenschaften, die vergleichbar sind mit jenen der normal belasteten Mischung aus CM-a.

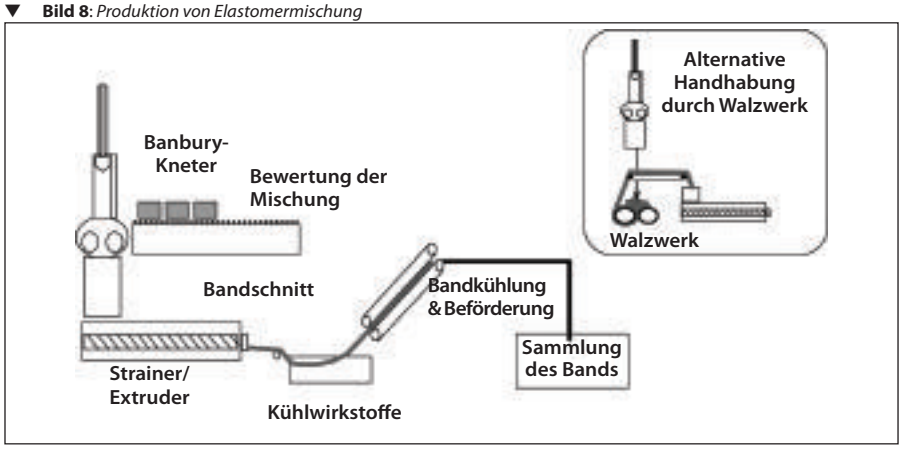
5.3 Physikalische Eigenschaften

Wenn Füllmaterialniveaus von „normal" auf „hoch" in der CM-a-basierenden Mischung erhöht werden, entsteht ein entsprechender Verlust der physikalischen Eigenschaften (siehe *Tabelle 3*). Insbesondere zeigen Zugfestigkeit und Beibehaltung der Dehnung nach der Alterung eine beträchtliche Reduzierung auf. Wenn jedoch das „hohe" Füllmaterialniveau mit CM-d (oder einer Mischung von CM-d und EO-b) eingesetzt wird, sind die physikalischen Eigenschaften mit jenen der „normalen" Belastung des Füllmaterials in CM-a vergleichbar.

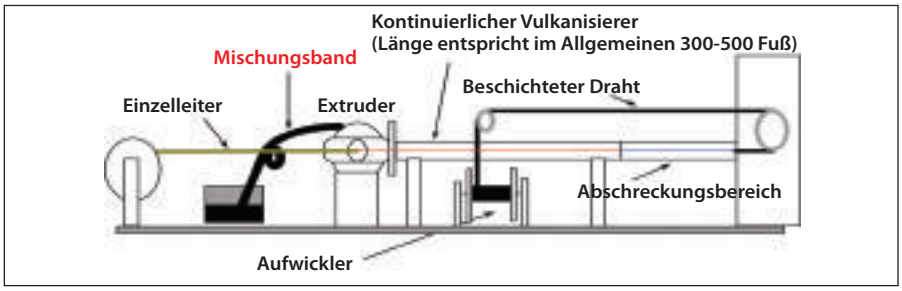
5.4 Die Bedeutung des Aufbaus der Elastomere-Kettenarchitektur

Durch CM-d kann die Mischung ein „normal belastetes" Rezept ändern indem die Niveaus des Füllmaterials und der Öle erhöht werden, während weiterhin die Leistungen der physikalischen Eigenschaften eingehalten werden. Typische CPE-Klassen mit hohem Molekulargewicht, wie z. B. CM-a weisen nicht so gute Leistungen wie CM-d

▼ **Bild 8**: *Produktion von Elastomermischung*



▼ **Bild 9**: *Elastomerextrusion bei Draht*



	„Normale Belastung“	„Hohe Belastung“		
	CM-a	CM-a	CM-d	CM-d/EO-b
Dichte	1.607	1.648	1.648	1.622
CM-a	100	100	--	--
CM-d	--	--	100	85
EO-b	--	--	--	15
Drei-funktioneller Acrylester (Coagents)	5	5	5	5
a,a'-bis(t-Butylperoxid) Diisopropylbenzen, 40% aktiv	5	5	5	6.5
N-550 Ruß	35	--	--	--
N-774 Ruß	--	80	80	80
Kalziumkarbonat	150	200	200	200
DINP	38	60	60	60
Kalziumkarbonat	2	1.5	1.5	1.5
Magnesiumoxid	5	5	5	5
Gesamt-phr:	340	456.5	456.5	458

▲ **Tabelle 1**: *Rezepte für flexible Leitungsschnüre*

	„Normale Belastung“	„Hohe Belastung“		
	CM-a	CM-a	CM-d	CM-a/EO-b
Verfahrenseigenschaften				
Mooney-Anvulkanisation bei 121°C, kleiner Roto				
Minimum, MU	28.5	23.2	39.5	31.5
t3, Minuten	>25	>25	>25	24.2
t5, Minuten	>25	>25	>25	24.7
RPA (Analysator der Verarbeitbarkeit von Kautschuk) bei 110°C, 10% Dehnung				
Viskosität bei 150 rad/s, Pa-s	4577	3842	5282	4764
Drahtextrusion, 38,1 mm Extruder,, 15:1 L:D, ~ 110°C)				
Extruderdruck, MPa	27	23	29	25
Eigenschaften der Aushärtung				
Schwingscheibenrheometer bei 200°C, 6 Minuten lang				
Minimum, dN-m	11.2	6.6	15.2	13.3
Maximum, dN-m	80.7	56.3	75.8	82.1
delta Drehmoment, dN-m	69.5	49.7	60.6	68.8
t90, Minuten	1.7	1.8	1.9	1.8

▲ **Tabelle 2**: *Verarbeitungs- und Aushärtungseigenschaften*

▼ **Tabelle 3**: *Physikalische Eigenschaften*

	„Normale Belastung“	„Hohe Belastung“		
	CM-a	CM-a	CM-d	CM-d/EO-b
Ursprüngliche physikalische Angaben*				
Belastung bei 100% Dehnung, MPa	3.4	3.5	2.6	4.6
Zugfestigkeit, MPaa	9.2	7.6	9.8	9.7
Dehnung beim Bruch, %	514	518	350	306
IRM 902/18 hr bei 121°C*				
Beibehaltung der Zugfestigkeit, %	87	90	94	96
Beibehaltung der Dehnung, %	91	58	86	89
Alterung im Luftofen -- 10 Tage bei 110°C				
Beibehaltung der Zugfestigkeit, %	93	108	98	92
Beibehaltung der Dehnung, %	80	52	79	75
Brüchigkeit bei niedriger Temperatur, °C -**	-27.5	-29.5	-32.5	-35.5

*14 AWG (1.63mm Durchmesser) Aluminiumdraht/0,76mm Ummantelung/2 Minuten lang in 1,72 MPa Dampf ausgehärtet
**Brammen/ 2 Minuten lang bei 200°C ausgehärtet

mit hochbelasteten Mischungen auf. CM-d wurde spezifisch als Unterstützung für Mischungen entworfen, um höhere Leistungen bei ähnlichen oder niedrigen Kosten zu erzielen (dank höherer Belastungen von Füllmaterial/Öl).

Das Beispiel in den Tabellen 1-3 dient als Beweis dazu, daß verbesserte Mischungsleistungen, wie z. B. höhere physikalische Eigenschaften und Leistungen mit niedriger Temperatur durch Einsatz einer geeigneten Elastomermatrix mit optimierter Kettenarchitektur erzielt werden können, damit eine höhere Belastung der Zusatzstoffe, die Mischungsleistungen weiterhin ausgleichen und möglicherweise eine positive Auswirkung auf die Mischungswirtschaftlichkeit haben kann.

6. Schlußfolgerungen

Elastomere können sich an einem breiten Anwendungsbereich beteiligen, einschließlich thermoplastischen oder wärmehärtenden Systemen, wie z. B. Ummantelung, Isolierung, Füllmaterial sowie raucharme, halogenfreie Systeme und Niederspannungsisolierung.

Höhere Niveaus von Füllmaterial können in den Elastomeren aufgenommen werden, um deren Eigenschaften an Mischungsleistung zu erweitern, damit sie sich besonders für anspruchsvolle Umgebungen eignen. Die Kettenarchitektur der Elastomere ist wichtig, um zu bestimmen wie und wieviel der verschiedenen Zusatzstoffe in der Mischung eingesetzt werden können oder sollten, um die Gebrauchsleistung zu erzielen. Vernetzte Elastomere-Mischungen weisen eine hervorragende Wärme- und Ölbeständigkeit auf, und die Aushärtungsgeschwindigkeit kann einfach durch Dien-Niveaus eingestellt werden. Die meisten EPR oder EPDM eigenen sich für Anwendungen, bei denen gute mechanische Eigenschaften erfordert werden, dank deren hohen Molekulargewicht, jedoch ist EB oder EO als Rheologiemodifikator beliebt wegen seiner relativ niedrigen Viskosität. Das Vorhandensein von Chlor in chloriertem Polyethylen verbessert seine Chemie, Öl- und Flammbeständigkeit im Vergleich zu Chlor nicht enthaltendem Ethylen-Elastomere. Infolgedessen können einfache Änderungen in den Parametern der Strukturarchitektur in ethylenenthaltendem Elastomere die Leistungseigenschaften der typischen Polyethylenkabel für umfassende Anwendungen sehr erweitern. ■

7. Literatur

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Олефиновые эластомеры для производства кабельно-проводниковых изделий

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Аннотация

Полимерная изоляционные и оболочные материалы являются надежным и экономически эффективным средством защиты кабелей, проводов и волокон, используемых в настоящее время для передачи электроэнергии и информационных данных. Выбор полимерного покрытия для конкретного применения зависит от многих факторов, включая требования к электрическим и физическим свойствам кабеля и вопросы защиты окружающей среды. Пластикаты и эластомерные компаунды – два типа материалов из числа наиболее распространенных, которые используются в большинстве конструкций проводов и кабелей. Благодаря своим хорошим эксплуатационным характеристикам и относительно невысокой стоимости значительную часть рынка сохраняет за собой полиэтилен – один из наиболее популярных пластиков, используемых в проволочно-кабельной промышленности. Кабели, произведенные из компаундов с использованием эластомеров, в дополнение к пластикам, обладают собственными функциональными свойствами, обусловленными особой структурой полимера.

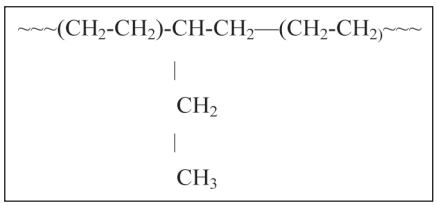
Эластомеры представляют собой полимеры, которые под воздействием относительно небольшого механического напряжения демонстрируют высокую эластическую растяжимость и пластичность. Сравнение полимерного строения полиэтилена с тремя обычными коммерчески доступными эластомерами (этилен-октеном (EO) или этилен–бутеном (EB)), хлорированным полиэтиленом (CM) и EPDM (этилен-пропилен-диеновым терполимером) раскрывает сходства и различия этих разных типов материалов и дает возможность пристально взглянуть на их эксплуатационные характеристики. Все эти полимеры имеют насыщенную структуру основной цепи, однако пластичность, тактильные ощущения при контакте и эксплуатационные характеристики компаундов сильно различаются. На основе более аморфных эластомерных материалов EO (или EB), CM или EPDM обычно получаются компаунды, обладающие более высокой пластичностью, чем компаунды на основе полиэтилена.

В настоящей работе будет рассмотрена роль этих эластомерных полимеров в производстве кабельно-проводниковой продукции, и проведено обсуждение сходных свойств и различий этих материалов в зависимости от их полимерного строения. Акцент будет сделан на эластомерных смолах. Авторы рассмотрят вопросы зависимости свойств от строения, чтобы помочь уяснить основные преимущества и недостатки каждого типа полимеров для кабельно-проволочной промышленности.

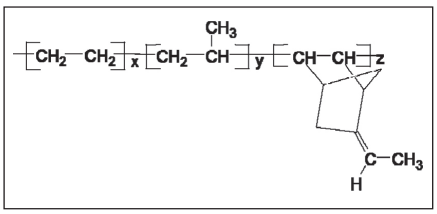
Эластомеры могут иметь широкий спектр применения, включая термопластические и термореактивные системы, используемые, например, при изготовлении оболочек, изолирующих материалов, подложек, малодымной, безгалогенной и низковольтной изоляции. Технические данные по использованию этих полимеров в типичных применениях при производстве проводов и кабелей будут представлены в качестве примера.

1. Структура эластомеров

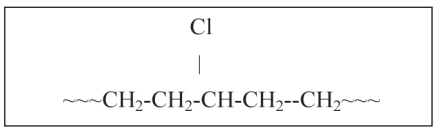
Промышленно выпускаемые полиолефиновые эластомеры представляют собой сополимеры этилена с одним или более высших α-олефинов, таких как этилен-октен (EO), этилен-гексен (EH), или этилен-бутен (EB), как показано на рис. 1.



▲ **Рис. 1.** *Структурная формула этилен-бутенового эластомера*



▲ **Рис. 2.** *Структурная формула EPDM, содержащего ENB*



▲ **Рис. 3.** *Структурная формула CPE*

Этиленпропиленовые каучуки (EPR) представляют собой сополимеры этилена и пропилена, расположенные в случайном порядке и образующие резиноподобные и стабильные полимеры. Третий, несопряженный диеновый мономер может быть терполимеризован управляемым способом для того, чтобы получить насыщенную основную цепь и оставить свободные реактивные ненасыщенные связи в боковой цепи для облегчения процесса вулканизации или полимерной модификации. По стандарту ASTM, EPR обозначается как EPM для сополимеров и EPDM для терполимеров, где «E» обозначает этилен, «P» обозначает пропилен, «D» обозначает диен, и «M» обозначает насыщенную цепь полиметиленового типа. Структурная формула полимера EPDM с использованием этилиденнорборнена (ENB) в качестве диенового мономера показана на рис. 2.

Хлорированный полиэтилен (CPE) представляет собой синтетический эластомер, получаемый контролируемым хлорированием полиэтиленового сырья [1] со случайным распределением атомов хлора в основной цепи полимера. Обобщенная химическая формула CPE представлена на рис. 3.

По стандарту ASTM хлорированный полиэтилен обозначается как CM или хлорполиэтилен, где «C» обозначает хлор, а «M» обозначает насыщенную цепь полиметиленового типа.

Ввиду наличия стабильной насыщенной основной полимерной цепи компаунды, полученные из этиленсодержащих эластомеров, высоко ценятся за прекрасное сочетание тепло- и маслостойкости, что отражено и классифицировано в стандарте ASTM D2000/SAE J200 [2,3] (см. рис. 4).

В дополнение к стойкости к агрессивным средам, их пластичность облегчает монтаж кабеля и обеспечивает надежное сращивание и концевую заделку, особенно в холодную погоду. Это делает их привлекательными материалами для производства изоляции и оболочки кабеля. Пределы пластичности этиленсодержащих эластомеров в сравнении с другими распространенными пластиками представлены на рис. 5.

2. Соотношение структура-свойства

Степень кристаллизации, молекулярная масса (MW), молекулярно-массовое распределение (MWD), наличие боковых цепей, тип сополимера и диена, их соотношение и содержание хлора являются одними из ключевых переменных строения цепи, которые можно варьировать для оптимизации свойств различных промышленно выпускаемых этиленсодержащих эластомеров.

2.1 Кристалличность и молекулярная масса

Кристалличность может быть обусловлена упорядоченным, периодическим расположением атомов или групп атомов. Степень кристалличности и точка плавления кристалла зависят от длины звеньев сегментов этилена и наличия пороков в кристаллах этиленсодержащих эластомеров. По сравнению с сополимерами этилена и высших α-олефинов этиленпропиленовый сополимер обычно включает более короткие этиленовые звенья с бóльшим количеством дефектов в кристаллических фазах. Кристалличность CPE может регулироваться в процессе хлорирования для получения аморфного или полукристаллического продукта. Уровень остаточной кристалличности полиэтилена также играет роль в определении общих физических свойств CPE. Звенья этилена в неупорядоченном сополимере слишком коротки, чтобы кристалличность была значительной, в результате чего образуется аморфный полимер. Аморфный этиленовый сополимер отличается мягкостью и технологичностью при переработке и обычно обладает худшими физическими свойствами, чем более высококристалличный эластомер. При содержании этилена в районе 60 % по массе олефиновый эластомер обладает достаточным уровнем кристалличности и твердости для его последующей грануляции. Благодаря процессу хлорирования CPE всегда существует в порошкообразной форме, вне зависимости от уровня кристалличности.

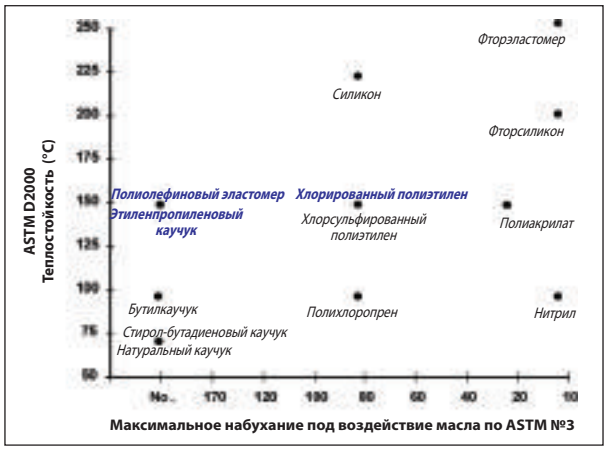
Кристалличность оказывает существенное влияние на физические свойства. Например, с повышением уровня кристалличности модуль упругости и прочность на растяжение, а также твердость и прочность на истирание увеличиваются, однако значения температуры отверждения на холоде, упругого восстановления и сопротивления изгибу уменьшаются. С повышением уровня кристалличности также улучшается когезионная прочность в холодном невулканизированном состоянии. В полимеры с более высокой молекулярной массой можно ввести большее количество наполнителя, и они обладают лучшими физическими свойствами, включая повышенную прочность на растяжение и истирание, однако, с точки зрения технологичности при переработке, их свойства нуждаются в оптимизации.

2.2 Молекулярно-массовое распределение

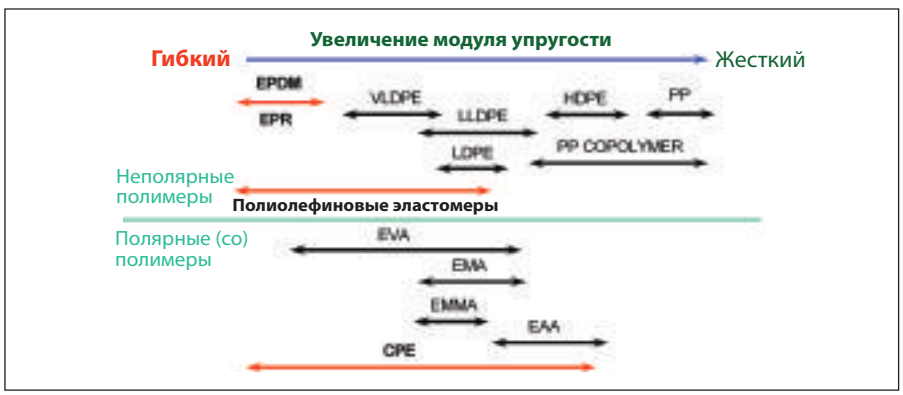
Молекулярно-массовое распределение (MWD) этиленсодержащих эластомеров оказывает влияние на технологические характеристики. Широкое молекулярно-массовое распределение указывает на хорошую смешиваемость на вальцах, более высокую когезионную прочность горячей невулканизированной смеси, улучшенные экструзионные характеристики и, в общем случае, на лучший внешний вид поверхности после экструдирования.

Однако скорость вулканизации и степень вулканизации могут быть ниже для эластомеров с широким молекулярно-массовым распределением. В целом, полимеры с более широким молекулярно-массовым распределением обладают лучшими технологическими, но худшими вулканизационными характеристиками, чем полимеры с узким молекулярно-массовым распределением.

▼ **Рис. 4.** *Тепло- и маслостойкость различных эластомеров*



▼ **Рис. 5.** *Диапазон пластичности олефиновых (этиленовых) эластомеров*



2.3 Диены

Подобно сшитому полиэтилену, полиолефиновые эластомеры, EPDM и CM могут быть сшиты перекисью. В случае с EPDM введение диена позволяет проводить вулканизацию с помощью серы. Однако перекисная вулканизация предпочтительна для производства изоляции силовых кабелей, так как при использовании перекиси в качестве вулканизирующего агента обычно обеспечиваются лучшие электрические свойства, чем при использовании серы. Наиболее часто используемые диеновые термономеры включают в себя этилиденнорборнен (ENB) и дициклопентадиен (DCPD). Среди этих диенов самая высокая скорость вулканизации у ENB, а самая низкая – у DCPD. Присутствие диена увеличивает вероятность ветвления EPDM и приводит к образованию периодически расположенных звеньев CH2 на боковой цепи, ответвляющейся от основной цепи полимера. Разветвление понижает вязкость полимера при высокой скорости сдвига, улучшая экструзионные характеристики, а также повышает вязкость полимера при низкой скорости сдвига, повышая устойчивость к провисанию. В общем случае, DCPD с большей вероятностью образует длинные разветвленные цепи, чем ENB.

2.4 Содержание хлора

Подобно тому, как введение в полимер галогенсодержащих добавок повышает стойкость к воспламенению, присутствие хлора в основной цепи CM улучшает характеристики полимера по горючести и огнестойкости. Как показано на рис. 7, стойкость к воспламенению (на которую указывает более высокое значение предельного кислородного индекса (LOI)) повышается с увеличением содержания хлора в CPE. Присутствие хлора усиливает стойкость компаундов на основе CPE к жидким нефтепродуктам и топливам, поэтому CPE с повышенным содержанием хлора обычно выбирают, когда масло- и топливостойкость являются критичными эксплуатационными параметрами для кабельных применений.

3. Приготовление компаундов

Экструзия этиленсодержащего эластомера с высокой молекулярной массой без использования добавок обычно приводит к получению экструдата с неровной поверхностью по причине растрескивания расплава. Добавка наполнителя повышает степень чистоты поверхности экструдата, а также механическую прочность компаунда. Другие ингредиенты, такие как пластификаторы, смазки, антиоксиданты, сшивающие агенты, поглотители ультрафиолетового излучения, антипирены, часто используются для улучшения функциональных свойств компаунда.

Состав эластомерного компаунда определяет потребительские качества продукта, но тип и количество различных ингредиентов, которые могут или должны использоваться в компаунде, определяются свойствами матрицы эластомера.

Шнековые смесители непрерывного действия сочетают высокую скорость и достаточное качество смешивания для эффективного производства пластикатов. Однако для правильной загрузки смесителей непрерывного действия компоненты смеси должны быть в виде гранул или порошка. Для подготовки эластомерных компаундов обычно используются закрытые смесители периодического действия, такие как смесители Бенбери (Banbury®) корпорации «Фаррел» (Farrel Corporation) или двухвалковые вальцы. Аморфные маловязкие

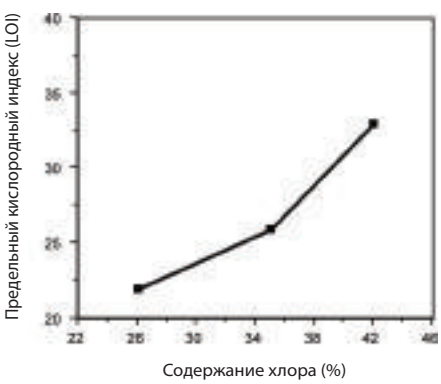
▲ **Рис. 6.** *Соотношение структура-свойства олефиновых эластомеров*

полимеры с широким молекулярно-массовым распределением лучше всего подходят для смешивания на вальцах. Компаунды, приготовленные на основе эластомеров с высокой вязкостью и высокой кристалличностью, крайне плохо поддаются смешиванию на двухвалковых вальцах, и наиболее высокая эффективность и приемлемое время смешивания достигаются при использовании смесителей Бенбери. Эластомеры в форме гранул или кип рыхлой прессовки легко смешиваются в смесителе периодического действия, так как кипы прессуются неплотно и легко рассыпаются в смесителе Бенбери под действием лопастей. В зависимости от предполагаемого применения эластомерные компаунды, приготовленные на вальцах или в смесителях периодического действия, могут направляться на фильтрующий экструдер или загружаться в экструдер напрямую, как показано на рис. 8.

4. Процесс экструзии

Для производства кабельно-проводниковой продукции компаунды на основе аморфных эластомеров лучше экструдировать с использованием шнеков для каучука, в то время как полукристаллические эластомеры лучше обрабатывать с использованием шнеков для полиэтилена. Компаунды аморфных эластомеров обычно подаются в виде лент, а полукристаллические эластомеры, как правило, в виде гранул или кубиков.

▼ **Рис. 7.** *Зависимость величины предельного кислородного индекса от содержания хлора в CM*



Компаунды этиленсодержащих эластомеров могут быть экструдированы с использованием оборудования как холодного, так и горячего питания. В экструдер холодного питания с удлиненным цилиндром полосы компаундированного материала загружают при температуре окружающей среды, при этом обычно требуется компаунд с высокой когезионной прочностью резиновой смеси при комнатной температуре. В компаундах холодной подачи следует использовать эластомеры с достаточной кристалличностью, иначе полосу будет заедать в шнеке экструдера, что приведет к перерывам в подаче материала. В экструдер горячего питания с коротким цилиндром обычно загружают полосы сырья, предварительно разогретые на вальцах. Такое сырье должно содержать эластомер с широким молекулярно-массовым распределением для обеспечения когезионной прочности при высоких температурах. Загружаемые полосы должны быть как можно более холодными, чтобы уменьшить комкование загружаемого материала в бункере. Минимизация использования вспомогательных технологических средств и правильный подбор ароматических масел позволяют улучшить контакт полосы с поверхностью шнека и эффективность подачи. Для улучшения сопротивления смятию экструдированного материала может потребоваться некоторое количество высоковязких или кристаллических полимеров.

При правильно организованной подаче в виде полос или гранул эластомерные компаунды затем быстро и беспрепятственно экструдируются на проводники при помощи экструдеров со шнеком для каучука или со шнеком для полиэтилена, либо литьем под давлением при помощи поперечной экструзионной головки, как показано на рис. 9. Температура поперечной экструзионной головки обычно поддерживается на уровне, достаточном для размягчения полимера и обеспечения выпрессовки, но ниже температуры разложения перекиси, чтобы избежать подвулканизации. В большинстве случаев провод с эластомерной изоляцией затем подвергается вулканизации в установке непрерывной вулканизации (НВ). Смотанный на бобины провод после этого или поступает в продажу, или используется для последующего каблирования.

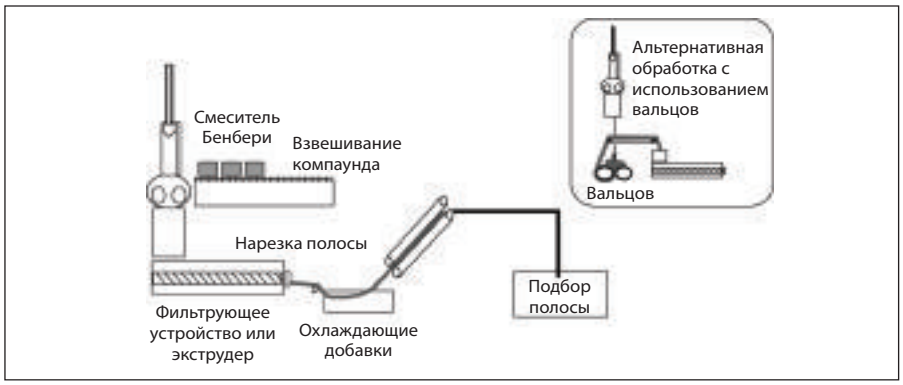
5. Оптимизация строения цепи для использования в производстве кабельно-проводниковой продукции

Эксплуатационные свойства компаундов для кабельно-проводниковой продукции зависят от сочетания эксплуатационных свойств применяемых ингредиентов и от выбора полимера. Эластомерная матрица и ее сочетаемость с ингредиентами, вводимыми в эластомер, в большой степени влияют на успешную разработку компаунда. Таким образом, правильное конструирование строения цепи представляет собой одну из наиболее важных стадий в разработке компаунда для применения в проводах и кабелях. Однако именно свойства эластомерной матрицы, которая определяет тип и количество различных ингредиентов, могут или должны быть использованы в компаунде для регулирования конечных эксплуатационных качеств продукта.

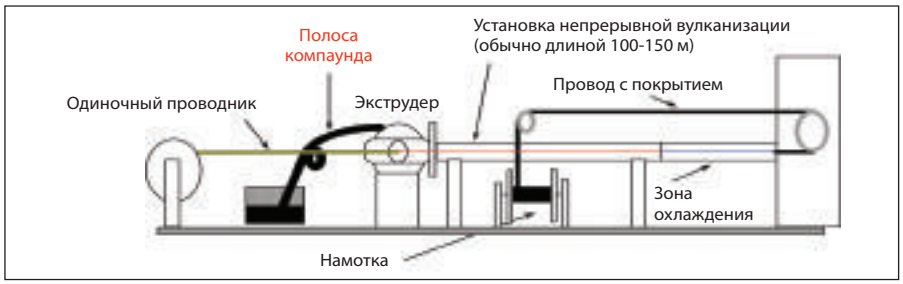
Например, CM-d является экспериментальной маркой аморфного хлорированного полиэтилена (CM), которая была разработана специально для введения большого количества наполнителей с сопоставимыми или лучшими физическими характеристиками, чем у стандартных CM продуктов. Отличный баланс термостойкости и химической инертности CM-d позволяет ему найти применение в производстве специальных проводов и кабелей. Данные, приведенные в таблицах 1–3, демонстрируют потенциальные преимущества марки CM-d.

5.1 Увеличение массы наполнителей

CM-d был разработан с целью введения большого количества наполнителей при сохранении физических свойств. К примеру проводился сравнительный анализ CM-d и CM-a при применении в качестве оболочки гибкого провода в соответствии со стандартом 62 Лаборатории по технике безопасности США (UL®). Стандартная рецептура смеси, содержащая CM-a с «нормальным» количеством наполнителей и пластификаторов, сравнивалась с компаундами,



▲ **Рис. 8.** *Получение эластомерного компаунда*



▲ **Рис. 9.** *Экструзия эластомерного провода*

содержащими «большое» их количество. Общее весовое количество добавок в компаундах с высоким их содержанием приблизительно на 34 % превышало весовое количество добавок, содержащихся в «нормальном» компаунде (см. таблицу 1). Компаунды экструдировались в виде 0,76-мм оболочки на цельноалюминиевую проволоку калибром 14 AWG (1,63 мм в диаметре) с использованием 38,1-мм одношнекового экструдера с отношением длины к диаметру (L/D), равным 15. Провод вулканизировался в установке непрерывной вулканизации (HB) в течение 2 мин паром под давлением 1,72 МПа. Образцы листов (для испытаний на хрупкость при низких температурах) подвергались вулканизации в течение 2 мин при 200 °C. Технологические данные и данные по вулканизации указаны в таблице 2.

Испытания образцов проводились в соответствии с требованиями применимых стандартов ASTM:

- прочность на разрыв – ASTM D412;
- испытание при погружении в технические масла IRM 902 согласно стандарту ASTM D471;
- тепловое старение – ASTM D573;
- хрупкость при низких температурах – ASTM D746;
- физические свойства указаны в таблице 3.

5.2 Учет вязкости

Прямая замена CM-d в существующем компаунде на хлорированную полиэтиленовую смолу обычно приводит к увеличению вязкости по сравнению с исходным компаундом. Однако путем введения большей массы пластификаторов и (или) введения EO-b в количестве 10–15 весовых частей на сто частей смеси вязкость компаунда может быть уменьшена, как показано в таблице 2. Высоконаполненный компаунд с эластомером EO обладает технологическими характеристиками, сравнимыми с характеристиками содержащего CM-a компаунда с нормальным содержанием добавок.

5.3 Физические свойства

Когда масса наполнителей в компаунде на основе CM-a увеличивается с «нормального» до «высокого» уровня, наблюдается соответствующее ухудшение физических свойств (см. табл. 3). В частности, значительно уменьшаются прочность на разрыв и остаточное относительное удлинение после старения. Однако при «высоком» уровне наполнителей в компаунде с CM-d (или в смеси CM-d и EO-b) физические свойства сопоставимы с наблюдаемыми при использовании в CM-a «нормального» количества наполнителей.

5.4 Важность конструирования строения цепи эластомера

CM-d позволяет производителям компаундов изменять рецептуру с «нормальным наполнением» путем увеличения массы наполнителей и масел, сохраняя при этом физические свойства. Типичные марки CPE с высокой молекулярной массой, такие как CM-a, не демонстрируют таких хороших эксплуатационных качеств, как CM-d в компаундах с высоким уровнем наполнителей. CM-d был разработан специально для того, чтобы помочь производителям компаундов достичь более высоких результатов при той же или меньшей стоимости (за счет более высокого содержания наполнителей и масел).

Пример, приведенный в таблицах 1-3, дает возможность продемонстрировать, что более высокие характеристики компаунда, такие как улучшенные физические свойства и эксплуатационные характеристики при низких температурах, могут быть достигнуты путем использования подходящей эластомерной матрицы с оптимизированным строением цепи для того, чтобы обеспечить возможность увеличения количества вводимых ингредиентов для достижения большей сбалансированности характеристик компаунда и возможного позитивного влияния на стоимость компаунда.

6. Выводы

Эластомеры могут иметь широкий спектр применения, включая

	«Нормальное наполнение»	«Высокое наполнение»		
	CM-a	CM-a	CM-d	CM-d/EO-b
Плотность	1.607	1.648	1.648	1.622
CM-a	100	100	--	--
CM-d	--	--	100	85
EO-b	--	--	--	15
Трифункциональный эфир акриловой кислоты (соагент)	5	5	5	5
a,a'-бис(т-бутил перокси) диизопропилбензол, 40 %	5	5	5	6.5
Технический углерод N-550	35	--	--	--
Технический углерод N-774	--	80	80	80
Карбонат кальция	150	200	200	200
ДИНФ	38	60	60	60
Парафин	2	1.5	1.5	1.5
Окись магния	5	5	5	5
Общее весовое количество:	340	456.5	456.5	458

▲ **Таблица 1.** *Рецептуры для оболочки гибкого провода*

	«Нормальное наполнение»	«Высокое наполнение»		
	CM-a	CM-a	CM-d	CM-a/EO-b
Технологические характеристики				
Подвулканизация по Муни при 121 °C, малый ротор				
Минимум, ед.	28.5	23.2	39.5	31.5
t3, мин	>25	>25	>25	24.2
t5, мин	>25	>25	>25	24.7
АТК (Анализатор технологичности каучука) при 110 °C, деформация 10 %				
Вязкость при 150 рад/сек, Па•с	4577	3842	5282	4764
Экструзия оболочки провода, 38,1- мм экструдер, 15:1 L:D, ~ 110 °C)				
Давление в экструдере, МПа	27	23	29	25
Характеристики вулканизации				
Вискозиметр с колеблющимся диском при 200 °C в течение 6 мин				
Минимум, дН•м	11.2	6.6	15.2	13.3
Максимум, дН•м	80.7	56.3	75.8	82.1
Приращение крутящего момента, дН•м	69.5	49.7	60.6	68.8
t90, мин	1.7	1.8	1.9	1.8

▲ **Таблица 2.** *Технологические характеристики и данные по вулканизации*

▼ **Таблица 3.** *Физические свойства*

	«Нормальное наполнение»	«Высокое наполнение»		
	CM-a	CM-a	CM-d	CM-d/EO-b
Исходные физические свойства*				
Напряжение при 100 % удлинении, МПа	3.4	3.5	2.6	4.6
Предел прочности на разрыв, МПа	9.2	7.6	9.8	9.7
Удлинение при разрыве, %	514	518	350	306
Погружение в технические масла IRM 902 (18 ч при 121 °C)*				
Остаточная прочность на разрыв, %	87	90	94	96
Остаточное удлинение, %	91	58	86	89
Старение в воздушной печи – 10 дней при 110 °C				
Остаточная прочность на разрыв, %	93	108	98	92
Остаточное удлинение, %	80	52	79	75
Хрупкость при низкой температуре, °C**	-27.5	-29.5	-32.5	-35.5

* Алюминиевая проволока калибром 14 AWG (диаметром 1,63 мм), оболочка 0,76 мм, вулканизация паром при 1,72 МПа в течение 2 мин
**Лист, вулканизация в течение 2 мин при 200 °C

термопластические и термореактивные системы, используемые, например, при изготовлении оболочек, изолирующих материалов, подложек, малодымной, безгалогенной и низковольтной изоляции.

В эластомеры можно вводить повышенное количество наполнителей для расширения эксплуатационных свойств компаундов, чтобы сделать их более приспособленными к предъявляющим высокие требования средам. Строение цепи эластомера важно при определении того, каким образом и в каком количестве различные составляющие могут или должны быть использованы в компаунде для достижения требуемых конечных свойств. Сшивные эластомерные компаунды обладают прекрасной термо- и маслостойкостью, а скорость вулканизации можно легко контролировать, изменяя концентрацию диенов. Большинство эластомеров типа EPR или EPDM подходят для применений, требующих хороших механических свойств, благодаря своей большой молекулярной массе, а EB и EO популярны в качестве реологических регуляторов по причине их относительно низкой вязкости. Присутствие хлора в хлорированном полиэтилене в еще большей степени повышает его химическую инертность, масло- и огнестойкость по сравнению с этиленовым эластомером, не содержащим хлора. В результате легко производимые изменения в параметрах структурной формулы этиленсодержащего эластомера могут значительноулучшитьэксплуатационные характеристики стандартного кабеля с полиэтиленовой изоляцией для большего числа применений. ■

7. Справочная литература

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Élastomères oléfiniques pour applications de fils et câbles

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Résumé

Les matériaux polymériques d'isolement et de gainage représentent des moyens fiables et économiquement rentables pour la protection des câbles, des fils et des fibres utilisés aujourd'hui dans les applications de transmission de puissance et de données. Le choix du revêtement polymérique pour une application spécifique dépend de nombreux facteurs comme les propriétés électriques, environnementales et physiques requises pour le câble. Les composés plastiques et élastomériques représentent deux des classes de matériaux les plus communs utilisés dans la majorité des configurations de fils et de câbles. Grâce à ses performances satisfaisantes et à son coût relativement réduit, le polyéthylène est l'un des matériaux plastiques les plus utilisés dans le secteur des fils et des câbles, en maintenant ainsi une vaste portion de marché. Comme dans le cas des plastiques, les câbles réalisés en utilisant des composés élastomériques possèdent des caractéristiques de performance spécifiques en fonction de leur architecture polymérique particulière.

Les élastomères sont des polymères caractérisés par une extrême extensibilité élastique et flexibilité lorsqu'ils sont soumis à des sollicitations mécaniques relativement réduites. La comparaison entre l'architecture polymérique du polyéthylène et trois élastomères actuellement commercialisés (éthylène-octène (EO) (ou–éthylène-butène (EB)), le polyéthylène chlorifié (CM) et l'EPDM (terpolymère d'éthylène propylène diène) révèle les similitudes et les différences de ces classes de matériaux et offre un aperçu des caractéristiques de leurs performances. La totalité de ces polymères présente une structure de base saturée, mais la flexibilité, la nature tactile e les performances de ces composés sont très différentes. Les matériaux élastomériques EO/EB, CM, ou EPDM les plus amorphes ont tendance à produire des composés qui sont plus flexibles que les composés de polyéthylène.

La présente étude donne une vue d'ensemble du rôle des polymères élastomériques dans les applications des fils et des câbles et examine les similitudes et les différences des matériaux en fonction de leur architecture polymérique, en axant l'attention sur les résines élastomériques. Les rapports entre la structure et les propriétés seront en particulier soulignés pour expliquer plus clairement les principaux avantages et désavantages offerts par chaque type de polymère à l'industrie des fils et des câbles. Les élastomères peuvent être utilisés dans une vaste gamme d'applications, y compris les systèmes thermoplastiques et thermodurcis tels que: gainage, isolement, matériau de remplissage, faible émission de fumées sans halogène et isolement à basse tension. Des données techniques relatives à l'utilisation de ces polymères dans des applications de fils et câbles typiques seront présentées dans un but explicatif.

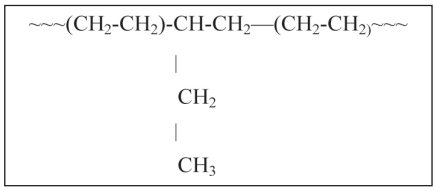
1. Structure des élastomères

Les élastomères de polyoléfine commerciaux sont des co-polymères d'éthylène avec une ou plusieurs alpha-oléfines élevées telles que l'éthylène-octène (EO), l'éthylène-hexène (EH), ou l'éthylène-butène (EB) comme représenté à la *Figure 1*. Les caoutchoucs à base d'éthylène-propylène (EPR) sont des co-polymères à base d'éthylène et de propylène arrangés de façon aléatoire pour produire des polymères caoutchoutés et stables. Un troisième monomère diénique non-conjugué peut être terpolymérisé d'une façon contrôlée afin de maintenir une structure de base saturée et de placer l'insaturation réactive dans une chaîne latérale disponible pour la chimique de vulcanisation ou de modification des polymères. La désignation ASTM pour le EPR est EPM pour les copolymères et EPDM pour les termopolymères où «E» indique l'»éthylène», «P» le propylène, «D» le «diène» et «M» une chaîne saturée du type de polyméthylène. Une structure polymérique EPDM avec éthylidène norbornène (ENB) comme le monomère diénique est illustré à la *Figure 2*.

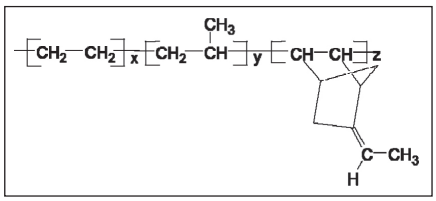
Le polyéthylène chlorifié (CPE) est un élastomère synthétique produit par la chloration contrôlée de la matière première d'alimentation du polyéthylène[1] avec des atomes de chlore distribués au hasard sur le squelette polymérique. Une structure chimique généralisée pour le CPE est représentée à la *Figure 3*. La désignation ASTM pour le CPE est CM ou chloropolyéthylène où «C» indique le «chlore» et «M» indique une chaîne saturée du type polyméthylènique. Grâce à leur structure de base polymérique stable e saturée, les composés obtenus d'élastomères d'éthylène sont précieux pour leur excellente combinaison de résistance thermique et à l'huile comme indiqué et classé par la spécification ASTM D2000/SAE J200[2,3] et représenté à la *Figure 4:* Outre leur durabilité dans des conditions environnementales difficiles, la flexibilité de ces composés permet une installation aisée des câbles et la réalisation d'épissures et des raccordements fiables, surtout dans des conditions de température très basse. Ces caractéristiques en font donc des candidats intéressants pour l'isolement et le revêtement des câbles. Les gammes de flexibilité des élastomères d'éthylène comparées à d'autres matériaux plastiques sont illustrées à la *Figure 5*.

2. Relation entre la structure et les propriétés

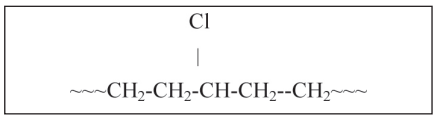
La cristallinité, le poids moléculaire (MW), la distribution de poids moléculaire (MWD), la ramification, le type/niveau de copolymère/diène et le contenu de chlore représentent certaines des principales variables de l'architecture de la



▲ **Figure 1**: *Structure élastomère d'éthylène-butène*



▲ **Figure 2**: *Structure du EPDM contenant éthylidène-norbornène (ENB)*



▲ **Figure 3**: *Structure du CPE*

chaîne pouvant être modifiées pour optimiser les performances de différents élastomères d'éthylène commerciaux.

2.1 Cristallinité et poids moléculaire

Une disposition ordonnée et régulière d'atomes ou des groupes d'atomes peut former une structure cristalline. La cristallinité et le point de fusion cristallin dépendent de la longueur des blocs des segments d'éthylène et des imperfections cristallines des élastomères d'éthylène. Par rapport aux copolymères d'éthylène avec alpha-oléfines plus élevées, le copolymère d'éthylène-propylène présente typiquement des blocs d'éthylène plus courts et avec plus de défauts dans la phase cristalline. La cristallinité du CPE peut être ajustée au moyen du processus de chloration pour obtenir un produit amorphe ou semi-cristallin Le niveau de cristallinité du polyéthylène résiduel joue également un rôle dans le contrôle des propriétés physiques glo-bales du CPE. Les blocs d'éthylène sont trop courts dans un copolymère statistique pour donner comme résultat une cristallinité significative et un polymère amorphe.

Le copolymère d'éthylène amorphe est doux et malléable et il présente généralement des propriétés physiques inférieures à celles d'un élastomère avec une cristallinité supérieure. À environ 60 wt% d'éthylène, un élastomère oléfinique présente une cristallinité et une rigidité suffisantes pour être granulé. Du fait du processus de chloration, le CPE se présente toujours sous forme de poudre indépendamment de la cristallinité. La cristallinité exerce une forte influence sur les propriétés physiques. Par exemple, au rythme de l'augmentation de la cristallinité, du module et de la résistance à la traction même la dureté et la résistance

au déchirement augmentent, tandis que le réglage aux basses températures, la recouvrance élastique et la résistance à la flexion diminuent. Avec l'augmentation de la cristallinité, même la résistance mécanique en vert résulte améliorée. Les polymères avec un poids moléculaire supérieur peuvent accepter une quantité supérieure de matériau de remplissage et présentent des propriétés physiques meilleures, telles qu'une résistance à la traction et au déchirement supérieure, mais ils doivent être optimisés pour améliorer l'ouvrabilité.

2.2 Distribution de poids moléculaire

La distribution de poids moléculaire (MWD) des élastomères d'éthylène influence les caractéristiques du processus. Une large distribution de poids moléculaires améliore le mélange, la résistance en vert à chaud et, en général, la surface après l'extrusion. Toutefois, les caractéristiques de vulcanisation comme la vitesse de vulcanisation et la condition de vulcanisation peuvent être inférieures dans le cas d'élastomères avec une distribution du poids moléculaire plus ample. En général, les polymères avec une distribution du poids moléculaire plus ample présentent de meilleures capacités de processus, mais des caractéristiques de vulcanisation inférieures par rapport aux polymères ayant une distribution du poids moléculaire plus large.

2.3 Diène

De même que le polyéthylène réticulé, les élastomères polyoléfiniques, l'EPDM et le CM peuvent être réticulés par le peroxyde. Dans le cas de l'EPDM, l'addition de diène permet d'effectuer la vulcanisation avec le soufre.

Toutefois, pour l'isolement des câbles de puissance la vulcanisation par peroxyde est préférable puisque l'on obtient de meilleures propriétés électriques par rapport à la vulcanisation par soufre. Les termonomères au diène les plus utilisés comprennent l'éthylidène norbornène (ENB) et le dicyclopentadiène (DCPD). Pour ces dienes, le ENB présente la vitesse de vulcanisation la plus rapide et le DCPD la vitesse la plus lente. La présence de diène favorise la formation de ramification de l' EPDM avec pour résultat la répétition des unités de CH2 à partir d'une chaîne latérale s'étendant de la structure principale du polymère. La ramification diminue la viscosité du polymère à des vitesses de cisaillement supérieures pour offrir des caractéristiques d'extrusion améliorées et augmente la viscosité du polymère à des vitesses de cisaillement inférieures pour améliorer la résistance à la flexion. En général, le DCPD présente la probabilité majeure de créer plus de ramifications de chaîne longues par rapport à l'ENB.

2.4 Contenu de chlore

Comme dans le cas de l'ajout d'additifs contenant de l'halogène au polymère pour améliorer la résistance à l'allumage, la présence de chlore dans la structure de base du CM améliore les caractéristiques de résistance à l'allumage et à la combustion du polymère. Comme démontré à la *Figure 7*, la résistance à l'allumage, indiquée par la valeur supérieure de l'indice limite d'oxygène (LOI), augmente au rythme de l'augmentation du contenu de chlore du CPE. La présence de chlore améliore la résistance aux huiles d'hydrocarbure et aux combustibles dans les composés à base de CPE. Par conséquent, normalement on utilise un CPE à teneur de chlore plus élevée lorsque la résistance à l'huile et aux combustibles représente un facteur critique pour les performances des câbles.

3. Composés

L'extrusion d'élastomères d'éthylène à poids moléculaire élevé généralement entraîne un produit extrudé avec une surface rugueuse à cause des marques de coulée. L'addition de matériau de remplissage améliore le poli de la surface du produit d'extrusion ainsi que la résistance mécanique du composé. D'autres éléments tels que les plastifiants, les lubrifiants, les antioxydants, les agents de réticulation, les stabilisants anti-UV, les retardeurs de flamme sont fréquemment utilisés pour améliorer la fonctionnalité du composé. La composition du composé élastomérique détermine les performances de l'utilisation finale du produit, mais les propriétés de la matrice élastomérique déterminent le type et la quantité des différents ingrédients pouvant ou devant être utilisés dans le composé.

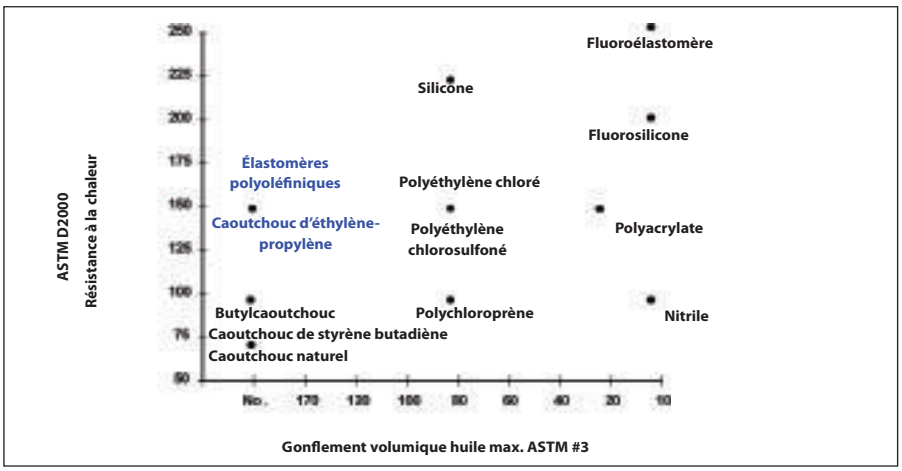
Les mélangeurs à vis en continu offrent d'excellentes vitesses et une dispersion acceptable pour la production de matières plastiques efficaces. Toutefois, les ingrédients du composé doivent se présenter sous forme de boulettes ou de poudre pour alimenter correctement les mélangeurs en continu. Pour la préparation des composés élastomériques l'on utilise généralement les mélangeurs discontinus internes tels que le Banbury® (Farrel Corporation) ou les malaxeurs à deux rouleaux. Les polymères amorphes à faible viscosité avec une large distribution de poids moléculaires sont plus aptes pour le mélange avec malaxeur, tandis que les composés à base d'élastomères à haute viscosité et hautement cristallins sont très difficiles à mélanger sur les malaxeurs à deux rouleaux et conviennent au mélangeur Banbury pour obtenir une haute efficacité de mélange et un temps de cycle raisonnable. Les élastomères sous forme de boulettes ou de balles friables peuvent être aisément mélangés dans un mélangeur discontinu puisque les balles friables étant compactées lâchement sont susceptibles de se casser dans le Banbury sous l'action de cisaillement. En fonction de l'application, les composés élastomériques produits par le malaxeur à rouleaux ou par le mélangeur discontinu peuvent être alimentés à travers une extrudeuse Strainer ou directement dans l'extrudeuse comme illustré à *la Figure 8*.

4. Extrusion du fil

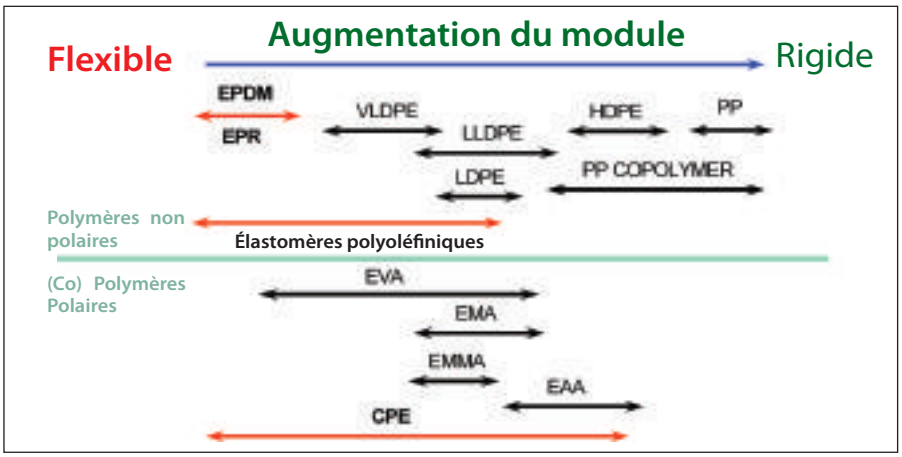
Pour la production des fils et des câbles, les composés à base d'élastomères amorphes sont mieux extrudés avec une vis en caoutchouc alors que les élastomères semi-cristallins se préparent mieux avec la vis en polyéthylène. Les composés élastomériques amorphes sont normalement alimentés sous forme de bandes alors que les élastomères semi-cristallins sont typiquement alimentés sous forme de boulettes ou de petits cubes. Les élastomères d'éthylène peuvent être extrudés en utilisant des équipements d'alimentation à froid ou à chaud. Les extrudeuses équipées d'un cylindre long et caractérisées par une alimentation à froid, sont alimentées avec des bandes composées à température ambiante et en général elles exigent un composé ayant une résistance en vert élevée à température ambiante.

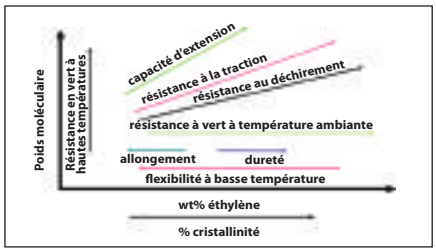
Les élastomères ayant une cristallinité suffisante devraient être utilisés dans les composés avec alimentation à froid pour éviter que la vis de

▼ **Figure 4**: *Résistance à la chaleur et à l'huile des différents élastomères*

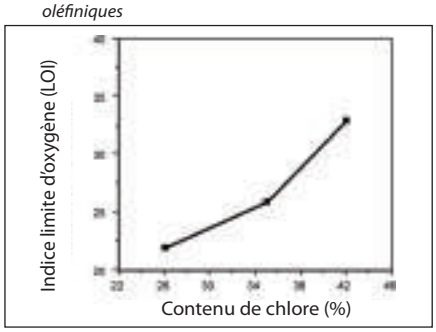


▼ **Figure 5**: *Gamme de flexibilité des élastomères d'éthylène oléfiniques*





▲ **Figure 6**: *Structure-propriété des élastomères oléfiniques*



▲ **Figure 7**: *Indice Limite d'Oxygène par rapport au contenu de chlore du CM*

l'extrudeuse déchire la bande en causant une alimentation irrégulière. Les extrudeuses équipées d'un cylindre court et caractérisées par une alimentation à chaud sont alimentées avec des bandes de matériau préalablement chauffé dans un malaxeur. Ce matériau devrait contenir des élastomères avec une large distribution de poids moléculaire pour donner une résistance en vert à des températures élevées. Les bandes alimentées devraient être les plus froides que possible afin de réduire au minimum l'agglomération du matériau alimenté dans la trémie. La réduction au minimum de l'utilisation d'agents favorisant le processus avec une sélection appropriée d'huiles aromatiques peut améliorer le contact de la bande avec la surface de la vis ainsi que l'alimentation. Des polymères à haute viscosité ou cristallinité peuvent être nécessaires pour améliorer la résistance au flambage du produit extrudé.

Avec une alimentation appropriée avec bandes ou boulettes, les composés élastomériques peuvent être extrudés rapidement et aisément sur des conducteurs en utilisant des vis ou bien des filières sous pression à tête d'équerre en caoutchouc ou en plastique comme illustré à la *Figure 9*. Généralement, les températures des têtes d'équerre sont suffisamment élevées de façon à adoucir le polymère pour permettre un flux régulier, mais au-dessous de la température de décomposition du peroxyde pour éviter la prévulcanisation.

La majorité des fils isolés avec les élastomères est ensuite vulcanisée dans un tube à vulcanisation continue (CV). Le fil enroulé peut être vendu ou utilisé dans des opérations de câblage successives.

5. Optimisation de l'architecture de la chaîne pour les applications des fils et des câbles

Les performances des composés pour fils et câbles dépendent des combinaisons des caractéristiques de performance des éléments concernés et du type de polymère sélectionné.

La matrice élastomérique et sa compatibilité avec les éléments incorporés dans l'élastomère influence considérablement le succès d'un composé. Il s'ensuit que la conception correcte de l'architecture de chaîne représente l'une des phases les plus critiques dans la conception des composés pour les applications des fils et des câbles. Toutefois ces sont les propriétés de la matrice élastomérique qui déterminent le type et la quantité des différents éléments pouvant être utilisés dans le composé pour contrôler les performances d'utilisation finale du produit. Par exemple, Le CM-d représente une qualité amorphe en évolution du polyéthylène chlorifié (CM) qui a été conçue pour accepter des charges élevées de matériaux de remplissage ayant des propriétés physiques comparables ou meilleures par rapport aux produits CM standard. Le CM-d présente un excellent équilibre de résistance thermique et chimique, qui rend ce matériau apte pour l'utilisation dans des applications de fils et câbles spécifiques. Les données des *Tableaux 1-3* illustrent les avantages potentiels du CM-d.

5.1 Charges de matériau de remplissage supérieures

Le CM-d a été conçu pour accepter des charges de matériau de remplissage supérieures tout en maintenant les propriétés physiques. A titre illustratif, le CM-d a été comparé avec le CM-a dans une application de gainage de cordon flexible conformément à la norme 62 de Underwriters Laboratories (UL®).

Une formulation typique contenant le CM-a avec une charge «normale» de matériau de remplissage et de plastifiants a été comparé avec des composants contenant une «charge élevée». Les composés hautement chargés contenaient un phr total de ~34% en plus par rapport au composé «normal» (voir *Tableau 1*). Les composés ont été extrudés comme gaine de 0,76mm dans un fil d'aluminium solide de 14 AWG (diamètre de 1,63mm) en utilisant une extrudeuse à vis simple de 38,1mm avec un rapport longueur/diamètre (L/D) de 15. Le fil a été vulcanisé dans un tube de vulcanisation continue (CV) pour 2min. en vapeur à 1,72 Mpa.

Les échantillons de brames (pour le test de fragilité à basse température) ont été vulcanisés pour 2min. à 200°C. Les données de traitement et de vulcanisation sont illustrées au *Tableau 2*.

Les échantillons ont été testés conformément aux spécifications ASTM appropriées.

- Résistance à la traction ASTM D412
- Immersion IRM 902 ASTM D471
- Vieillissement par chaleur ASTM D573
- Friabilité a basse température ASTM D746
- Les propriétés physiques sont illustrées au *Tableau 3*

5.2 Considérations relatives à la viscosité

Le CM-d, lorsqu'il est directement remplacé par la résine de polyéthylène chlorifié dans un composant existant déjà, entraîne une viscosité supérieure à celle du composé d'origine. Toutefois, comme représenté au *Tableau 2*, avec l'addition de quantités supérieures de plastifiants et/ou l'addition de EO-b à 10–15 phr, la viscosité du composé peut être réduite. Le composé hautement chargé avec l'élastomère EO, présente des caractéristiques de processus comparables à celles du composé CM-a normalement chargé.

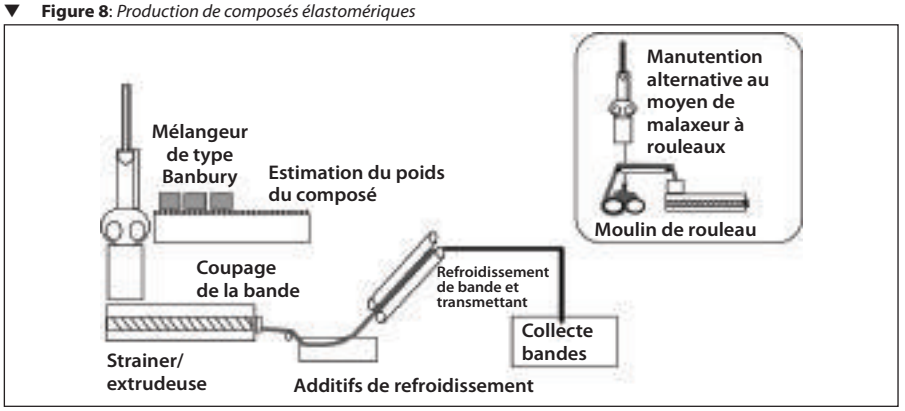
5.3 Propriétés physiques

L'augmentation des niveaux du matériau de remplissage de „normal" à „haut" dans un composé à base de CM-a, entraîne une perte correspondante des propriétés physiques (voir *Tableau 3*). En particulier, la résistance à la traction et la rétention de l'allongement après le vieillissement révèlent une diminution significative. Toutefois, lorsque l'on utilise un niveau de charge de matériau „élevé" avec le CM-d (ou un mélange de CM-d et EO-b), les propriétés physiques peuvent être comparées à celles obtenues en utilisant le niveau de charge „normal" dans le CM-a.

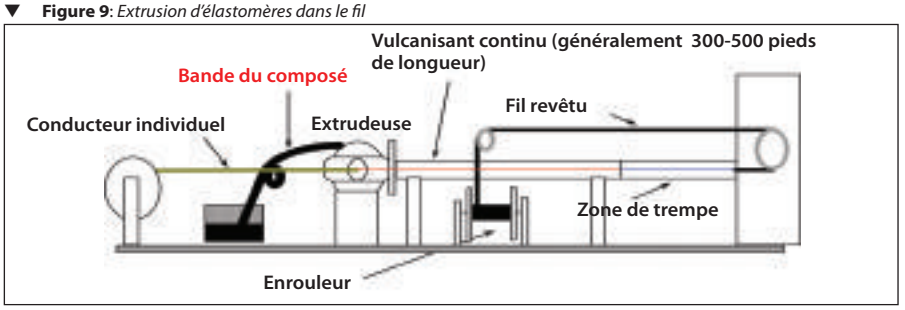
5.4 Importance de la conception de l'architecture à chaîne de l'élastomère

Le CM-d permet de modifier la recette de "charge normale" en augmentant les niveaux du matériau de remplissage et des huiles, tout en maintenant les performances des propriétés physiques.

▼ **Figure 8**: *Production de composés élastomériques*



▼ **Figure 9**: *Extrusion d'élastomères dans le fil*



	«Chargement normal»	«Chargement haut»		
	CM-a	**CM-a**	**CM-d**	**CM-d/EO-b**
Densité	1,607	1,648	1,648	1,622
CM-a	100	100	--	--
CM-d	--	--	100	85
EO-b	--	--	--	15
Ester acrylique trifonctionnel (co-agent)	5	5	5	5
a,a'-bis(t-butyle peroxyde) diisopropyl benzène. 40% active	5	5	5	6.5
N-550 Noir de charbon	35	--	--	--
N-774 Noir de charbon	--	80	80	80
Carbonate de calcium	150	200	200	200
DINP	38	60	60	60
Paraffine	2	1,5	1,5	1,5
Oxyde de magnésium	5	5	5	5
Phr total:	340	456,5	456,5	458

▲ **Tableau 1**: *Recettes pour gaines de cordons flexibles*

	«Chargement normal»	«Chargement haut»		
	CM-a	**CM-a**	**CM-d**	**CM-a/EO-b**
Caractéristiques du processus				
Grillage Mooney à 121°C, Rotor petites dimensions				
Minimum, MU	28,5	23,2	39,5	31,5
t3, Min	>25	>25	>25	24,2
t5, Min	>25	>25	>25	24,7
RPA (Analyseur processabilité caoutchouc) à 110°C 10% Contraint				
Viscosité à 150 rad/s, Pa-s	4577	3842	5282	4764
Extrusion sur ligne câble métallique Extrudeuse de 38,1mm 15:1 L:D, ~ 110°C)				
Pression extrudeuse, MPa	27	23	29	25
Caractéristiques de vulcanisation				
Rhéomètre disque d'oscillation à 200°C pour 6min				
Minimum, dN-m	11,2	6,6	15,2	13,3
Maximum, dN-m	80,7	56,3	75,8	82,1
delta couple, dN-m	69,5	49,7	60,6	68,8
t90, Min	1,7	1,8	1,9	1,8

▲ **Tableau 2**: *Caractéristiques de processus et de vulcanisation*

▼ **Tableau 3**: *Propriétés physiques*

	«Chargement normal»	«Chargement haut»		
	CM-a	**CM-a**	**CM-d**	**CM-d/EO-b**
Données physiques originelles*				
Sollicitation à 100% allongement, MPa	3,4	3,5	2,6	4,6
Tension de rupture, MPa	9,2	7,6	9,8	9,7
Allongement à la rupture, %	514	518	350	306
IRM 902/18 hr à 121°C*				
Rétention de traction, %	87	90	94	96
Rétention d'allongement, %	91	58	86	89
Vieillissement à l'air chaud – 10 jours à 110°C				
Rétention de traction, %	93	108	98	92
Rétention d'allongement, %	80	52	79	75
Friabilité à basse température, °C** -	-27,5	-29,5	-32,5	-35,5

*14 AWG (1,63mm dia) fil d'aluminium/gaine de 0,76mm/vulcanisée pour 2min. en vapeur à 1,72MPa
**brame/vulcanisée 2min à 200°C

Les qualités de CPE à haut poids moléculaire typiques telles que le CM-a ne sont pas aussi performantes que le CM-d dans les composés hautement chargés. Le CM-d a été spécifiquement conçu pour obtenir des performances améliorées à des coûts similaires ou inférieurs (grâce aux chargements plus élevés de matériau de remplissage /huile). L'exemple reporté aux *Tableaux 1-3* contribue à démontrer qu'il est possible d'obtenir des composés plus performants (meilleures propriétés physiques et performances aux basses températures) en utilisant la matrice élastomérique correcte avec une architecture à chaîne optimisée, permettant une charge supérieure des ingrédients, afin d'équilibrer davantage les performances du composé et entraîner un impact potentiellement positif sur l'économie de ce dernier.

6. Conclusions

Les élastomères peuvent être utilisés dans une vaste gamme d'applications, y compris les systèmes thermoplastiques et thermodurcis tels que: gainage, isolement, matériau de remplissage, faibles émissions de fumées sans halogène et isolement à basse tension.

Des niveaux plus élevés de matériau de remplissage peuvent être incorporés dans les élastomères pour améliorer leurs performances et les rendre spécifiquement aptes pour les environnements exigents. L'architecture à chaîne de l'élastomère est importante pour déterminer le mode d'utilisation et la quantité des différents ingrédients à utiliser dans le composé pour obtenir les performances d'utilisation finale désirées. Les composés élastomériques réticulés présentent une excellente résistance à la chaleur et à l'huile, et la vitesse de vulcanisation peut être convenablement ajustée en fonction des niveaux de dienes. La majorité des EPR et des EPDM convient aux applications exigeant des propriétés mécaniques satisfaisantes du fait de leurs poids moléculaires élevés, mais le EB ou le EO est connu comme modificateur rhéologique du fait de sa viscosité relativement réduite.

La présence de chlore dans un polyéthylène chlorifié améliore davantage sa résistance chimique, à l'huile et à la flamme par rapport à un élastomère sans chlore. Il s'ensuit que de simples changements des paramètres architecturaux de la structure des élastomères d'éthylène peuvent augmenter considérablement les performances typiques des câbles de polyéthylène pour des applications plus étendues. ■

7. Références

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[2] Classification System for Rubber Material (SAE J200), Society of Automotive Engineers, Warrendale, Pa., 2000.

[3] Standard Test Method for Rubber Property—Effect of Liquids (ASTM D471-79) 1979.

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Elastomeri olefinici per applicazioni di fili e cavi

A cura di Day-Chyuan Lee, Ray Laakso, Larry Gross e Jack Muskopf, The Dow Chemical Company

Riassunto

I materiali di isolamento e di rivestimento polimerici rappresentano un mezzo affidabile ed economico per la protezione di cavi, fili e fibre attualmente utilizzati per la trasmissione di energia e dati. La scelta del rivestimento polimerico per un'applicazione specifica dipende da numerosi fattori come le proprietà elettriche, ambientali e fisiche richieste per il cavo.

I composti plastici ed elastomerici rappresentano due dei gruppi di materiali più comuni utilizzati nella maggioranza delle strutture di fili e cavi.

Grazie alle sue buone prestazioni ed al suo costo relativamente basso, il polietilene è uno dei materiali plastici più utilizzati nell'industria del filo e del cavo, e per questo motivo mantiene un'ampia quota di mercato. Come per i materiali plastici, i cavi realizzati utilizzando composti elastomerici posseggono caratteristiche di prestazione specifiche che dipendono dalla loro particolare struttura polimerica.

Gli elastomeri sono polimeri caratterizzati da un'estrema estensibilità elastica e flessibilità qualora soggetti a sollecitazioni meccaniche relativamente basse. La comparazione della struttura polimerica del polietilene con tre elastomeri attualmente commercializzati (etilene-ottene (EO) (o etilene–butene (EB)), il polietilene clorurato (CM) e l'EPDM (terpolimero di etilene propilene diene) rivela delle somiglianze e delle differenze di queste classi di materiali e offre un'analisi delle relative prestazioni.

Tutti questi polimeri presentano una catena principale satura, ma la flessibilità, la natura tattile e le prestazioni dei composti sono molto diverse. I materiali elastomerici EO/EB, CM, o EPDM più amorfi tendono a produrre composti più flessibili dei composti di polietilene.

Il presente studio darà una visione generale del ruolo che questi polimeri elastomerici hanno nelle applicazioni dei fili e dei cavi ed illustrerà le somiglianze e le differenze dei materiali dovute alla loro struttura polimerica, focalizzando l'attenzione sulle resine elastomeriche.

Verranno evidenziati in particolare i rapporti fra la struttura e le proprietà per spiegare più chiaramente i principali vantaggi e svantaggi offerti da ciascun tipo di polimero per l'industria del filo e del cavo

Gli elastomeri possono essere utilizzati in una vasta gamma di applicazioni, inclusi i sistemi termoplastici e termoindurenti come i sistemi di rivestimento, isolamento, materiale di riempimento, basse emissioni di fumo senza alogeno e isolamento a bassa tensione. A titolo esemplificativo, verrano forniti dei dati tecnici relativi all'utilizzo di questi polimeri nelle applicazioni tipiche di fili e cavi.

1. Struttura degli elastomeri

Gli elastomeri delle poliolefine sono copolimeri d'etilene con una o più alte alfa-olefine quali l'etilene-octene (EO), l'etilene-exene (EH) o l'etilene-butene (EB) come illustrato nella *Figura 1*.

Le gomme di etilene-propilene (EPR) sono copolimeri di etilene e propilene disposti in modo aleatorio per produrre polimeri gommosi e stabili. Per mantenere una catena principale satura e porre l'insaturazione reattiva in una catena laterale disponibile per la chimica di vulcanizzazione o di modifica del polimero si può utilizzare un terzo monomero dienico non coniugato ottenendo in modo controllato un terpolimero. La designazione ASTM per l'EPR è EPM per i copolimeri e EPDM per i termopolimeri dove "E" indica l'"etilene", "P" il propilene, "D" il "diene" e "M" una catena satura tipo polimetilene. Una struttura polimerica EPDM con etilene norbornene (ENB) come il monomero dienico è illustrata nella *Figura 2*. Il polietilene clorurato (CPE) è un elastomero sintetico prodotto per clorazione controllata della materia prima di alimentazione del polietilene[1] con atomi di cloro distribuiti aleatoriamente sulla catena principale del polimero. Una struttura chimica generalizzata per il CPE è illustrata nella *Figura 3*.

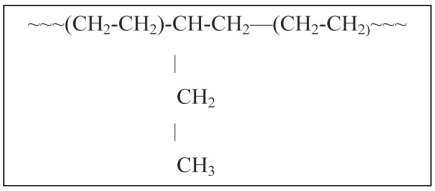
La designazione ASTM per il CPE è CM o cloropolietilene dove "C" indica il "cloro" e "M" indica una catena satura tipo polimetilene. Grazie alla catena principale stabile e satura del polimero, i composti ottenuti a partire da elastomeri di etilene sono preziosi per la loro eccellente combinazione di resistenza al calore e all'olio come indicato e classificato nella specifica ASTM D2000/SAE J200[2,3] e illustrato nella *Figura 4*.

Oltre alla loro durevolezza in condizioni ambientali difficili, la loro flessibilità consente un'installazione più semplice dei cavi e permette di realizzare giunzioni e raccordi affidabili, in particolare a temperature molto basse. Grazie a queste caratteristiche, sono materiali particolarmente indicati per l'isolamento ed il rivestimento dei cavi.

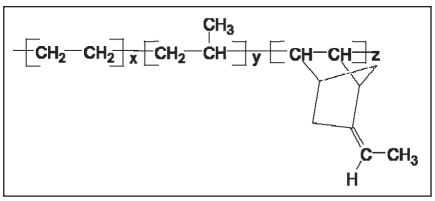
Le gamme di flessibilità degli elastomeri di etilene paragonati a quelle di altri materiali plastici sono illustrate nella *Figura 5*.

2. Relazione fra struttura e proprietà

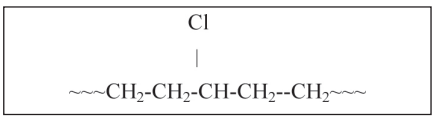
La cristallinità, il peso molecolare (MW), la distribuzione del peso molecolare (MWD), la ramificazione, il tipo/livello di colipolimero/dieno ed il contenuto di cloro sono alcune delle principali variabili della struttura della catena che si possono modificare per ottimizzare le prestazioni dei vari elastomeri di etilene commerciali.



▲ **Figura 1**: *Struttura dell'elastomero di etilene-butene*



▲ **Figura 2**: *Struttura dell'EPDM con etilidene norbornene (ENB)*



▲ **Figura 3**: *Struttura del CPE*

2.1 Cristallinità e peso molecolare

Una disposizione ordinata e regolare di atomi o gruppi di atomi può formare una struttura cristallina. La cristallinità ed il punto di fusione cristallino dipendono dalla lunghezza dei blocchi di segmenti d'etilene e dalle imperfezioni cristalline degli elastomeri di etilene. Rispetto ai copolimeri di etilene con alfa-olefine più elevati, il copolimero di etilene propilene presenta tipicamente blocchi di etilene più corti e con più difetti nella fase cristallina.

La cristallinità del CPE può essere modificata mediante il processo di clorazione per ottenere un prodotto amorfo o semi-cristallino. Il livello di cristallinità del polietilene residuo è altrettanto importante per controllare le proprietà fisiche globali del CPE. I blocchi di etilene sono troppo corti in un copolimero statistico per dare come risultato una cristallinità significativa ed un polimero amorfo. Il copolimero d'etilene amorfo è morbido e malleabile e generalmente presenta delle proprietà fisiche inferiori a quelle di un elastomero con una cristallinità superiore.

A circa 60 wt% di etilene, un elastomero olefinico presenta una sufficiente cristallinità e durezza per essere ridotto in granuli. A causa del processo di clorazione, il CPE si presenta sempre sotto forma di polvere indipendentemente dalla cristallinità. La cristallinità ha una forte influenza sulle proprietà fisiche.

Ad esempio con l'aumentare della cristallinità, del modulo e della resistenza alla trazione, aumentano anche la durezza e la resistenza alla lacerazione, mentre il comportamento a basse temperature, il recupero elastico e la resistenza alla flessione diminuiscono.

All'aumentare della cristallinità, anche la resistenza meccanica a verde risulta migliorata. I polimeri con maggiore massa molecolare possono accettare una quantità superiore di materiale di riempimento e possono avere proprietà fisiche migliori, come una maggiore resistenza alla trazione e alla lacerazione, ma devono essere ottimizzate per migliorare la lavorabilità.

2.2 Distribuzione del peso molecolare

La distribuzione del peso molecolare (MWD) degli elastomeri d'etilene influisce sulle caratteristiche del processo. Un'ampia distribuzione del peso molecolare migliora la mescolatura, la resistenza meccanica a verde, le caratteristiche di estrusione e, in generale, la superficie dopo l'estrusione.

Tuttavia, le caratteristiche di vulcanizzazione come la velocità e lo stato di vulcanizzazione possono essere inferiori nel caso di elastomeri caratterizzati da una più ampia distribuzione del peso molecolare. In generale, i polimeri con una più ampia distribuzione del peso molecolare presentano migliori capacità di lavorazione, ma inferiori caratteristiche di vulcanizzazione rispetto ai polimeri con più ampia distribuzione del peso molecolare.

2.3 Diene

Analogamente al polietilene reticolato, gli elastomeri polefinici, l'EPDM ed il CM possono essere reticolati con perossido. Nel caso dell'EPDM, l'aggiunta di diene consente di effettuare la vulcanizzazione con lo zolfo. Tuttavia, per l'isolamento dei cavi di potenza è preferibile la vulcanizzazione con perossido poiché normalmente si ottengono caratteristiche elettriche migliori rispetto alla vulcanizzazione con lo zolfo. I dieno termonomeri più utilizzati comprendono l'etilene norbornene (ENB) ed il diciclopentadiene (DCPD).

Per questi dieni, l'ENB è caratterizzato dalla velocità di vulcanizzazione più rapida mentre il DCPD ha la velocità più lenta. La presenza di diene favorisce la formazione di ramificazioni dell'EPDM con conseguente ripetizione delle unità CH2 a partire da una catena laterale dalla catena principale del polimero.

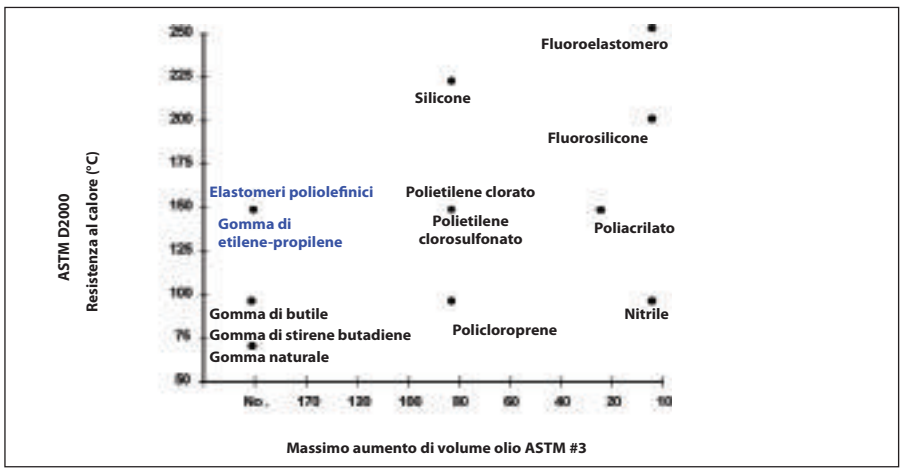
La ramificazione riduce la viscosità del polimero a velocità di taglio superiori per offrire caratteristiche di estrusione migliori ed aumenta la viscosità del polimero a velocità di taglio inferiori per migliorare la resistenza alla flessione. In generale, il DCPD presenta una maggiore probabilità di creare più ramificazioni lunghe rispetto all'ENB.

2.4 Contenuto di cloro

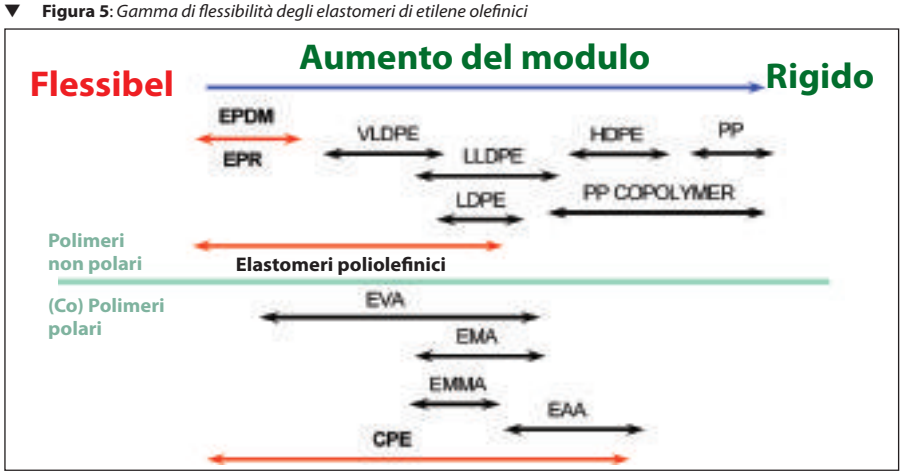
Analogamente all'aggiunta di additivi contenenti alogeno al polimero per migliorare la resistenza all'accensione, la presenza di cloro nella catena principale del CM migliora la resistenza all'accensione e alla combustione del polimero. Come illustrato nella *Figura 7*, la resistenza all'accensione, indicata dal maggiore valore dell'indice limite di ossigeno (LOI), aumenta con l'aumentare del contenuto di cloro del CPE.

La presenza di cloro migliora la resistenza agli oli di idrocarburo e ai combustibili in composti a base di CPE. Pertanto, normalmente si utilizza un CPE a più elevato contenuto di cloro quando la resistenza all'olio ed ai combustibili costituisce un fattore critico per le prestazioni del cavo.

▼ **Figura 4**: *Resistenza al calore e all'olio dei diversi elastomeri*



▼ **Figura 5**: *Gamma di flessibilità degli elastomeri di etilene olefinici*



3. Composti

L'estrusione di un elastomero di etilene ad alto peso molecolare comporta normalmente un prodotto estruso dalla superficie rugosa a causa dei segni di saldatura. L'aggiunta di materiale di riempimento migliora la levigatezza del prodotto estruso e la resistenza meccanica del composto. Altri elementi quali i plastificanti, i lubrificanti, gli antiossidanti, gli agenti di reticolazione, gli stabilizzatori ai raggi UV, i ritardanti di fiamma, si utilizzano frequentemente per aumentare la funzionalità del composto.

La composizione del composto elastomerico determina le prestazioni per l'utilizzo finale del prodotto, ma le proprietà della matrice dell'elastomero determinano il tipo e la quantità dei diversi ingredienti che possono o dovrebbero essere utilizzati nel composto.

I miscelatori a coclea in continuo offrono velocità eccellenti ed una dispersione accettabile per la produzione di composti plastici efficaci. Tuttavia, gli ingredienti del composto devono presentarsi sotto forma di granuli o di polvere per alimentare correttamente i miscelatori in continuo. Per la preparazione di composti elastomerici si utilizzano generalmente i miscelatori discontinui interni del tipo Banbury® (Farrel Corporation) o i mescolatori a due cilindri. I polimeri amorfi a bassa viscosità con un'ampia distribuzione del peso molecolare (MWD) sono più adatti alla mescola nel mescolatore, mentre i composti a base di elastomeri ad elevata viscosità e altamente cristallini sono molto difficili da miscelare nei mescolatori a due cilindri e sono più adatti al mescolatore Banbury che permette di ottenere un'elevata efficacia di mescolatura ed un tempo di ciclo ragionevole.

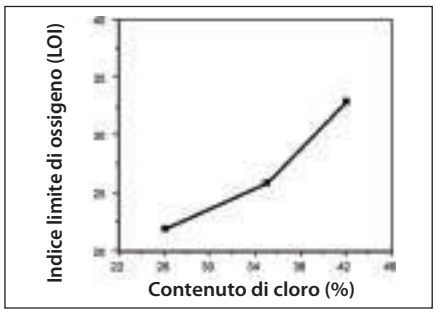
Gli elastomeri sotto forma di granuli o agglomerati friabili possono essere facilmente miscelati nel miscelatore discontinuo poiché gli agglomerati friabili sono poco compattati e possono facilmente rompersi nel miscelatore Banbury sotto l'azione del taglio. A seconda dell'applicazione, i composti elastomerici prodotti con il miscelatore a cilindri e il miscelatore discontinuo possono essere alimentati con estrusori con Strainer o direttamente nell'estrusore come illustrato nella *Figura 8*.

4. Estrusione del filo

Per la produzione di fili e cavi, i composti a base di elastomeri amorfi si estrudono meglio utilizzando una vite di gomma mentre gli elastomeri semi-cristallini funzionano meglio con la vite in polietilene. I composti elastomerici amorfi vengono normalmente alimentati sotto forma di nastri mentre gli elastomeri semicristallini sono generalmente alimentati sotto forma di granuli oppure di cubetti.

Gli elastomeri di etilene possono essere estrusi utilizzando equipaggiamenti di alimentazione a freddo o a caldo. Gli estrusori provvisti di un tamburo lungo e di alimentazione a freddo, vengono alimentati con nastri composti a temperatura ambiente e normalmente richiedono un composto ad alta resistenza meccanica a verde a temperatura ambiente. Gli elastomeri con sufficiente cristallinità dovrebbero essere utilizzati nei composti con alimentazione a freddo per evitare che la vite dell'estrusore laceri il nastro provocando un'alimentazione irregolare. Gli estrusori con tamburo corto ed alimentazione a caldo, sono alimentati con

▲ **Figura 6**: *Struttura-proprietà degli elastomeri olefinici*



▲ **Figura 7**: *Indice Limite d'Ossigeno rispetto al contenuto di cloro del CM*

nastri di materiale precedentemente riscaldato in un mescolatore. Questo materiale dovrebbe contenere elastomeri caratterizzati da un'ampia distribuzione del peso molecolare per fornire resistenza a verde a temperature elevate. I nastri alimentati dovrebbero essere più freddi possibile per ridurre al minimo le agglomerazioni del materiale alimentato nella tramoggia. La riduzione al minimo dell'utilizzo di agenti che favoriscono il processo con un'adeguata selezione di oli aromatici può migliorare il contatto del nastro con la superficie della vite e l'alimentazione. Possono essere necessari alcuni polimeri ad alta viscosità o cristallinità per migliorare la resistenza al collasso del prodotto estruso.

Con un'alimentazione adeguata con nastri o granuli, i composti elastomerici possono essere estrusi rapidamente ed agevolmente sui conduttori utilizzando viti oppure filiere a pressione con la testa di iniezione di gomma o di plastica come illustrato nella *Figura 9*. Generalmente, le temperature della testa di iniezione sono sufficientemente elevate da ammorbidire il polimero e permettere un flusso regolare, ma al di sotto della temperatura di decomposizione del perossido per evitare la prevulcanizzazione. La maggioranza dei fili isolati con elastomeri viene successivamente vulcanizzata in un tubo di vulcanizzazione continua (CV). Il filo avvolto può essere venduto o utilizzato in operazioni di cablaggio successive.

5. Ottimizzazione della struttura della catena per applicazioni di cavo e filo

Le prestazioni dei composti per filo e cavo dipendono dalle combinazioni delle caratteristiche degli elementi utilizzati e dal tipo di polimero selezionato. La matrice elastomerica e la sua compatibilità con gli elementi incorporati nell'elastomero influenzano notevolmente il successo di un composto. La corretta progettazione della struttura della catena rappresenta dunque una delle fasi più critiche nella concezione dei composti per applicazioni di filo e cavo. Tuttavia, sono le proprietà della matrice elastomerica che determinano il tipo e la quantità dei diversi elementi che possono o dovrebbero essere utilizzati nel composto per controllare le prestazioni di utilizzo finale del prodotto.

Ad esempio, il CM-d rappresenta una qualità amorfa, in fase di sviluppo del polietilene clorato (CM), che è stata progettata per accettare elevate cariche di materiali di riempimento con proprietà fisiche comparabili o migliori rispetto ai prodotti CM standard. Il CM-d presenta un eccellente equilibrio di resistenza termica e chimica, che rende tale materiale adatto all'utilizzo in applicazioni specifiche di filo e cavo. I dati nelle *Tabelle 1-3* illustrano i potenziali vantaggi del CM-d.

5.1 Cariche più elevate di materiali di riempimento

Il CM-d è stato progettato per accettare carichi di materiali di riempimento più elevati pur mantenendo le proprietà fisiche. A titolo esemplificativo, è stata effettuata una comparazione fra il CM-d ed il CM-a in un'applicazione di rivestimento di un conduttore flessibile conformemente alla norma 62 di Underwriters Laboratories (UL®). Una formulazione tipica contenente il CM-a con una carica "normale" di materiale di riempimento e di plastificanti è stata confrontata con composti con carica "alta". I composti altamente caricati contenevano un phr totale maggiore di ~34% rispetto al composto "normale" (vedi Tabella 1).

I composti sono stati estrusi come guaina di 0,76mm in un filo di alluminio solido di 14 AWG (del diametro di 1,63mm) utilizzando un estrusore a una vite da 38,1mm con un rapporto lunghezza/diametro (L/D) pari a 15. Il filo è stato vulcanizzato in un tubo di vulcanizzazione continua (CV) per 2min. in vapore a 1,72 Mpa. I campioni di bramme (per il test di fragilità a basse temperature) sono stati vulcanizzati per 2min. a 200°C. I dati di processo e di vulcanizzazione sono illustrati nella *Tabella 2*.

I campioni sono stati testati conformemente a specifiche ASTM appropriate:

- Resistenza alla trazione ASTM D412
- Immersione IRM 902 ASTM D471
- Invecchiamento a caldo ASTM D573
- Fragilità a basse temperature ASTM D746
- Le proprietà fisiche sono illustrate nella *Tabella 3*

5.2 Considerazioni sulla viscosità

Il CM-d, quando viene sostituito direttamente da una resina di polietilene clorato in un composto esistente, normalmente produce una viscosità superiore rispetto a quella del composto d'origine. Tuttavia, come illustrato nella *Tabella 2*, con l'aggiunta di quantità superiori di plastificanti e/o l'aggiunta di EO-b a 10–15 phr, la viscosità del composto può essere ridotta. Il composto altamente caricato con l'elastomero EO, presenta caratteristiche di processo paragonabili a quelle del composto CM-a normalmente caricato.

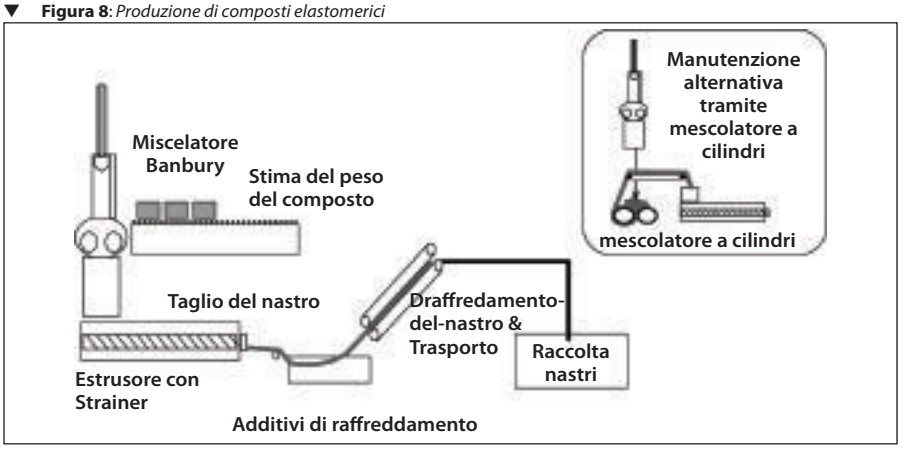
5.3 Proprietà fisiche

L'aumento dei livelli di materiale di riempimento da "normale" ad "alto" in un composto a base di CM-a, comporta una perdita corrispondente delle proprietà fisiche (si veda *Tabella 3*). In particolare, la resistenza alla trazione e la ritenzione dell'allungamento in seguito all'invecchiamento evidenziano una diminuzione significativa. Tuttavia, quando si utilizza un livello di carica di materiale "alto" con il CM-d (o una miscela di CM-d e EO-b), le proprietà fisiche si possono comparare con quelle ottenute utilizzando il livello di carica "normale" nel CM-a.

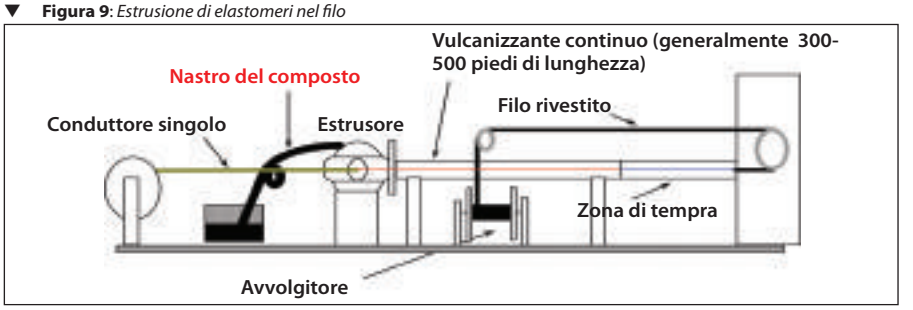
5.4 Importanza della concezione della struttura della catena dell'elastomero

Il CM-d consente di modificare la ricetta di "carica normale" aumentando i livelli di materiali di riempimento e di oli, mantenendo contemporaneamente le prestazioni delle proprietà fisiche. Le tipiche qualità di CPE ad elevato peso molecolare, come il CM-a non hanno buone prestazioni come il CM-d nei composti altamente caricati. Il CM-d è stato specificamente progettato per ottenere prestazioni migliorate a costi analoghi o inferiori (grazie alle cariche più elevate di materiali di riempimento/olio).

▼ **Figura 8**: *Produzione di composti elastomerici*



▼ **Figura 9**: *Estrusione di elastomeri nel filo*



	"Carica normale"	"Carica alta"		
	CM-a	CM-a	CM-d	CM-d/EO-b
Densità	1,607	1,648	1,648	1,622
CM-a	100	100	--	--
CM-d	--	--	100	85
EO-b	--	--	--	15
Ester acrilico trifunzionale (co-agente)	5	5	5	5
a,a'-bis(t-butyle peroxyde) diisopropile benzene. 40% attivo	5	5	5	6.5
N-550 Carbone vegetale	35	--	--	--
N-774 Carbone vegetale	--	80	80	80
Carbonato di calcio	150	200	200	200
DINP	38	60	60	60
Paraffina	2	1,5	1,5	1,5
Ossido di magnesio	5	5	5	5
Phr totale:	340	456,5	456,5	458

▲ **Tabella 1**: *Ricette per rivestimento in conduttori flessibili*

	"Carica normale"	"Carica alta"		
	CM-a	CM-a	CM-d	CM-a/EO-b
Caratteristiche di processo				
Scottatura Mooney a 121°C, Rotore di piccole dimensioni				
Minimo, MU	28,5	23,2	39,5	31,5
t3, Minuti	>25	>25	>25	24,2
t5, Minuti	>25	>25	>25	24,7
RPA (Analizzatore lavorabilità gomma) a 110°C 10% Deformazione				
Viscosità a 150 rad/s, Pa-s	4577	3842	5282	4764
Estrusione cavo metallico Estrusore da 38,1mm 15:1 L:D, ~ 110°C)				
Pressione estrusore, MPa	27	23	29	25
Caratteristiche di vulcanizzazione				
Reometro disco oscillante a 200°C per 6min				
Minimo, dN-m	11,2	6,6	15,2	13,3
Massimo, dN-m	80,7	56,3	75,8	82,1
delta coppia, dN-m	69,5	49,7	60,6	68,8
t90, min	1,7	1,8	1,9	1,8

▲ **Tabella 2**: *Caratteristiche di processo e di vulcanizzazione*

▼ **Tabella 3**: *Proprietà fisiche*

	"Carica normale»	"Carica alta"		
	CM-a	CM-a	CM-d	CM-d/EO-b
Dati fisici originali*				
Sollecitazione a 100% di allungamento, MPa	3,4	3,5	2,6	4,6
Tensione di rottura, MPa	9,2	7,6	9,8	9,7
Allungamento a rottura, %	514	518	350	306
IIRM 902/18 hr a 121°C*				
Ritenzione di trazione, %	87	90	94	96
Ritenzione di allungamento, %	91	58	86	89
Invecchiamento con forno ventilato – 10 giorni a 110°C				
Ritenzione di trazione, %	93	108	98	92
Ritenzione di allungamento, %	80	52	79	75
Fragilità a basse temperature, °C -**	-27,5	-29,5	-32,5	-35,5

*14 AWG (1,63mm dia.) filo d'alluminio/rivestimento di 0,76mm/vulcanizzato per 2min in vapore a 1,72 MPa
**bramma/vulcanizzata 2min a 200°C

L'esempio riportato nelle *Tabelle 1-3* contribuisce a dimostrare che è possibile ottenere composti con prestazioni superiori (migliori proprietà fisiche e prestazioni a bassa temperatura) utilizzando la matrice elastomerica corretta con una struttura di catena ottimizzata, che permetta una carica più alta degli ingredienti, al fine di equilibrare ulteriormente le prestazioni del composto con un impatto potenzialmente positivo sull'economia dello stesso.

6. Conclusioni

Gli elastomeri possono essere utilizzati in una vasta gamma di applicazioni, inclusi i sistemi termoplastici e termoindurenti quali il rivestimento, l'isolamento, il materiale di riempimento, le basse emissioni di fumo senza alogeno, e l'isolamento a bassa tensione.

Livelli superiori di materiale di riempimento possono essere incorporati negli elastomeri per aumentare le prestazioni dei composti e renderli particolarmente adatti per ambienti difficili. La struttura della catena dell'elastomero è importante per determinare il modo di utilizzo e la quantità degli ingredienti da incorporare nel composto per ottenere le prestazioni desiderate per l'utilizzo finale. I composti elastomerici reticolati presentano un'eccellente resistenza al calore e all'olio e la velocità di vulcanizzazione può essere opportunamente modificata in funzione dei livelli di dieni.

Dato il loro peso molecolare elevato, la maggior parte degli EPR e degli EPDM è particolarmente adatta ad applicazioni che richiedono buone proprietà meccaniche, ma l'EB o l'EO è noto come modificatore reologico per la sua viscosità relativamente bassa. La presenza di cloro in un polietilene clorato migliora ulteriormente la resistenza chimica, la resistenza all'olio e alla fiamma rispetto ad un elastomero senza cloro.

Pertanto semplici modifiche dei parametri strutturali degli elastomeri possono aumentare notevolmente le prestazioni tipiche dei cavi di polietilene per applicazioni più ampie. ■

7. Riferimenti

[1] Polymeric Materials Encyclopedia, Volume 2/C, CRC Press, 1996, Editor-in-Chief J C Salamone, chapter on "Chlorinated Polyethylene", G R Marchand

[2] Classification System for Rubber Material (SAE J200), Society of Automotive Engineers, Warrendale, Pa, 2000.

[3] Standard Test Method for Rubber Property–Effect of Liquids (ASTM D471-79) 1979.

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Elastómeros olefínicos para aplicaciones de alambre y cable

Por Day-Chyuan Lee, Ray Laakso, Larry Gross y Jack Muskopf, The Dow Chemical Company

Resumen

Los materiales poliméricos de aislamiento y revestimiento representan un medio fiable y rentable para proteger cables, alambres y fibras de alimentación y datos. La selección de un revestimiento polimérico para uso específico depende de numerosos factores, como las propiedades eléctricas, ambientales y físicas requeridas por el cable. Los compuestos plásticos y elastoméricos son dos de los grupos más comunes de materiales utilizados en la mayoría de las estructuras de alambres y cables. Gracias a sus buenas prestaciones y a su coste relativamente bajo, el polietileno es uno de los materiales plásticos más usados en la industria del alambre y cable, por lo que posee una gran cuota de mercado. Como para los plásticos, los cables realizados con compuestos elastoméricos poseen características de prestaciones específicas que dependen de su estructura polimérica especial.

Los elastómeros son polímeros que poseen una extrema extensibilidad elástica y flexibilidad cuando se someten a esfuerzos mecánicos relativamente bajos. La comparación entre la estructura polimérica del polietileno y tres elastómeros comercializados actualmente (etileno octeno (EO) (o etileno buteno (EB)), polietileno clorado (CM), y EPDM (terpolímero de etileno propileno dieno) revela las similitudes y las diferencias de estas clases de materiales, y ofrece un análisis de sus prestaciones. Todos estos polímeros presentan una estructura de esqueleto saturado, pero la flexibilidad, la naturaleza táctil y las prestaciones de los compuestos son muy diferentes. Los materiales elastoméricos EO/EB, CM, o EPDM más amorfos tienden a producir compuestos más flexibles que los compuestos de polietileno.

En este estudio se dará una visión general del papel que juegan estos polímeros elastoméricos en las aplicaciones de alambre y cable, y se ilustrarán las similitudes y diferencias de los materiales debidas a su estructura polimérica. Se analizarán en particular las resinas elastoméricas. Se resaltarán las relaciones existentes entre estructura y propiedades para explicar más claramente los beneficios y desventajas principales que ofrece cada tipo de polímero para la industria del alambre y del cable.

Los elastómeros pueden ser usados en una amplia gama de aplicaciones, incluidos los sistemas termoplásticos y termoendurecibles, como los sistemas de revestimiento, aislamiento, relleno, baja emisión de humo sin halógenos, y aislamiento de baja tensión. Como ejemplo, se presentarán los datos técnicos pertinentes al uso de estos polímeros en las aplicaciones típicas de alambre y cable.

1. Estructura de los elastómeros

Los elastómeros de poliolefina comerciales son copolímeros de etileno con una o más altas alfa oleofinas como el etileno-octeno (EO), etileno-hexeno (EH), etileno-buteno (EB), como se ilustra en la *Figura 1*.

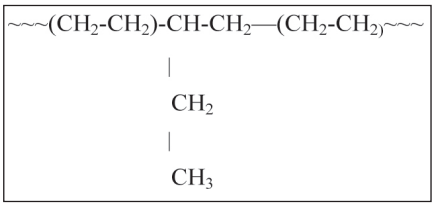
Los cauchos de etileno-propileno (EPR) son copolímeros de etileno y propileno organizados aleatoriamente para producir polímeros gomosos y estables. Para mantener el esqueleto saturado y poner la insaturación reactiva a un lado de la cadena se puede usar un tercer monómero dieno no conjugado obteniendo de manera controlada un terpolímero. La designación ASTM para el EPR es EPM para los copolímeros y EPDM para los terpolímeros, donde "E" indica "etileno", "P" indica "propileno", "D" indica "dieno" y "M" indica una cadena saturada tipo polimetileno. En la *Figura 2* se ilustra una estructura polimérica EPDM con etilideno norboneno (ENB) como monómero dieno.

El polietileno clorado (CPE) es un elastómero sintético producido por cloración controlada de la materia prima de alimentación de polietileno[1] con átomos de cloro distribuidos aleatoriamente en el esqueleto del polímero. En la *Figura 3* se ilustra una estructura química generalizada del CPE.

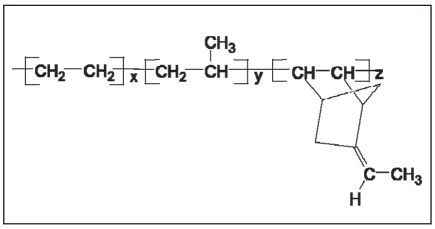
La designación ASTM para el CPE es CM o cloropolietileno, donde "C" indica "cloro" y "M" indica una cadena saturada tipo polimetileno. Gracias a la estructura estable y saturada del esqueleto del polímero, los compuestos obtenidos a partir de elastómeros de etileno son muy preciados por su excelente combinación de resistencia al calor y al aceite, como se indica y clasifica en la especificación ASTM D2000/SAE J200[2,3] y se ilustra en la *Figura 4*. Además de la durabilidad en ambientes difíciles, la flexibilidad de estos compuestos facilita la instalación de los cables y permite obtener empalmes y terminaciones fiables, especialmente a bajas temperaturas. Gracias a estas características, son especialmente indicados para el aislamiento y revestimiento de cables. Las gamas de flexibilidad de los elastómeros de etileno comparadas a las de los plásticos comunes están ilustradas en la *Figura 5*.

2. Relación entre estructura y propiedades

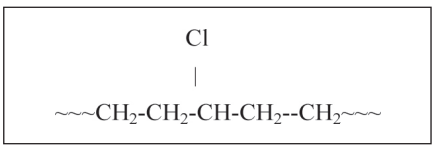
Cristalinidad, peso molecular (MW), distribución de peso molecular (MWD), ramificación, tipo/nivel de copolímero/dieno y contenido de cloro son algunas de las principales variables de la estructura de la cadena que se pueden modificar para optimizar las prestaciones de los elastómeros de etileno comerciales.



▲ **Figura 1**: *Estructura de elastómero de etileno-buteno*



▲ **Figura 2**: *Estructura de EPDM con etilideno norboneno (ENB)*



▲ **Figura 3**: *Estructura de CPE*

2.1 Cristalinidad y peso molecular

Una disposición ordenada y repetida de átomos o grupos de átomos puede formar una estructura cristalina. La cristalinidad y el punto de fusión cristalino dependen de la longitud de los bloques de segmentos de etileno, y de las imperfecciones cristalinas de los elastómeros de etileno. Comparados con los copolímeros de etileno con alfa-olefinas más altas, el copolímero de etileno-propileno presenta típicamente bloques de etileno más cortos y con más defectos en la fase cristalina. La cristalinidad del CPE puede ser ajustada a través del proceso de cloración para obtener un producto amorfo o semicristalino. El nivel de cristalinidad residual del polietileno también es importante para controlar las propiedades físicas globales de CPE. Los bloques de etileno son demasiado cortos en un copolímero aleatorio para dar como resultado una cristalinidad significativa y un polímero amorfo. El copolímero de etileno amorfo es blando y maleable, y generalmente presenta propiedades físicas inferiores a las de un elastómero con cristalinidad más alta. A aproximadamente 60 wt% de etileno, un elastómero olefínico presenta una cristalinidad y dureza suficientes para ser reducido en gránulos. Debido al proceso de cloración, el CPE se encuentra siempre en forma

de polvo, independientemente de la cristalinidad. La cristalinidad tiene una fuerte influencia en las propiedades físicas. Por ejemplo, al aumentar la cristalinidad, aumentan también el módulo y la resistencia a la tracción, además de la dureza y resistencia al desgarro, pero el comportamiento (*set*) a bajas temperaturas, la recuperación elástica y la resistencia a la flexión disminuyen. Una mayor cristalinidad mejora también la resistencia mecánica en verde. Los polímeros con más peso molecular pueden aceptar una cantidad mayor de material de relleno y pueden tener propiedades físicas mejores, como una mayor resistencia a la tracción y al desgarro, pero deben ser optimizados para mejorar su procesabilidad.

2.2 Distribución de peso molecular

La distribución de peso molecular (MWD) de los elastómeros de etileno influye en las características de procesamiento. Con una amplia distribución de peso molecular se mejora el mezclado con molino, la resistencia mecánica en verde, las características de extrusión y, en general, se obtiene un aspecto mejor de la superficie después de la extrusión.

Sin embargo, las características de curado como la velocidad de curado y el estado de curado pueden ser inferiores para elastómeros con una amplia distribución de peso molecular.

En general, los polímeros con distribución de peso molecular más amplia tienen capacidades de procesamiento mejores, pero características de curado peores respecto a polímeros con distribución de peso molecular más estrecha.

2.3 Dieno

Como el polietileno entrecruzado, los elastómeros de poliolefina, EPDM y CM, pueden ser entrecruzados con peróxido. Para el EPDM, la adición de dienos permite el curado con azufre. Sin embargo, se prefiere el curado con peróxido para el aislamiento de cables de energía porque normalmente se obtienen características eléctricas mejores respecto al curado con azufre.

Los termonómeros dieno más usados incluyen el etilideno norboneno (ENB) y el diciclopentadieno (DCPD). Para estos dienos, el ENB presenta la velocidad de curado más rápida, y el DCPD la más lenta. La presencia del dieno mejora la formación de ramificaciones del EPDM y produce unidades repetidas CH2 a partir de una cadena lateral del esqueleto principal del polímero. La ramificación reduce la viscosidad del polímero a velocidades de cizallamiento más altas pero mejora sus propiedades de extrusión y al contrario, aumenta la viscosidad del polímero a velocidades de cizallamiento más bajas pero mejora su resistencia a flexión. En general, el DCPD tiene mayor probabilidad de crear ramificaciones de cadena más largas respecto al ENB.

2.4 Contenido de cloro

Al igual que la agregación de aditivos que contienen halógenos al polímero para mejorar su resistencia a la ignición, la presencia de cloro en el esqueleto del CM mejora la resistencia a la ignición y a la combustión del polímero.

Como se muestra en la *Figura 7*, la resistencia a la ignición, indicada por el índice de oxígeno (LOI) más elevado, aumenta al aumentar el contenido de cloro del CPE. La presencia de cloro mejora la resistencia a los aceites y a los combustibles de hidrocarburos en compuestos a base de CPE; por lo tanto, normalmente se usa CPE con contenido de cloro más alto cuando la resistencia al aceite y a los combustibles constituye un factor crítico para las prestaciones del cable.

Figura 4: *Resistencia al calor y al aceite de varios elastómeros*

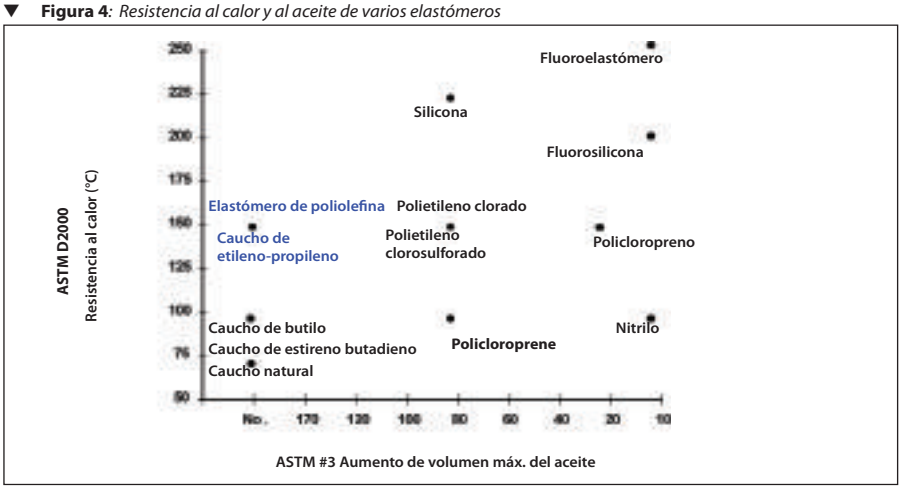
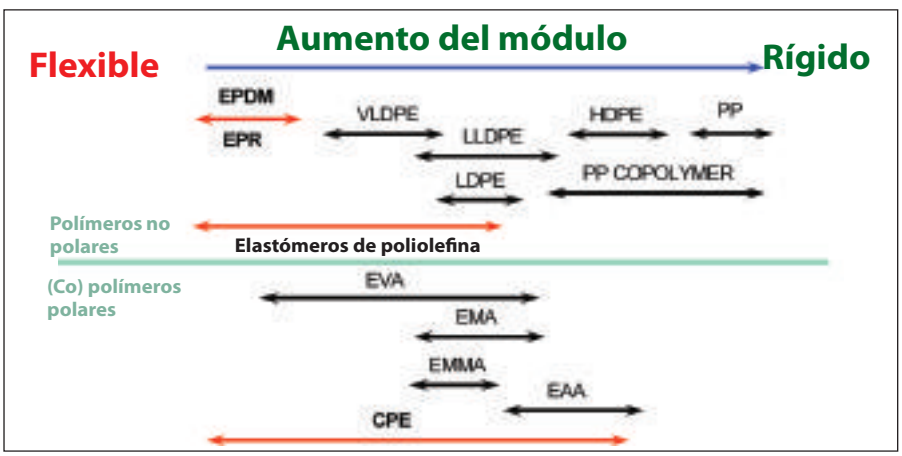


Figura 5: *Gama de flexibilidad de los elastómeros de etileno olefínicos*



3. Compuestos

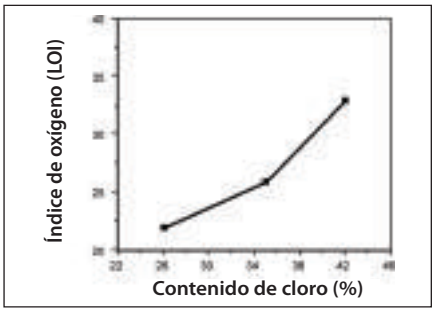
La extrusión de un elastómero de etileno de alto peso molecular que contiene solamente etileno produce normalmente una pieza extruida con superficie áspera debido a la fractura de fusión. La agregación de material de relleno, mejora la tersura de la pieza extruida y la resistencia mecánica del compuesto. Otros ingredientes, como plastificantes, lubricantes, antioxidantes, agentes de reticulación, absorbentes de ultravioleta, retardantes de la llama, son usados a menudo para mejorar la funcionalidad del compuesto. La composición del compuesto elastomérico determina las prestaciones para el uso final del producto, pero las propiedades de la matriz del elastómero determinan el tipo y la cantidad de los ingredientes que se pueden o se deberían usar en el compuesto.

Las mezcladoras continuas de tornillo ofrecen velocidades excelentes y una dispersión razonable para la producción de compuestos plásticos eficaces. Sin embargo, los ingredientes del compuesto deben tener forma de gránulos o polvo para alimentar debidamente las mezcladoras continuas. Normalmente, para preparar compuestos elastoméricos se usan mezcladores internos como el Banbury® (Farrel Corporation) o los molinos de dos rodillos. Los polímeros amorfos de baja viscosidad con amplia distribución de peso molecular (MWD) son más adecuados para el mezclado con molino, mientras que los compuestos basados en elastómeros de elevada viscosidad altamente cristalinos son muy difíciles de mezclar con molinos de dos rodillos y son más adecuados para el mezclador Banbury, que permite obtener una alta eficiencia de mezclado y un tiempo de ciclo razonable. Los elastómeros en forma de gránulos o aglomerados desmenuzables pueden ser mezclados fácilmente en un mezclador interno, porque los aglomerados desmenuzables son poco compactados y se rompen fácilmente en el mezclador Banbury bajo la acción de cizallamiento. Según la aplicación, los compuestos elastoméricos producidos con molino de rodillos o mezclador interno pueden ser elaborados con extrusoras con placa perforada (*strainer*) o alimentados directamente en la extrusora como se ilustra en la *Figura 8*.

4. Extrusión del alambre

Para la producción de alambre y cable, los compuestos a base de elastómeros amorfos se extruyen mejor con un tornillo de goma, mientras que los elastómeros semicristalinos se elaboran mejor con un tornillo de polietileno. Los compuestos elastoméricos amorfos suelen ser alimentados en forma de tiras, mientras que los elastómeros semicristalinos son alimentados normalmente en forma de gránulos o cubos. Los elastómeros de etileno pueden ser extruidos usando equipos de alimentación en frío y en caliente. Las extrusoras de tambor largo y alimentación en frío son alimentadas con tiras compuestas a temperatura ambiente y normalmente requieren un compuesto con alta resistencia mecánica en verde a temperatura

▲ **Figura 6:** *Relación estructura-propiedades de los elastómeros olefínicos*



▲ **Figura 7**: *Índice de oxígeno frente a contenido de cloro del CM*

ambiente. Los elastómeros con una suficiente cristalinidad deberían ser usados en compuestos con alimentación en frío para evitar que el tornillo de la extrusora corte la tira y cause una alimentación no uniforme. Las extrusoras de tambor corto con alimentación en caliente son alimentadas con tiras de material previamente calentado en un molino. Estos materiales deberían contener elastómeros de amplia distribución de peso molecular para proporcionar resistencia mecánica en verde a temperaturas elevadas. Las tiras de alimentación deberían estar lo más frías posible para reducir al mínimo el apelotonamiento del material alimentado en la tolva. La reducción al mínimo de adyuvantes, además de la selección apropiada de aceites aromáticos, puede mejorar el contacto de la tira con la superficie del tornillo, y la alimentación. Se pueden necesitar algunos polímeros de alta viscosidad o cristalinos para mejorar la resistencia al colapso del material extruido.

Con una alimentación adecuada de tiras o gránulos, los compuestos elastoméricos pueden ser extruidos rápidamente y con facilidad sobre conductores usando tornillos o hileras de presión con de cabezal inyector de goma o plástico, como se ilustra en la *Figura 9*. El cabezal suele ser puesto a temperaturas bastante altas para suavizar el polímero y permitir un flujo correcto, pero manteniéndolo por debajo de la temperatura de descomposición del peróxido para evitar quemaduras. La mayor parte del alambre aislado con elastómeros es curada luego en un tubo de vulcanización continua (CV). El alambre bobinado puede ser vendido o usado en operaciones de cableado sucesivas.

5. Optimización de la estructura de la cadena para aplicaciones de cable y alambre

Las prestaciones de los compuestos para alambre y cable dependen de las combinaciones de las características de los ingredientes usados y del tipo de polímero seleccionado. La matriz elastomérica y su compatibilidad con los ingredientes que se agregan al elastómero influencian fuertemente el éxito de un compuesto. Por lo tanto, el diseño correcto de la estructura de la cadena representa una de las fases más críticas en el diseño del compuesto para las aplicaciones de alambre y cable. Sin embargo, son las propiedades de la matriz del elastómero las que determinan el tipo y la cantidad de los ingredientes que se pueden o se deberían usar en el compuesto para controlar las prestaciones para el uso final del producto.

Por ejemplo, el CM-d es una calidad amorfa evolucionada del polietileno clorado (CM), que ha sido diseñada para aceptar altas cargas de material de relleno con propiedades físicas comparables o mejores respecto a los productos estándares CM. El CM-d presenta un equilibrio excelente de resistencia al calor y a los agentes químicos que lo hacen apto para aplicaciones específicas de alambre y cable. Los datos en las *Tablas 1-3* ilustran las ventajas potenciales del CM-d.

5.1 Cargas mayores de material de relleno

El CM-d ha sido diseñado para aceptar mayores cargas de material de relleno manteniendo las propiedades físicas. Para ilustrarlo, el CM-d ha sido comparado con el CM-a en una aplicación de revestimiento de conductor flexible según la norma 62 de los Underwriters Laboratories (UL®). Una fórmula típica de CM-a con carga "normal" de materiales de relleno y plastificantes ha sido comparada con compuestos con carga "alta". Los compuestos con carga alta contenían un phr total de aproximadamente un 34% más alto que el compuesto "normal" (véase *la Tabla 1*).

Los compuestos han sido extruidos como cubierta de 0,76mm sobre un alambre de aluminio macizo de 14 AWG (1,63mm de diámetro) usando una extrusora de tornillo de 38.1mm con una relación longitud-diámetro (L/D) de 15. El alambre ha sido curado en un tubo de vulcanización continua (CV) por 2 minutos en 1,72 MPa de vapor. Se han curado muestras en forma de losa (para la prueba de fragilidad a baja temperatura) durante 2 minutos a 200ºC. Los datos de proceso y curado están ilustrados en la *Tabla 2*.

Las muestras han sido probadas según apropiadas especificaciones ASTM:

- Resistencia a la tracción ASTM D412
- Inmersión IRM 902 ASTM D471
- Envejecimiento al calor ASTM D573
- Fragilidad a baja temperatura ASTM D746
- Las propiedades físicas están ilustradas en la *Tabla 3*

5.2 Consideraciones sobre la viscosidad

El CM-d, cuando es sustituido directamente por una resina de polietileno clorado en un compuesto existente, suele dar una viscosidad más alta respecto al compuesto original. Sin embargo, con la agregación de cantidades mayores de plastificante y/o el añadido de EO-b a 10–15 phr, la viscosidad del compuesto puede ser reducida como se ilustra en la *Tabla 2*. El compuesto carga "alta" con elastómero EO tiene características de proceso comparables a las del compuesto CM-a con carga "normal".

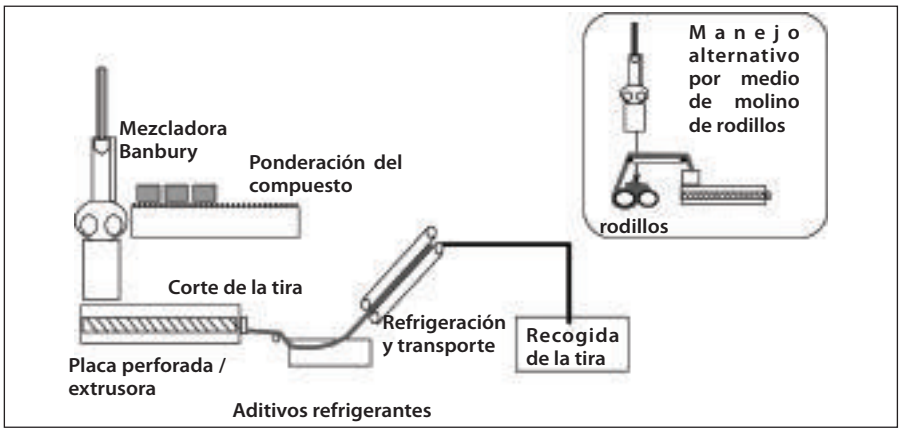
5.3 Propiedades físicas

Cuando se aumentan los niveles de material de relleno de "normales" a "altos" en el compuesto basado en CM-a, se produce una pérdida de propiedades físicas (véase la *Tabla 3*). En concreto, la resistencia a tracción, y la retención de elongación después del envejecimiento muestran una significativa reducción. Sin embargo, cuando se usa un nivel de carga de material de relleno "alto" con el CM-d (o una mezcla de CM-d y EO-b), las propiedades físicas pueden ser comparadas con las obtenidas usando el nivel de carga "normal" en el CM-a.

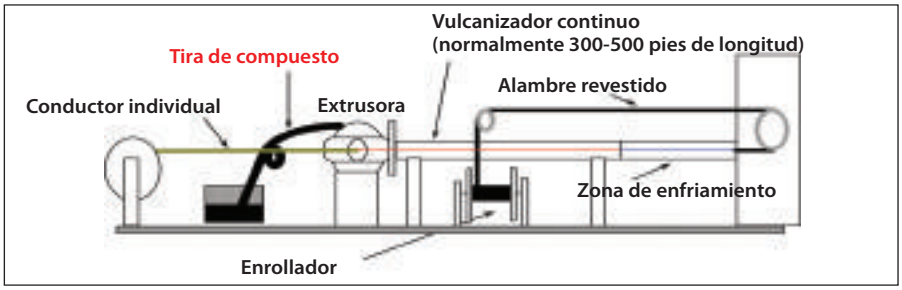
5.4 Importancia del diseño de la estructura de la cadena del elastómero

El CM-d permite modificar una receta con "carga normal" aumentando los niveles de materiales de

▼ **Figura 8**: *Producción de un compuesto elastomérico*



▼ **Figura 9**: *Extrusión de elastómeros sobre alambre*



	'Carga normal'	'Carga alta'		
	CM-a	CM-a	CM-d	CM-d/EO-b
Densidad	1.607	1.648	1.648	1.622
CM-a	100	100	--	--
CM-d	--	--	100	85
EO-b	--	--	--	15
Éster acrílico trifuncional (co-agente)	5	5	5	5
a,a'-bis(peróxido de t-butilo) Diisopropilbenceno, activo 40%	5	5	5	6.5
Negro de carbón N-550	35	--	--	--
Negro de carbón N-774	--	80	80	80
Carbonato de calcio	150	200	200	200
DINP	38	60	60	60
Cera de parafina	2	1.5	1.5	1.5
Óxido de magnesio	5	5	5	5
phr total:	340	456.5	456.5	458

▲ **Tabla 1**: *Recetas para cubierta de conductor flexible*

	'Carga Normal'	'Carga Alta'		
	CM-a	CM-a	CM-d	CM-a/EO-b
Características de procesamiento				
Tiempos de quemado de Mooney a 121°C, rotor pequeño				
Mínimo, MU	28.5	23.2	39.5	31.5
t3, minutos	>25	>25	>25	24.2
t5, minutos	>25	>25	>25	24.7
RPA (Analizador de procesabilidad del caucho) a 110°C, Deformación 10%				
Viscosidad a 150 rad/s, Pa-s	4577	3842	5282	4764
Extrusión sobre alambre, Extrusora de 38,1mm, 15:1 L:D, ~ 110°C)				
Presión extrusora, MPa	27	23	29	25
Características de curado				
Reómetro de disco oscilante a 200°C por 6 minutos				
Mínimo, dN-m	11.2	6.6	15.2	13.3
Máximo, dN-m	80.7	56.3	75.8	82.1
Delta par de torsión, dN-m	69.5	49.7	60.6	68.8
t90, minutos	1.7	1.8	1.9	1.8

▲ **Tabla 2**: *Características de proceso y curado*

▼ **Tabla 3**: *Propiedades físicas*

	'Carga Normal'	'Carga Alta'		
	CM-a	CM-a	CM-d	CM-d/EO-b
Datos físicos originales*				
Esfuerzo a 100% de elongación, MPa	3.4	3.5	2.6	4.6
Límite de resistencia a tracción, MPa	9.2	7.6	9.8	9.7
Elongación de ruptura, %	514	518	350	306
IRM 902/18 hr a 121°C				
Retención de resistencia a tracción, %	87	90	94	96
Retención de elongación, %	91	58	86	89
Envejecimiento en horno ventilado -- 10 días a 110°C				
Retención de resistencia a tracción, %	93	108	98	92
Retención de la elongación, %	80	52	79	75
Fragilidad a baja temperatura, °C**	-27.5	-29.5	-32.5	-35.5

*14 AWG (diám. 1,63mm) alambre de aluminio/cubierta de 0,76mm/curado de 2 min. en vapor a 1,72MPa
**Losa/curado de 2 min. a 200°C

rellenos o aceites, manteniendo al mismo tiempo las prestaciones de las propiedades físicas. Las calidades de CPE de alto peso molecular típicas, como el CM-a, no tienen buenas prestaciones como el CM-d en compuestos con cargas "altas". El CM-d ha sido diseñado especificadamente para obtener prestaciones mejoradas a costes similares o inferiores (gracias a cargas más altas de materiales de relleno/aceite). El ejemplo ilustrado en las *Tablas 1-3* ayuda a demostrar que se pueden obtener compuestos con prestaciones mejoradas (como propiedades físicas y prestaciones a bajas temperaturas), usando una matriz de elastómero correcta con una cadena de estructura optimizada que admite cargas de ingredientes más altas para equilibrar aún más las prestaciones del compuesto y tener un impacto potencialmente positivo en la rentabilidad del compuesto.

6. Conclusiones

Los elastómeros pueden ser usados en una amplia gama de aplicaciones, incluidos los sistemas termoplásticos y termoendurecibles, como los sistemas de revestimiento, aislamiento, relleno, baja emisión de humo sin halógenos, y aislamiento de baja tensión.

En los elastómeros se puede añadir más material de relleno para potenciar las prestaciones de los compuestos y hacerlos especialmente adecuados para ambientes duros. La estructura de la cadena del elastómero es importante para determinar cómo y cuántos ingredientes se pueden o se deberían usar en el compuesto para obtener las prestaciones deseadas para el uso final. Los compuestos elastoméricos entrecruzados tienen una excelente resistencia al calor y al aceite, y la velocidad de curado puede ser ajustada convenientemente por los niveles de dienos. La mayoría de los EPRs o EPDMs son adecuados para aplicaciones que requieren propiedades mecánicas buenas debido a su alto peso molecular, pero el EB o el EO suele ser utilizado como modificador reológico por su viscosidad relativamente baja. La presencia de cloro en un polietileno clorado mejora aún más su resistencia química, resistencia al aceite y a la llama respecto a un elastómero de etileno sin cloro. Por consiguiente, cambios simples en los parámetros estructurales de los elastómeros de etileno pueden aumentar mucho las prestaciones típicas del cable de polietileno para aplicaciones más amplias. ■

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