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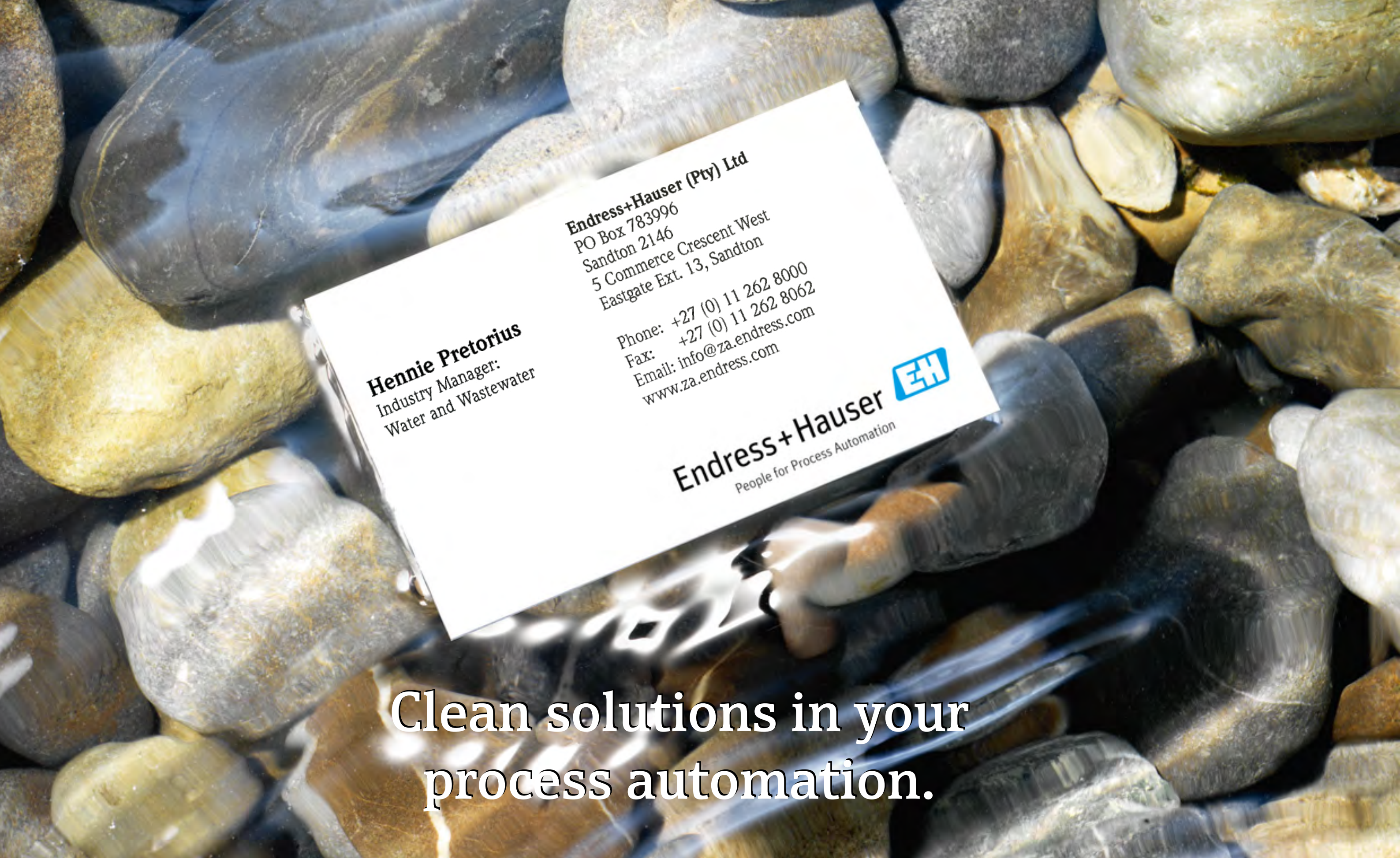

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Opportunities for
African research institutions

by Bernard Slippers, Department of Genetics, Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria, Coleen Vogel, Department of Geography, Geoinformatics and Meteorology, University of Pretoria, and Lorenzo Fioramonti, Centre for the Study of Governance Innovation (GovInn), Department of Political Sciences, University of Pretoria, Pretoria, South Africa

Recent decades have vividly shown that traditional definitions of research excellence and training do not automatically resolve the complex problems facing the future of society and the planet. This situation has been called a 'crisis of research effectiveness', considering the lack of progress on a number of critical issues, such as climate change, biodiversity loss and environmental degradation, over the past two decades.

This 'crisis' highlights the need for transdisciplinarity as a new frontier for research communities. This new paradigm strives towards a 'new form of learning and problem-solving involving cooperation between different parts of society and science in order to meet complex challenges of society'. Transdisciplinarity [.....] is also at the heart of the recently launched Future Earth project (www. futureearth.info) of the International Council for Science (ICSU), which attempts to embrace such an approach to increase the impact of global change and sustainable development research.

Kueffer and colleagues from the Alliance of Global Sustainability at ETH Zurich (Switzerland) argue that transdisciplinarity will require a fundamental institutional and cultural re-orientation at research universities. They argue that both institutional innovations and structural optimisations will be critical in achieving these goals, while at the same time it is necessary to preserve the traditional strengths of disciplinary excellence and scientific rigour.

In his book The Challenge of Developing World Class Universities, Salmi concludes that, although there is a need for a range of institutional types, "...institutions will inevitably, from here on out, be increasingly subject to comparisons and rankings, and those deemed to be the best in these rankings of research universities will continue to be considered the best in the world." This factor, more than any other, will determine the future of universities, as it will increasingly impact the migration of talent, funding and opportunities.

African research institutions are well placed to build effective transdisciplinary networks which focus on developmental issues. The problems faced by the continent have indeed placed particular emphasis on issues such as natural resource and diversity management, urbanisation and health, bioenergy, agricultural and forestry development, global change and food security.

The number of transdisciplinary networks with an African focus is growing. Examples include the Australia-Africa Universities Network which is currently hosted at the University of Pretoria and has a project portfolio covering food security, health, mining, education and public sector reform.

Some of these efforts are, however, in their infancy and face a number of challenges. Nonetheless, it is critical for African universities to persist with the development of transdisciplinary projects and networks, and for institutions to incorporate specific efforts in their strategic plans for this purpose. These activities will support higher impact research, locally and globally, which will enable better rankings in the globalised and competitive higher education environment.

Ultimately, the knowledge co-produced through transdisciplinary networks should help to accelerate development and address a number of critical challenges facing the continent.

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New generation of

encapsulated disc spring system from AESSEAL

AESSEAL recently launched LiveStar, a new-generation live-loading system, designed to be compact without requiring extra bolt length to accommodate the uncompressed disc spring stack – a system which will find a major market in control valves in environmentally sensitive applications.

The problem

Valve live-loading systems are often complicated. Most require the use of torque-measuring tools and incorporate a disc spring stack that is often too long for the available bolt length (see pics 1 and 2) . As a result, the bolts usually need to be replaced, which is both costly and time-consuming.

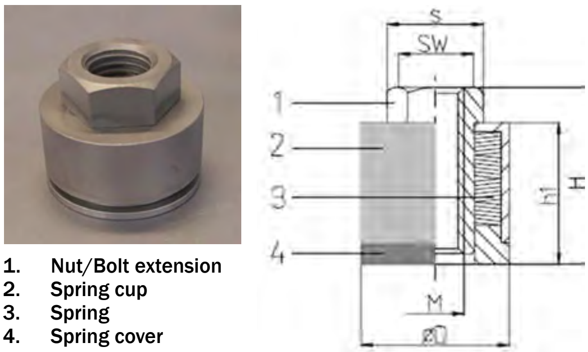
The solution

LiveStar, recently launched, has been designed as an encapsulated disc spring configuration with defined compression length to automatically adjust the gland and maintain constant pressure on the valve packing set. Relaxation of the spring set by volume loss of the packing stack will show a gap upon inspection (see pic 5). Simply tighten the nut until the gap closes.

During operation, this closed gap serves as an indicator of valve packing wear or consolidation, either of which will cause the gap to reappear, whereupon the assembly is simply retightened to its optimal set point.

The live loading system design is compact and provides plenty of extra length to accommodate the uncompressed disc spring stack (see pic 3). LiveStar needs no new longer bolts fitted to the valve to accommodate the system. The system fits on existing gland bolts (see pic 4) and is tightened on installation until the visible assembly gap closes (see pic 6). No torque wrench required!

A major advantage of the AESSEAL design over other live-loading systems is that the disc spring, which is encapsulated against environmental impact by an outer cylinder, slides on an even, machined surface rather than on a bolt thread. The disc spring can therefore never become over-compressed, hang up on threads or shift asymmetrically on the bolt.



1. **Nut/Bolt extension**
2. **Spring cup**
3. **Spring**
4. **Spring cover**

Figure 1: Cross-section of LiveStar valve live-loading components

Other features include compensation for thermal expansion of the valve parts, optimum and pre-determined compression set by the dimension of the spring housing, protection of the spring set from dirt and outside contaminants, and sustained maintenance of a constant gland load and sealing force.

Available for all standard metric bolt diameters from 8 mm to 27 mm and Imperial UNC from 5/16” to 1”, the complete LiveStar range can be sourced from AESSEAL branches and distributors throughout Africa.

For more information contact Rob Waites on tel: +27 11 466-6500, or email rwaites@aesseal.co.za ▮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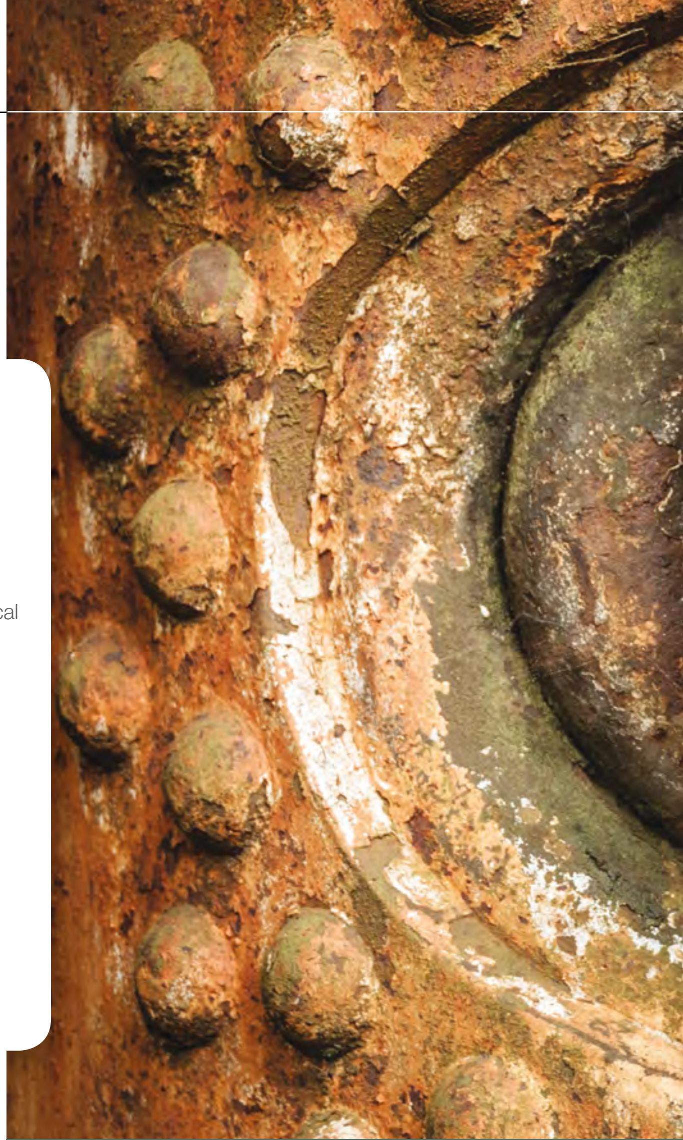
Corrosion problems in incinerators **and biomass-fuel-fired boilers**



by Deepa Mudgal, Surendra Singh, and Satya Prakash, all of the Department of Metallurgical and Materials Engineering, Indian Institute of Technology, Roorkee, Uttarakhand, India

Incinerators are widely used to burn municipal waste, biowaste, wood, straw, and biomedical waste. Combustion of these wastes results in the generation of chlorides of sodium and potassium which may attack the metallic part of the incinerator. In biofuel-fired boilers, a similar type of highly corrosive environment is also found.

Incineration is a high temperature process that reduces the organic and combustible waste to inorganic, combustible matter and results in drastic reduction in volume and weight of waste [1–3]. Incinerators are widely used to dispose of industrial, hazardous, nonhazardous, commercial, municipal, some agriculture, and hospital wastes [4]. Normally, incinerators are operated at high temperature between 300 °C and 1 100 °C based on the volume and type of waste, incinerator, and fuel used [5]. In recent literature it is opined that incineration is a dying technology for waste treatment, as it is unreliable and produces a secondary waste stream more dangerous than the original [6].

Establishment of the incinerator to dispose of hazardous waste was passed by US EPA in 1976 as "Resource Conservation and Recovery Act PL 94-580." Post-managing systems for flue gases are widely used in incinerators to reduce any harm which can be created by a stream of flue gases. These systems consist of devices such as electrostatic precipitator, venturi scrubber, packed bed scrubber, plate tower, dry scrubber, semidry scrubber, bag filters or bag houses, wet electrostatic precipitator, and ionising wet scrubber [7]. Hence, a secondary stream can be cleaned so as to make it harmless by application of the above mentioned equipment.

As waste generation has increased considerably worldwide in the last few decades; the combustion of biomedical waste, municipal solid wastes, and biomass in fluidised-bed boiler facilities is an attractive solution for both energy production and conservation of land, otherwise wasted in landfills [8, 9]. Landfill disposal of waste may result in ground water pollution if the landfill site is inadequately designed or operated [1]. In locations where population densities are high, the use of landfill for waste disposal has become less feasible and waste incineration becomes a more attractive option [10]. Millions of tons of municipal solid waste (MSW) are produced every year which have been treated using an incineration technique which reduces waste mass by 70 % and volume by up to 90 %, as well as providing energy to generate electricity [11]. Waste generated from biomedical activities reflects a real problem for living nature and the human world [8]. Improper disposal of health care wastes, syringes, and needles that are scavenged and reused may lead to the spreading of diseases such as hepatitis C and AIDS [12]. Hence, such waste is desired to be disposed properly.

Incineration is a thermal process, which destroys most of the waste including microorganisms [13]. Surveys show that most incinerators are operated at incorrect temperatures and do not destroy the waste completely due to use of insufficient fuel [14]. It is necessary to adequately oxidise the principal organic hazardous waste to the 99,99 % destruction. Near complete destruction of hazardous waste can be achieved only at temperatures of around 1 000 °C and above where intense reaction conditions can be provided with the help of increased turbulence in the combustion zone to maximise the reaction and minimise residence time. Adequate pressure has to be provided for creating necessary scrubbing of halogens and particulate matter [14]. Use of a very high

temperature in the incinerator will lead to degradation of construction material, thereby decreasing the service life of components facing higher temperatures.

High temperature corrosion problems

Corrosion damage is a major issue in waste incinerators which required constant repair thereby adding to running costs [15]. Fireside corrosion has frequently been encountered in incinerators [16]. During combustion of waste and some types of biomass, high levels of HCl, NaCl, and KCl are released. Both chlorides and sulphates containing melts may form on superheater tubes during waste incineration. Molten chlorides are more frequently encountered due to their lower melting points [17]. Miller and Krause [18] found that an accumulation of elements such as sulphur, chlorine, zinc, aluminium, potassium, and occasionally lead and copper, occurred at the metal/scale interface as a deposit in municipal incinerators. Ma and Rotter [19] reported that municipal solid waste maintains a large quantity of chlorine, as one of the free elements that causes high temperature corrosion after fine fly ash particles condense on heat exchanger surfaces.

Yokoyama *et al* [20] suggested that HCl gas, salts, and sulphates in the bed cause corrosion of the heat-exchanger tubes in a fluidised bed waste disposal incinerator, while abrasion is due to the vigorous movement of sand in the bed. Agarwal and Grossmann [21] found that high temperature corrosive attacks in incinerators are caused by constituents such as oxygen, carbon, hydrogen, nitrogen, halides (Cl, F, and Br), sulphur, organophosphate compounds, and molten salts and/or liquid metal attacks due to the presence of low melting point metals, such as lead, tin, antimony, bismuth, zinc, magnesium, and aluminium. Material wastage in the high temperature region of most waste incinerators mainly occurs by chlorination and chloride-induced corrosion, although attack by acid/basic fluxing caused by sulphate deposits, molten chlorides, and erosion may also play an important role [21].

Several studies have been reported regarding corrosion in incinerator environments. Ishitsuko and Nose [22] discuss the stability of protective oxide films in waste incineration environments such as NaCl-KCl and NaCl-KCl-Na_2SO_4-K_2SO_4 conducted in three different levels of basicity. In a waste incineration environment, a protective Cr_2O_3 film easily dissolves in molten chlorides because the molten chlorides tend to have a small value due to the effect of water vapour contained in the combustion gas. Li *et al* [23] conducted a study on various Fe-based alloys with different Cr and Ni content and Fe, Cr, and Ni pure metals. The studies have been conducted in a simulated waste incinerator environment at 450 °C beneath $ZnCl_2$-KCl deposits in flowing pure oxygen. They concluded that adherence of corrosion products to the substrate was worse for higher Cr-containing materials, while the corrosion resistance to the environment could be improved significantly by increasing the Ni content, whereas Zhang *et al* [24] investigated the corrosion behaviour of Fe and four commercial steels with different Cr contents in an oxidising atmosphere containing HCl at 500–600 °C, which did simulate the environment to which materials are usually exposed in a waste incinerator. All the specimens underwent an accelerated corrosion. They suggested that increasing Cr content in the alloy can improve their corrosion resistance. Sorell [25] found out that in the municipal solid waste incinerator dominant corrosive species are chlorides, typically in combination with alkali metals [Na, K] and heavy metals [Pb, Zn]. A new probe design consisting of a water-cooled support lance made from a nickel-base superalloy with an air-cooled probe head in which the samples were kept between the ceramic plates and the probe was introduced into the WTE plant [15]. From this study they concluded that corrosion is mainly due to a high temperature chlorine attack, either through gaseous species like HCl or Cl_2 or by chloride particles, which are deposited on superheater tubes leading to strong damage by acceleration of oxide formation [15]. The effect of adding molybdenum and silicon in steels was also examined and it was found that in a hot corrosion environment, molybdenum as well as up to about 1 % silicon decreased the corrosion rate. Tests were conducted on T91 ferritic steel and AC66 austenitic steel under several atmospheres present in coal-fired plant and waste incinerator in several ash mixtures and at different temperatures. Exposure time was generally 100 hours and sometimes 500 hours. In coal-fired plant, the actual degradation depended on the alkali sulphates and SO_2 contents and on temperature. The HCl presence had little impact. While in the waste incinerator the degradation was more pronounced, the development of a thick, badly adherent corrosion layer occurred, with deep internal degradation of the alloys which was attributed to the active oxidation due to molten alkali chlorides [26]. Jegede *et al* [27] also tested the Udimet alloy and the 310SS in simulated waste incineration flue gases at 750 °C, isothermally for 72 h and 120 h, and also cyclically tested for 120 h. In both conditions, the substrate showed initial weight gain followed by weight loss after some cycles. They reported that chlorine forms volatile species which may evolve through the cracked scale thereby leaving behind defective and porous scale. Oh *et al* [28] discussed corrosion behaviour of a series of commercial superalloys in flowing argon-20 pct oxygen-2 pct chlorine at 900 °C. They reported that the decrease in the mass of alloys may be due to the formation of volatile chloride or oxychloride as corrosion products. Delay *et al* [29] also confirmed that mobilisation of alkali and trace elements present in clinical waste can lead to accelerated deterioration of the plant components and may cause environmental damage. Covino *et al* [30] further suggested that the waste incinerators have more severe thermal gradient influenced corrosion problems than most coal combustors because the ash deposited in waste-to-energy (WTE) plants typically contains low melting fused salts and an eutectic mixture that can lead to accelerated corrosion [30]. Ni *et al* [31] determined the fly ash composition and bottom ash composition of the medical waste incinerator (MWI) operated in China. They discussed that fly ash mainly consisted of Ca, Al, Si, Mg, Na, O, C, Cl, and S while the bottom ash consisted of $CaCO_3$, SiO_2, and Ca[OH]2. They also reported that the chlorine content in fly ash from the MWI was higher than that in the fly ash generated by a municipal solid waste incinerator (MSWI).

"Increasing fuel prices and efforts towards sustainable energy production have led to the exploration of new biofuels."

Biofuel-fired boiler

Increasing fuel prices and efforts towards sustainable energy production has led to the exploration of new biofuels both in the energy sector for the production of heat and power in boilers and also in the transportation sector for the production of new high quality transportation fuels to be used directly in engines [32]. It was opined that biomass may be the only renewable energy source that can replace conventional fossil fuels directly [33]. Integration of biomass with combined cycle gas turbine (CCGT) power plants gives improvement in efficiency and possible cost reduction as compared to stand alone plants [34]. At present around 12 % of the global energy requirement is generated by combustion of biomass fuels, which vary from wood and wood waste (e.g., from construction or demolition) to crops and black liquor [35]. Biomass is a kind of low density fuel, is bulky, and releases the volatiles [36]. Biomass fuels are burned in three main types of boilers, namely, grate fired, bubbling bed, and circulating fluidised bed units. These boilers are normally operated solely to generate electricity but can also be operated to simultaneously generate a combination of heat and power [37]. It is found that there is a growing interest in the use of biofuels for energy purposes due to various reasons such as reduction in dependency on imported oil, generation of 20 times more employment, mitigation of greenhouse gases [38–40], and reduction of acid rain [41]. It is a thumb rule that co-combustion of mixtures of biomass waste-based fuel and coal with the energy input of biomass up to 10% causes a slight decrease in N_2O emissions and may cause only mild or practically no operational problems [42]. Apart from these benefits some technical issues associated with cofiring include fuel supply, handling and storage challenges, potential increase in corrosion, decrease in overall efficiency, ash deposition issues, pollutant emissions, carbon burnout impacts on ash marketing, impacts on selective catalytic reduction (SCR) performance, and overall economics [43]. The problem with fuel supply occurs as biofuels tend to have a high moisture content, which adds to weight and thereby increases the cost of transportation. It can add to the cost as biomass has low energy densities compared to fossil fuels. A significantly larger volume of biomass fuel is required to generate the same energy as a smaller volume of fossil fuel and so it will add to the cost. The low energy density means that the cost of the fuel collection and transportation can quickly outweigh the value of the fuel; hence, it should be transported from shorter distances [44]. It was also reported that many power plants burning fuels such as waste-derived fuels experience failures of the super heaters and/or increased water wall corrosion due to aggressive fuel components even at low temperatures [45]. One of the biggest challenges encountered in biomass-fired are the increased tendency for bed agglomeration and the increased fouling of convective heat transfer surfaces, sometimes associated with increased corrosion. The most destructive property of biomass towards agglomeration, fouling,

Figure 1: Corrosion with high chlorine biomass co-firing [50].

and corrosion appears to be due to their ash constituents such as sulphur, chlorine, and phosphorous [46]. Alkali chlorides are formed during biomass combustion and transported via aerosols or in the vapour phase within the combustion gas, subsequently depositing on the metallic surface or on the already formed oxide layer [47].

Corrosion and environmental effects in biofuel boilers

In recent years [48], in Sweden, there has been a move away from burning fossil fuels to biomass in order to reduce CO_2 emissions. Burning of 100 % biomass causes severe corrosion problems. The chlorine content of wood, peat, and coal are relatively similar, but there is considerably more sodium and potassium and less sulphur in wood fuels and it is suggested that the formation of complex alkali chlorides principally causes the corrosion problems. Experience from Swedish power stations fired with 100 % wood-based biofuels has shown that conventional superheater steels (low chromium ferritic steels) have to be replaced after about 20,000 hours if the steam temperature is 470 °C or higher [48]. Henderson *et al* [49] have reported that most biomass fuels have high contents of alkali metals and chlorine, but they contain very little sulphur compared to fossil fuels. The alkali metal of major concern in wood is potassium. The majority of potassium is released into the gas phase during combustion and is mainly present as potassium chloride [KCl] and potassium hydroxide [KOH]. The alkali metals form compounds with low melting temperatures and can condense as chlorides causing widespread fouling of superheater tubes and other operational problems during combustion. Figure 1 shows the superheater tube corroded at a 100 MW facility fired with high chlorine (>1 %) biomass with bituminous coal [50].

Chlorine may cause accelerated corrosion resulting in increased oxidation, metal wastage, internal attack, void formations, and loose non-adherent scales. The most severe corrosion problems in biomass-fired systems are expected to occur due to Cl-rich deposits formed on superheater tubes [51]. Viklund *et al* [52] have conducted corrosion testing in waste-fired boilers for short-term exposure (3 h) to analyse the composition of deposits and initial corrosion, as well as long-term exposure (1550 h) to investigate corrosion rates. These investigations were done with ferritic steels 13CrMo44 and HCM12A, the austenitic steels Super 304, 317L, Sanicro 28, and the nickel-base alloys Hastelloy C-2000 and Inconel 625. Analysis revealed a deposit dominated by $CaSO_4$, KCl, and NaCl, but also appreciable amounts of low melting salt mixtures such as $ZnCl_2$-KCl, $PbCl_2$-KCl, $FeCl_2$-KCl, and NaCl-$NiCl_2$. Metal loss measurements showed unacceptably high corrosion rates for 13CrMo44, HCM12A, and Super 304. The corrosion attack for these alloys was manifested by the formation of mixed metal chloride/metal oxides scales. A different type of behaviour was seen for the higher alloyed austenitic steels and nickel-base alloys, which were able to form a chromium rich oxide next to the metal. However, these alloys suffered from some localised pitting attack. The behaviour is explained by oxide dissolution in the molten salts that are present in the deposit [52]. Reidl *et al* [53] have found that the main biomass fuels used in Austria are bark wood chips and saw dust. They reported severe corrosion in several wood chips and bark combustion plants equipped with hot water fire-tube boilers which lead to leakage from several heat exchangers tubes after less than 10,000 operating hours. Uusitalo *et al* [54] reported that severe corrosion occurred in oxidising conditions of simulated biofuel-fired boiler environment where samples were exposed to synthetic salt containing 40 wt% K_2SO_4, 40 wt% Na_2SO_4, 10 wt% KCl, and 10 wt% NaCl at 550 °C in oxidising and reducing atmosphere for 100 h. Corrosion tests were performed on low alloy ferritic steel and austenitic stainless steel, HVOF coating (Ni-50Cr, Ni-57Cr, Ni-21Cr-9Mo, and Fe3Al), laser cladding (Ni-53Cr), and diffusion chromised steel. They also reported that oxides at splat boundaries were attacked by chlorine along which it penetrated [54]. Karlsson *et al* [55] reported the influence of NaCl, KCl, and $CaCl_2$ on corrosion in biomass fuel boilers and suggested that $CaCl_2$ is less corrosive as compared to NaCl and KCl. They further suggested that the presence of KCl and NaCl strongly accelerated the high temperature corrosion of 304L stainless steel in a 5 % O_2 + 40 % H_2O environment with nitrogen as the carrier gas at 600 °C. Corrosion is initiated by the formation of alkali chromate [VI] through the reaction of alkali with the protective oxide. Chromate formation is a sink for chromium in the oxide and leads to a loss of its protective properties. Pettersson *et al* [56] had studied the effect of KCl on 304 austenitic stainless steel in presence of 5 % O_2 and 5 % O_2 + 40 % H_2O environment at 400–600 °C for exposure time of 1 week. Their studies showed that KCl is a strongly corrosive species and maximum corrosion occurred at 600 °C. Corrosion is initiated by the reaction of KCl with the chromia containing oxide that normally forms a protective layer on the alloy. This reaction produces potassium chromate particles, leaving chromia-depleted oxides on the alloy surface. Pettersson *et al* [57] also reported the effect of KCl, K_2SO_4, and K_2CO_3 and concluded that KCl and $K2CO_3$ strongly accelerate the corrosion of 304L

"The most severe corrosion problems in biomass-fired systems are expected to occur due to Cl-rich deposits formed on superheater tubes."

while K_2SO_4 has little influence on the corrosion rate. Sharp *et al* [58] suggested that alkali metals and chlorine released in biofuel boilers cause accelerated corrosion and fouling at high superheater steam temperature, as a result of which they have to be operated at a lower temperature much below that of advanced fossil-fuel-fired boilers resulting in decreased efficiency. Hernas *et al* [59] confirm that high temperature corrosion of rotary air preheaters during combustion of biomass and coal is due to the presence of alkali metal chlorides in the deposits. Karlsson *et al* [60] studied the corrosion in biofuels boilers and concluded that corrosion is mainly due to alkali chlorides and hydrogen chloride. Studies [61] were conducted on two high temperature resistant steels, Sandvik 8LR30 [18Cr 10Ni Ti] and Sanicro 28 [27Cr 31Ni 4Mo], to determine the role of ash deposit in the refuse incinerator and the straw/wood fired power plant. Ash for this study was collected from the radiation chamber, superheater, and economiser sections in both waste incineration and the straw-fired/wood chip fired power plants. They carried out these investigations in the laboratory at flue gas temperature of 600 °C and metal temperature of 800 °C for up to 300 hours exposed to HCl and SO_2. They reported that both aggressive gases and ash deposits increase the corrosion rate synergistically, due to the reaction between potassium chloride with sulphur dioxide and oxygen which results in the formation of porous unprotective oxide [61]. The presence of elements such as chlorine and zinc, together with alkali metals from the biomass, has the potential to form sticky compounds that increase the deposit growth rate and rapidly increase corrosion rates [62]. The successful operation of combustion units depends on the ability to control and mitigate ash-related problems, which can reduce the efficiency, capacity, and availability of the facilities, thereby increasing the power cost. Such problems include fouling, slugging, and corrosion of equipment, and pollutant emissions [63]. Soot blowing is the most common method of reducing the effects of deposits on the heat transfer tubes [62]. One way to mitigate fireside corrosion is by changing the environment with fuel additives such as sulphur. It was also found that ammonium sulphate reduced the deposit growth rate and halved the corrosion rate of ferritic/martensitic steels in a wood-fired boiler. With the addition of the sulphate, iron sulphides were formed within the oxide, which are believed to have hindered the corrosion process and iron chlorides were largely absent [64]. Viklund *et al* [64] also found that addition of ammonium sulphate to biomass-fired boilers decreases corrosion tendencies. In situ exposures were carried out in a waste fired, 75 MW, CFB boiler in Händelö, Sweden. The plant is burning 30–50 % of household waste and 50–70 % of industrial waste and the deposit was found to be dominated by Na, K, Ca, Cl, S, and O. Low alloyed ferritic steel EN1.7380 [Fe-2.25Cr-1Mo] and the austenitic EN1.7380 [Fe-18Cr-9Ni] were exposed during 4 hours on air-cooled probes. Metallography shows a marked difference in corrosion attack between the two steels. It was suggested that addition of 300 ppm of SO_2 results in drastic reduction of the corrosion rate as it leads to the formation of K_2SO_4 which does not react with Cr_2O_3 and also suppresses the formation of alkali-chlorides rich deposits. Addition of sulphur or sulphur containing compounds to the fuel resulted in 50–70 % decrease in the corrosion rate of the exposed sample. Karlsson *et al* [65] reported that the addition of digestive sewage sludge to the 12-MWth CFB boiler at Chalmers University of Technology resulted in a decreased corrosion rate of 304L and Sanicro 28 at 600 °C after 24 hours of exposure. Lee *et al* [66] reported that addition of lime or MgO with the blast reduces the corrosion as magnesium combines with vanadium to form magnesium vanadate which is solid at the boiler temperature. Kaolin ($Al_2O_3 \cdot SiO_2$) addition can significantly reduce superheater deposits, corrosion, and slagging and thus enhance the operation of the biomass-fired boiler [67]. Kaolin, which is abundant in kaolinite ($Al_2Si_2O_5(OH)_4$), is employed to capture the alkali metal vapours eluding from the combustion region [68, 69].

"One way to mitigate fireside corrosion is by changing the environment with fuel additives such as sulphur."

Guilemany *et al* reported a possible solution for the oxidation of exchanger steel tubes through HVOF thermal spray coatings and concluded that wire and powder HVOF coatings show good properties to protect steel exchanger pipes against the erosion produced by the impact of the ashes in the flue gas [103]. Rezakhami [119] compared the effect of a simulated oil-fired boiler environment (70 % V2O5-20% Na_2SO_4-10% NaCl exposed to 550 °C and 650 °C for 6 cycles each of 48 hours) on various ferritic steels and austenitic steels as well as on some thermally sprayed coating. Austenitic steel suffers from uniform corrosion, while ferritic steel attacks by the grain boundary corrosion. Thermally sprayed FeCrAl, 50Ni-50Cr, Tafaloy 45LT, and Cr3C2NiCr coatings were also tested in the given condition and the result showed that all the coatings provide good resistance to corrosion and help in increasing the life of both the steels [119]. Singh *et al* [120] investigated superficially applied Y_2O_3 as the inhibitor which leads to the reduction in high temperature corrosion of super alloys in the presence of Na_2SO_4-60V_2O_5 at 900 °C under cyclic condition. Goyal *et al* [121] confirm that the addition of inhibitor such as ZrO_2 to the boiler environment such as Na_2SO_4-60% $V2O_5$ can help in decreasing the corrosion rate of superalloys at high temperature. Yamada *et al* [106] tested the D-gun, HVOF, and plasma sprayed 50 % Ni-50% Cr alloy coating on steel and Ni based superalloys in an actual refuse incineration environment. Analysis revealed the presence of chlorine, which is the main cause of hot corrosion in the coated areas. D-gun sprayed coatings give maximum corrosion resistance in the boiler of the actual refuse incineration plant working for 7 years without any problem and are expected to have longer life. Paul and Harvey [122] tested the corrosion resistance of four Ni alloy coating deposited by HVOF onto P91 substrate under simulated high temperature biomass combustion conditions. It was observed that alloy 625, NiCrBSiFe, and alloy 718 coating performed better than alloy C-276.

Discussion

Demand of electricity production is increasing constantly with the increase in population. In India, the electricity demand has been growing up to 3.6 % every year. Most of these energies are generated from fossil fuels like coal and so forth. Burning of coal leads to the emission of greenhouse gases such as carbon dioxide, which will cause global warming. These gases cause environmental pollution. Mining of coal also leads to environmental degradation. Hence, using the biofuels or organic and other waste

References

References for this article and Table 1 are available from the editor at chemtech@crown.co.za.

for generating power can lead to two basic advantages. Two requirements are needed: firstly decreasing the use of fossil fuel and secondly saving the area waste in landfills. The incineration technique is currently being used to dispose municipal solid waste, biowaste, and medical waste. In case of medical waste a higher incineration temperature is necessary to kill the microorganism to avoid the spread of diseases. The type of environment in the incinerator will depend on the type of fuel waste being burnt.

Burning of municipal waste produces compounds such as $ZnCl_2$, $PbCl_2$, KCl, and NaCl, whereas straw waste burning produces a higher concentration of KCl and K_2SO_4. Burning of wood will produce higher amounts of NaCl and Na_2SO_4 along with KCl and K_2SO_4, whereas coal as a fuel will lead to the production of salt species such as Na_2SO_4 K_2SO_4, and $(NaK)_2(FeSO_4)_3$. Production of all such types of species leads to corrosion which is breaking down the essential properties of metals due to an attack by corrosive compounds on the metal surface. The information regarding the behaviour of different alloy and coatings has been summarized in a Table which can be requested from the editor of 'Chemical Technology'.

The table shows that NaCl will lead to severe corrosion. Alloy steels and super alloys are resistant to a sulphates environment but the addition of chlorides increases the corrosion rate manifold. Active oxidation is the main mechanism for the corrosion in a chlorides environment leading to mass loss due to the formation of volatile species, formation of porous scale, and internal oxidation.

It may also be seen that Ni-based superalloys are more resistant to a chloride containing environment but are susceptible to corrosion in sulphur containing environments. Cr_2O_3 forming alloys are prone to corrosion in alkaline flux which dissolves chromium-based species leading to enhanced corrosion. In case of wood, municipal waste, and biomedical waste the burning can be carried out at a temperature around 500-1 000 °C, whereas in the case of a medical waste incinerator secondary burning is required where the temperature may be around 1 200 °C. This required the use of superalloys and coatings to take care of the aggressive environment at high temperature.

Conclusions

1. Incineration is a worldwide used technique to burn waste and to produce energy, but the corrosion problem encountered during the burning of waste is one of the reasons for the unforeseen shutdown of these incinerators.
2. Corrosion in incinerators and biomass-fuel-fired boilers may occur due to the presence of salts such as chlorides or sulphates.
3. Researchers showed that the presence of chlorine in the environment is mainly responsible for the damage of protective oxide.
4. Addition of sulphur or sulphur-containing compounds to the fuel resulted in decreases in the corrosion rate in incinerators and biofuel-fired boilers.
5. Coating can be sprayed using different thermal spray techniques which can save the material from direct contact with the salt and hence enhance the life. Already, D-gun and HVOF sprayed coatings such as 50 % Ni-50% Cr, alloy 625, NiCrBSiFe, and alloy 718 have been tried in a simulated refuse incinerator and biomass-fuel-fired boiler environment and had shown good performance.
6. Superficial application of inhibitors to decrease the corrosion in the given environment can be done. ∎

First listed powder FR supporting textile sectors' efforts to achieve Oeko-Tex® Standard 100

Archroma, a global leader in specialty chemicals, headquartered in Reinach near Basel, Switzerland, and operating with approximately 3 000 employees in over 35 countries, recently announced that its novel, halogen-free flame retardant powder coating additive, Pekoflam® HFC, has been officially recognised as a manufacturer-certified product by the Oeko-Tex® Association.

Being the first powder additive to be listed for coating applications, Pekoflam HFC will support textile producers and protective clothing manufacturers' efforts to achieve both Oeko-Tex 100 compliance and effective fire protection for their finished goods.

Pekoflam HFC p is an organic phosphorous/nitrogen compound with excellent performance on synthetic materials, including polyamide fibres and blends. The unique chemistry displays higher efficiency compared to commonly used nitrogen and/or phosphorous-based chemicals. It is applicable in water-based systems, as well as in Oeko-Tex Standard 100 compliant 'green' solvent-based coating systems, hence offers a higher flexibility to fabric coaters serving different end-use segments. The ecological profile enables use in both indirect and direct skin contact applications. Oeko-Tex criteria provide manufacturers in the textile and clothing industry with a uniform benchmark on a scientific basis for the evaluation of potentially harmful substances in textiles. The Oeko-Tex label indicates the additional benefits of tested safety for skin-friendly clothing and other textiles to interested end users. The test label therefore provides an important decision-making tool for purchasing textiles.

For more information contact Muriel Werlé on tel: +41 61 716 3375 or +41 79 536 9117, or email muriel.werle@archroma.com ∎

Corrosion effects on valves? – Call in the specialist

Uniform attack corrosion over the entire surface of a cupro-aluminium valve disc

Effect of worm hole corrosion on a super duplex valve disc

Uniform attack corrosion, also known as general attack corrosion, is the most common type of corrosion and is caused by a chemical or electrochemical reaction that results in the deterioration of the entire exposed surface of a metal. Ultimately, the metal deteriorates to the point of failure. This kind of corrosion accounts for the greatest amount of metal destruction by corrosion, but is considered as a safe form of corrosion, due to the fact that it is predictable, manageable and often preventable.

Unlike uniform attack corrosion, localised corrosion specifically targets one specific area of the metal structure, ending up as pitting, crevice corrosion or stress corrosion cracking. This form of corrosion is more dangerous and destructive due to its latent incubation and quick propagation. Pitting is encountered most frequently in metallic materials of technological significance such as carbon steel, low alloy and stainless steels, nickel base alloys, aluminum, copper, and many other metals and alloys.

Pitting results when a small hole, or cavity, forms in the metal, usually as a result of de-passivation of a small area. This area becomes anodic, while part of the remaining metal becomes cathodic, producing a localized galvanic reaction. The deterioration of this small area penetrates the metal and can lead to failure. Corrosion pits will continue to grow, since the interior of a pit is naturally deprived of oxygen and locally the pH decreases to very low values and the corrosion rate increases due to an autocatalytic process.

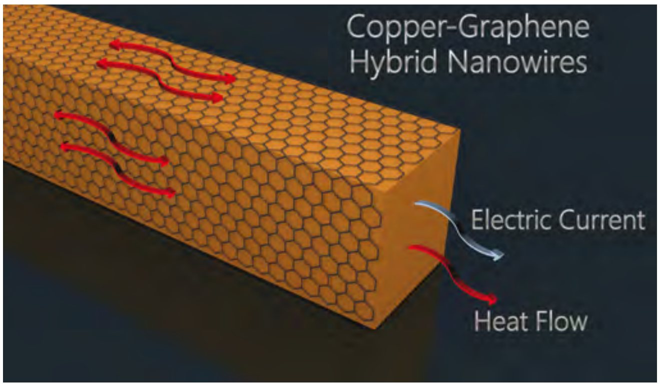
A special form of pitting corrosion is worm hole corrosion, which does not spread laterally across an exposed surface, but penetrates at 10 to 100 times the rate of general corrosion, usually at an angle of 90° to the surface.

Worm hole corrosion of discs made of Super Duplex can take place, mostly due to poor Super Duplex casting methodology, impurities on the metal surface (e.g., iron particles released when flame-cutting or welding in the proximity), but often due to insufficient passivation. It is essential that valve discs and components made out of Super Duplex are acid-pickled to remove impurities that may lead to such corrosion in service.

It is important to have exact knowledge of the working conditions involved, in order to design and recommend the most suitable valve technology. GEMÜ not only offers valves and solutions of high quality, but also offers its customers its expertise in designing the best cost/performance solutions for the problem.

For more information contact Claudio Darpin at GEMÜ Valves Africa at Claudio.darpin@gemue.co.za ∎

Hybrid nanowires eyed for computers, flexible displays



This graphic depicts a copper nanowire coated with graphene - an ultrathin layer of carbon (Purdue University)

A new process for coating copper nanowires with graphene - an ultrathin layer of carbon – lowers resistance and heating, suggesting potential applications in computer chips and flexible displays.

"Highly conductive copper nanowires are essential for efficient data transfer and heat conduction in many applications like high-performance semiconductor chips and transparent displays," said doctoral student Ruchit Mehta, working with Zhihong Chen, an associate professor of electrical and computer engineering at Purdue University.

Now, researchers have developed a technique for encapsulating the wires with graphene and have shown that the hybrid wires are capable of 15 % faster data transmission while lowering peak temperature by 27 % compared with uncoated copper nanowires. "This is compelling evidence for improved speed and thermal management by adapting the copper-graphene hybrid technology in future silicon chips and flexible electronic applications," he said.

Researchers and industry are trying to create smaller wires to increase the 'packing density' of electronic components in chips. However, while smaller wires are needed to increase performance and capacity, scaling down the size of the wires reduces electrical and thermal conductivity, which can lead to overheating and damage. The graphene coating prevents the copper wires from oxidising, preserving low resistance and reducing the amount of heating. "If the surface is covered with oxide then a lot of the electrical and thermal conductive properties of copper are lost," Mehta said. "This is very important because you want as much current as possible going through these wires to increase speed, but they cannot take too much current because they will melt. But if the copper has good electrical and thermal conductivity you can push more current through it."

The hybrid wires are promising for transparent and flexible displays because they could be used in sparse numbers, maintaining transparency, and they are bendable. "Copper wires usually aren't good for these displays because they eventually oxidize and stop working," Mehta said. "If you can prevent the oxidation, they potentially become a good fit."

Until now it has been difficult to coat copper nanowires with graphene because the process requires chemical vapour deposition at temperatures of about 1 000 °C, which degrades copper thin films and small-dimension wires. The researchers have developed a new process that can be performed at about 650 °C, preserving the small wires intact, using a procedure called plasma-enhanced chemical vapour deposition. Wires were tested in two width sizes: 180 nanometres - or more than 500 times thinner than a human hair - and 280 nanometres.

Story by Emil Venere, 765-494-4709, venere@purdue.edu ▮

Perstorp to launch new high-performance products at ECS 2015

Leading global specialty chemicals group Perstorp will unveil new products and enhanced support at the European Coatings Show 2015 as part of its on-going commitment to strengthen its offering for the global coatings and resins market.

Perstorp's raw materials enable customers to create coatings systems with high performance and low environmental impact, for a wide range of decorative and industrial applications used in emerging growth markets such as coatings for electronic parts and materials, printing inks and pre-coating wood.

Products making their European Coatings Show debut will include: a new addition to the Capa™ portfolio –Capa™ Lactide 8000 series, partially renewable polyols for 2 K and 1 K industrial coatings. These new transparent liquid polyols are particularly suitable for production of high performance soft-touch coatings as well as coatings with enhanced adhesion to various substrates, and which require no solvents.

The latest extension to Perstorp'sOxymer™ range of polycarbonate diols for increased weatherability of polyurethane dispersions (PUDs) as well as castable and thermoplastic elastomers will be seen. New Oxymer™ HD types Oxymer™ HD56 and Oxymer™ HD112 are based on 1,6-hexane diol.

Charmor™ PM40 Care, which provides the next development step in safe carbon source products for intumescent systems is another newcomer. It has an "unmatchable environmental profile", being based on renewable feedstocks. Charmor is a leading carbon source for intumescent coatings that preserve the integrity of steel structures when temperatures reach around 500 °C in a fire.

Perstorp has also invested in new capacity for its Neopentyl Glycol essential building blocks for powder coatings and stoving enamels, demonstrating its long-standing commitment to the Chinese coatings market.

For more information tel +46 435 380 00 or email perstorp@perstorp.com ▮

Functional safety
for machine controls

by SICK Safety Application Specialist, Chris Soranno

When implementing technical protective measures from the 'hierarchy of controls', each risk reduction measure will be associated with a safety function or combination of safety functions. For these safety functions to be designed and installed to a degree of reliability commensurate with the risk level of the associated hazard(s), the concepts of functional safety must be applied.

What is functional safety?

Functional safety is a part of the process used to design, test, and prove that the safety-relevant components and circuits of a machine's control system meet the intended reliability and risk reduction capability as determined by a risk assessment. As part of the overall risk reduction strategy for industrial machinery, it is typical to apply safeguards (or technical protective measures) employing one or more safety functions (as described below) to achieve some measure of risk reduction.

Parts of machinery control systems that are assigned to provide safety functions are called "safety-related parts of control systems" (SRP/CS). These can consist of hardware and/or software and can either be separate from the machine control system or an integral part of it. In addition to providing safety functions, SRP/CS can also provide operational functions, such as initiation of machine motion under safe conditions.

'Functional safety' is the term used to refer to the portions of the safety of the machine and the machine control system, which depend on the correct functioning of the SRP/CS. To best implement functional safety, safety functions must first be defined. Once identified, the required safety level must also be determined and then implemented with the correct components necessary to achieve acceptable risk reduction. To confirm that the minimum requirements have been met (if not exceeded), subsequent verification must be performed and documented.

To look at it from another perspective, functional safety is an engineering approach used to quantify the performance level of the SRP/CS to a level commensurate with the associated risk for a given technical protective measure. This includes the verification and validation aspects of the safety functions that have direct interaction with the machine control system, as represented in Figure 1.

Safety functions

Safety functions define how risks are reduced by engineering controls, and must be defined for each hazard that has not been eliminated through design measures. At its core, a 'safety function' is any element of the protective system whose failure leads to an immediate increase of risk. The risk assessment process will establish the minimum requirements for the reliability of safety functions, including mechanical, electrical, hydraulic, and pneumatic control system integrity. This level of reliability and integrity of the control portion of a safety function is referred to as 'functional safety.'

In order to accurately design, implement and validate safety functions to achieve the required level of risk reduction, it is necessary to provide a precise description of each safety function. The type and number of components required for the function are derived from the definition of the safety function. Many different safety functions are possible, and some applications may require more than one function in order to adequately reduce risk. Likewise, it is also possible for a single protective measure (safeguarding component) to play a part in more than one safety function simultaneously.

It is worth noting that not all safety functions have

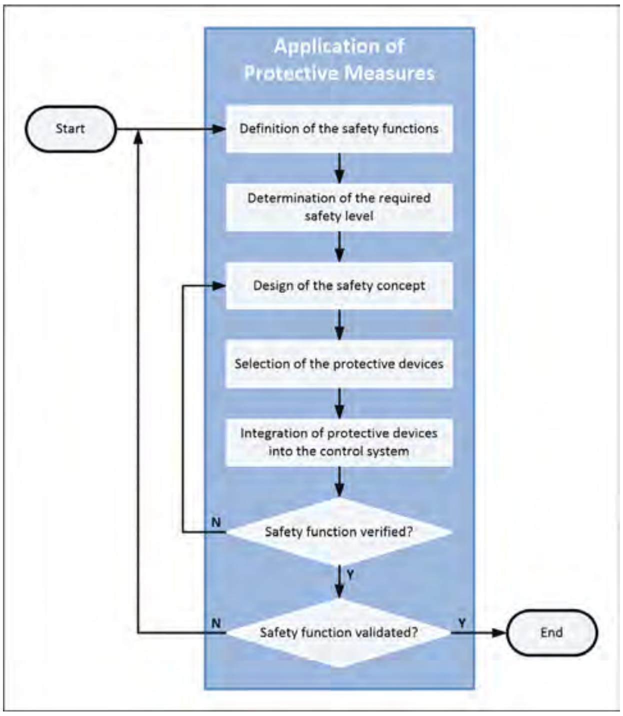


Figure 1: Application of protective measures

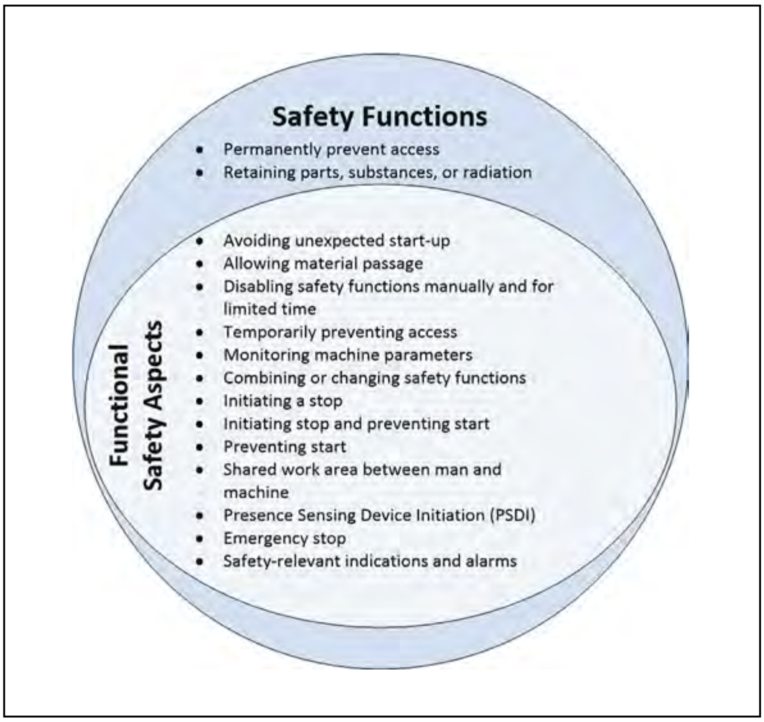


Figure 2: Visual representation

functional safety requirements, as is the case for the use of fixed barriers to permanently prevent access or to retain hazards. Permanent separation of individuals from hazards is clearly a safety function, as is evident by the number of machines on the market with permanently fixed guards or shields in place. While these components of the overall safety system have specific requirements pertaining to proper design and use, these elements do not have functional safety

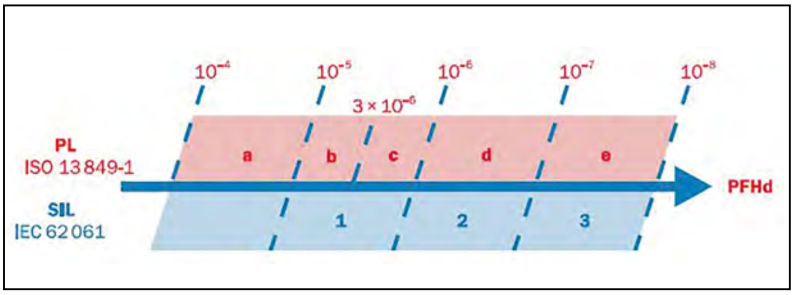


Figure 3: Scale of functional safety levels

considerations because there is no interface to the SRP/CS. A simpler way to distinguish between 'safety functions' and 'functional safety' is to view the idea visually, as shown in Figure 2. In essence, all functional safety concerns are related to a safety function, but not all safety functions require functional safety.

Why apply functional safety?

Safety technology continues to advance beyond simple electrical and electromechanical components toward more complex electrical systems using transistors, integrated circuits and software-based components (eg, microprocessors). With more basic elements, their behaviour in the event of a component failure can be determined to a high degree of certainty because each component can be completely defined. The failure modes of more complex systems, on the other hand, are more difficult to define and in some cases can only be estimated.

Many industrial controls engineers were just beginning to grasp the idea of circuit architecture, whether it was referred to as "Control Reliable," according to OSHA and older ANSI standards, or "Categories," under the EN 954-1 standard from Europe. The introduction of functional safety does not diminish the importance of the circuit design, but rather builds on the concept to account for the greater number of possible failure modes inherent with more complex control systems. Essentially, the benefit of functional safety is to provide a means to 'give credit', eg, oversizing contactors, selecting more robust and reliable components for use in the circuit, providing higher levels of diagnostics, or addressing common cause failures through the process or implementation.

The same reliability concerns exist when designing and evaluating SRP/CS – whether the control system is associated with simpler components or more complex elements. In order to consistently determine the overall reliability of these systems, various safety standards have been developed to outline the key elements. These elements must be considered to determine the overall reliability of the safety-critical control functions. Standards that address these elements include:

- ISO 13849-1 – Safety of machinery – Safety-related parts of control systems
- IEC 62061 – Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems
- IEC 61508 – Functional safety of electrical/electronic/programmable electronic safety-related systems
- IEC 61511 – Functional safety – Safety instrumented systems for the process industry sector
- ANSI B11.26 – Functional Safety for Equipment (Electrical/Fluid Power Control Systems) – Application of ISO 13849 – General Principles for Design

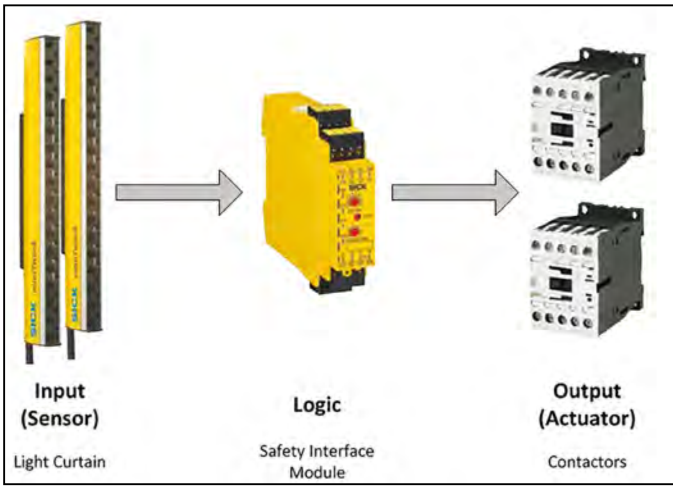


Figure 4: Basic elements of SRP/CS

The primary principle behind these standards is that the overall reliability of a safety function can be qualitatively estimated. In terms of safety, the most important concern is to determine the probability that the system will fail to a dangerous condition. In terms of the standards, the reliability of the SRP/CS is estimated as the probability of a dangerous failure per hour (PFHd).

There are currently two primary methodologies to determine the likelihood of a dangerous failure; "Performance Level" (PL) as outlined in ISO 13849-1 and "Safety Integrity Level" (SIL) as addressed in IEC 62061. Figure 3 illustrates these methodologies in terms of probability to a dangerous condition.

What are the elements of functional safety?

The SRP/CS is the part of a control system that responds to safety-related input signals and generates safety-related output signals. These are parts of machinery control systems that are assigned to provide safety functions. The combined elements start at the point where the safety-related input signals are initiated (for example, obstruction of an optical beam of the safety light curtain) and end at the output of the power control elements (for example, the main contacts of a contactor), as shown in Figure 4.

In some cases, the final element (such as the motor) is not included. It is also important to note that individual components of the safety system may play a role in multiple safety functions, with each safety function possibly requiring different levels of functional safety – again emphasizing the importance of precisely describing each safety function.

Primary considerations of functional safety

The central pillars supporting the functional safety concept are exhaustively outlined in a number of sources, including the standards listed previously. As an overview, the primary considerations for determining the Performance Level for a sub-system are outlined below.

1. **Structure and behaviour of the safety function under fault conditions (category)** This is the same circuit architecture concerns addressed previously in EN 954-1, utilising the same category ratings (B, 1, 2, 3 and 4).
2. **Reliability of individual components defined by mean time to a dangerous failure (MTTFd) values** This value represents a theoretical parameter expressing the probability of a

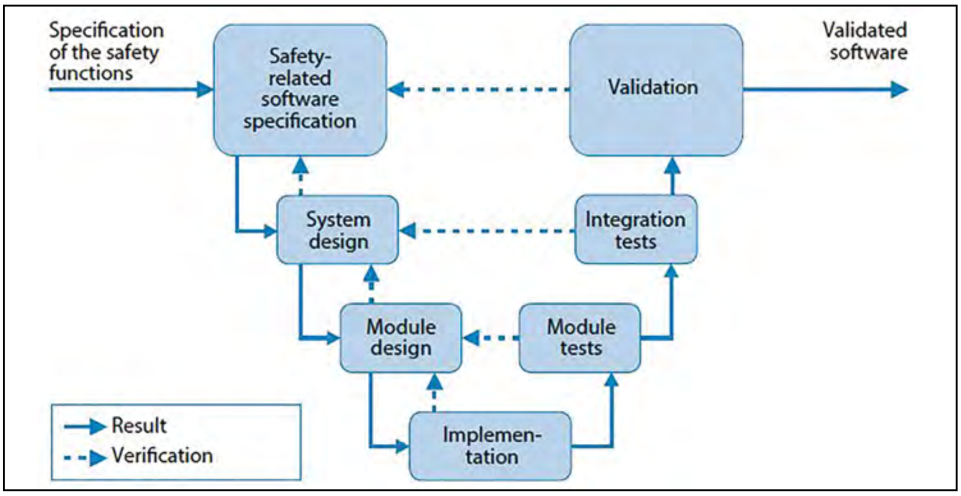


Figure 5: V-Model for Software Validation

dangerous failure of a component (not the entire subsystem) within the service life of that component.

3. **Diagnostic coverage (DC)** The level of safety can be increased if fault detection is implemented in the subsystem. The diagnostic coverage (DC) is a measure of capability of detecting dangerous faults.
4. **Common cause failure (CCF)** External influencing factors (eg, voltage level, over-temperature) can render identical components unusable regardless of how rarely they fail or how well they are tested. These common cause failures must always be prevented.
5. **Process** The process for the correct implementation of safety-relevant topics is a management task and includes appropriate quality management, including thorough testing and counter-checking, as well as version and change history documentation.

Achieving functional safety

Through the combination of the considerations above, the PL achieved can be probabilistically determined to be a specific level. The combination of component selection (MTTFd), diagnostic coverage (DC), and circuit architecture (Category) combine together to achieve various PL outcomes, with consideration for common cause failures (CCF).

Validation of functional safety

As with any risk reduction measure, it is essential to verify that the PL achieved is at least as high as the PL required (PLr). This can be easily represented as PL ≥ PLr.

The confirmation that adequate PL has been achieved is covered in the overall process applied to the design of SRP/CS. The primary features include:

- Organization and competence
- Rules governing design (eg, specification templates, coding guidelines)
- Test concept and test criteria
- Documentation and configuration management.

All lifecycle activities of safety-related embedded or application software must primarily consider the avoidance of faults introduced during the software lifecycle. The main objective is to have readable, understandable, testable and maintainable software. The ISO 13849-1 standard outlines a V-model as shown in Figure 5, which has proven particularly effective in practice for software design.

In common language (outside of safety standards), there is little difference between the terms 'verification' and 'validation.' In essence, the goal is to test and check that the overall reliability of each subsystem of the SRP/CS is adequate for the associated risk, and that accurate documentation is collected for future revalidation throughout the entire life cycle of the machine.

Confirmation of functional safety

Over the past ten to 15 years, industry has been progressively adopting the concepts of evaluating risks based on a systematic methodology and reducing identified risks through the application of multiple layers of protective measures from an orderly list of options based on their

Some notes regarding the standards and references used in the article

Please note that the specific standards and references mentioned in the above article are derived from European and American (USA) standards and references. Most of these standards are derived from the Machinery Directive, which forms the basis of requirements for factory machines placed on the market in these regions.

While South Africa uses many of the standards derived from European directives as the sources of our own standards, we do not directly make use of the Machinery Directive and related standards for the purposes of machine safety.

We have two local documents which are mostly applicable; the Driven Machinery Regulations and the Electrical Machinery Regulations. According to our regulations, the onus is on the designer, manufacturer, operator, maintenance personnel and any inspectors or testers of driven machinery to evaluate the danger presented by any hazardous areas on the machine and take any required precautionary actions deemed reasonable to prevent harm to personnel. This, in effect, means that it is up to the instigator of the safety system to explain the parameters of the system they implemented, especially in the event of an accident.

Therefore, while the standards and protocols mentioned in the article are not a legal requirement in our country, I would propose that adherence to them would provide a clear and direct reference supporting the decisions made in the selection and implementation of the safety system. This also ensures that we conform to the standards of best practice being used world-wide.

For more information, you are welcome to contact our local Safety Specialist, Stephen Eltze at Stephen.eltze@sickautomation.co.za.

effectiveness. The next step to further advance safety is the concept of confirming that the established goals have been achieved. As such, after risk reduction measures have been implemented, their effectiveness must be confirmed.

When dealing with simple SRP/CS comprised solely of electrical and electromechanical components, the confirmation is based on review of the circuit design. However, when the SRP/CS utilises more complex subsystems using software-based components, the confirmation must account for the other four pillars of functional safety as discussed above.

The process developed in Europe for conducting the necessary confirmation takes a mathematical approach to determine the reliability of the SRP/CS in terms of probability of a dangerous failure per hour (PFHd). The Institute for Occupational Safety and Health (IFA) in Germany has developed a tool to perform the mathematical calculations to apply the concepts of ISO 13849-1. This tool, called Safety Integrity Software Tool for the Evaluation of Machine Applications (SISTEMA), is available for free online at www.dguv.de.

SISTEMA accounts for the fact that safety-related parts of a control system are engineered from subsystems, blocks and elements using components for industrial use which can generally be purchased commercially. When calculating the PLr of a system, the system designer must enter various values and information. Component manufacturers typically provide this data in data sheets or in catalogues, but many also make the information available to SISTEMA users in the form of libraries. This collaboration within the safety market allows designers to copy the necessary data from a library directly into a SISTEMA project quickly and accurately.

Acceptance of functional safety

While the notion of confirming that minimum reliability and performance levels are attained has been widely acknowledged on a global scale, the implementation of this theory has not received the same level of acceptance. This can be attributed – at least in part – to the legal approach to safety and where the responsibilities lie.

A core element of the Machinery Directive 2006/42/EC is that machinery manufacturers (either the original OEM or the entity performing modifications to existing equipment) hold the responsibility to prove conformity to the essential requirements for machine safety. Conversely, the legal systems in North America place the liability directly on the user (employer). In the United States, the Occupation Safety and Health (OSH) Act of 1970 includes the General Duty Clause, which states, in Section 5(a)(1): "Each employer shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees."

When the global market is considered in terms of number of users versus the number of manufacturers, it is easy to see that the number of end users in the marketplace far outweigh the number of OEMs. (For this discussion, we are not including organizations that build and use their own equipment – essentially undertaking the responsibilities of both OEMs and users.) For discussion purposes, let's suppose that the ratio of users to suppliers is 99:1 (by some accounts, this may be considered a conservative estimation of the global market).

In the model where liability is placed on the supplier (such as in Europe), this implies that 1 % of the entities in the market assume the responsibility for implementing and verifying that the protective systems meet the essential requirements. Furthermore, this same 1 % of the organizations also happens to be the entities that are most familiar with the design and function of the equipment since they are the exact same groups who designed the equipment. In this model, implementing the approach of functional safety is relatively easy – or at least much more palatable, because the designers are the most familiar with the design specification. Additionally, these organizations have a moderately small number of machine types with which they are involved, in turn allowing them to become experts regarding the application of functional safety on those limited types of equipment.

On the other hand, where the model places the requirements on the end user (such as in North America), the other 99 % of the market now becomes responsible for verifying that an adequate level of risk reduction has been achieved. In this model, 99 % of the organizations are not experts in machine design, but rather in utilising machines built by others to produce their end products. Moreover, this portion of the industrial community typically uses many diverse machine types, making the task of achieving 'expert' level very difficult.

If we put the regional differences of market expectations and regulatory requirements aside, it is self-evident that machinery suppliers are in the best position to apply the concepts of functional safety, regardless of the geographic size of their market. Those entities responsible for the design and implementation of safety functions which interface with the SRP/CS possess the essential information pertaining to this concept: expected mission time (life span) of the equipment, specification of the individual safety-related components, design parameters for circuit architecture and diagnostic coverage of the circuits, and the steps and processes in place to reduce common cause failures and general human errors.

Conclusion

Achieving an acceptable or tolerable level of residual risk is possible through application of the hazard control hierarchy. However, to confirm that the desired degree of risk reduction is achieved, one must test and check that all safety functions are performing to the desired level of reliability. When the safety functions are directly interacting with the machine control systems, these portions of the control become SRP/CS, and in turn must be validated. Functional safety is an approach based on probabilistic evaluation of component data to validate the overall reliability of those safety functions as a necessary step to determine that minimum performance requirements have been achieved.

If the ideas of functional safety appear complex and intimidating, rest assured that you do not stand alone. As is the case with most new philosophies, change is often difficult to implement and even harder to accept. Do not hesitate to request assistance from outside resources to provide support as necessary.

Nota bene: *When implementing any safety measures, it is recommended that you consult with a safety professional.* ■

PLICSLED – See what it's about

VEGA has introduced their PLICSLED universal display module for all point level sensors. The module is compatible with all sensors in VEGA's plics© family with relay output.

With this new display module the switching status of a sensor can be read from a distance, even in strong sunlight. Since external wiring is unnecessary, the time needed for installation is reduced to a minimum. Power is supplied via the relay electronics. The second relay output is used to control the switching status display.

Depending on the module version, the switching status is displayed in the colour combination red-green or yellow-green

PLICSLED is installed directly inside the plics© sensor housing giving it protection from dust and water. The display module can be ordered directly with the sensor or, alternatively, as a separate unit for retrofitting.

For more on VEGA's PLICSLED module, contact Chantal Groom on tel: +27 11 795 3249 or email chantal.groom@vega.com ▮

"Internet of Things" takes centre stage at TAC 2015

A recent survey revealed that the Internet of Things (IoT) is overwhelmingly the first choice of topics capturing the interest of today's automation professionals.

The Automation Conference (TAC), May 19-20 in Chicago, will feature three sessions exploring the latest developments, technologies and applications related to the Internet of Things.

Dr Richard Mark Soley, Executive Director of the Industrial Internet Consortium, will present "How the Internet of Things Will Change – and Is Already Changing – the Manufacturing Industries". A panel discussion will educate attendees on industrial automation technologies comprising the IoT, and a second panel discussion will explore industrial applications of Internet of Things projects. Dr Soley will illustrate how the Industrial Internet of Things opens a new wave of opportunity for industry via machine-based analytics, which will drive deep domain expertise to enable increased automated and predictive capabilities. He will also explain how government, industry, technology and academics are already coming together behind the Industrial Internet of Things to improve the integration of the physical and digital worlds and drive adoption of Industrial Internet applications.

The Industrial Internet Consortium (IIC) was founded in March 2014 to bring together the organizations and technologies necessary to accelerate growth of the Industrial Internet by identifying, assembling and promoting best practices. Membership includes small and large technology innovators, vertical market leaders, researchers, universities and governments.

If the IoT is high on your company's agenda, don't miss TAC 2015 - the place to get current on the industrial Internet of Things from the world's leading authorities.

For more information go to http://www.theautomationconference.com/program/ ▮

Dr Richard Mark Soley, Executive Director of the Industrial Internet Consortium

New 3-in-1 temperature calibrator

Instrotech, a Comtest Group company, is proud to announce their locally designed and manufactured CALOG-TEMP, a multifunctional temperature calibrator. It's a high-precision, hand-held calibrator for the calibration and troubleshooting of process control instrumentation. The CALOG-TEMP simultaneously measures and sources ten types of thermocouples and seven resistance temperature detectors (RTD). It measures milliamps whilst sourcing or simulating millivolts, TCs, RTDs or ohms to calibrate transmitters.

The CALOG-TEMP logging facility stores data on the SD card supplied, which is easily downloaded to a PC via the on-board USB port and usable in most of the common spreadsheet formats.

The trend feature is ideal for graphing temperature profiles and PID controller optimization with a programmable timebase. In addition, the CALOG-TEMP has the functionality necessary to install and maintain all powered and non-powered transducers using the built-in 24V loop power supply. The CALOG-TEMP is an economical solution for industrial field and workshop calibration.

For more information contact Hugh du Plessis on tel: 010 595 1831 or email: sales@instrotech.co.za ▮

Effective gas analysis critical in biogas production

Biogas is a mixture of different gases produced by the breakdown of organic matter and is used as a renewable energy source that exerts a very small carbon footprint. Global production of biogas is increasing all the time, however, there are some important process challenges biogas producers face, one of these being accurate gas analysis.

The composition of biogas is typically 40-60 % methane, 40-50 % carbon dioxide, the remainder being water, hydrogen sulphide, and other impurities. Biogas producers need to know what the purpose and use of the biogas is for end users and they need to know the exact composition of the biogas. It's especially important that they know the carbon dioxide levels which are usually difficult to predict.

For example, biogas contains hydrogen sulphide, which is usually toxic, and it can be high in biogas that is produced from animal wastes, such as from chicken, or from certain vegetables. Biogas is also usually very wet, and when carbon dioxide and hydrogen sulphide are mixed with water, it can be quite corrosive.

For these reasons, it's usually good to remove or lower the amount of hydrogen sulphide, water, carbon dioxide and other impurities to minimal levels before the biogas is processed. If this isn't done, then the engines that generate electricity from biogas will experience high rates of corrosion, leading to inefficient running of the engines to produce electricity.

In addition, when the wastes used to process biogas are varied, the amount of methane will change due to the behaviour of the anaerobic bacteria in the digester used to generate the biogas.

A natural gas chromatograph can help address these operational and maintenance needs for biogas producers. Plants require a cost-effective, online gas chromatograph (GC) that can measure the biogas composition within a four-minute cycle time for ongoing real-time analysis. It's also critical that the GC is easy to use and has low maintenance requirements to reduce time personnel spend on maintenance.

Unlike larger gas processing plants, petrochemical plants and refineries that are able to employ skilled personnel for maintenance of the gas chromatographs, biogas plants usually will only have technicians who are skilled in the operation and maintenance of the typical instrumentation required in the plant. In addition to low maintenance requirements on an ongoing basis, the 370XA from Rosemount Analytical also includes maintainable module technology that allows operators to easily replace the

GC module in the field in under two hours, reducing downtime and repair costs.

Effective measurement of biogas composition is a critical step to ensure a high quality product and reduce the risk of corrosion and potentially dangerous toxic gas leaks, a cost-effective, easy-to-use gas chromatograph is a key element in biogas processing.

For more information go to http://community.emerson.com/process/emerson-exchange ∎

Self-cleaning surfaces have **widespread applications**

by Gavin Chait

A surface that is hydrophobic has an astonishing number of properties. Besides the obvious one of water pouring off, bacteria, fungi, algae and other pathogens cannot get a grip either. The difficulty in creating synthetic surfaces with similar properties is that they are damaged over time.

When I was a child, I discovered the simple delight of the way water behaves in a nasturtium leaf. Gathering into round blobs and refusing to disperse. The trick was to see how big a blob of water you could create and how long you could control it for before the leaf itself collapsed and the water bounced off.

As a kid, I imagined it had something to do with the fine 'hairiness' of the leaf surface. Turns out that this was somewhat advanced thinking as a huge amount of research went into specific chemicals which could mimic such superhydrophobic properties.

The development of the scanning electron microscope permitted researchers to see the physical structure of the leaf. What has become called the Lotus Effect is widespread in nature. Besides nasturtium (*Tropaeolum*) and lotus (*Nelumbo*), it is also seen in insects such as the morpho butterfly.

These surfaces are able to repel water to such an extent that dirt is shed too, resulting is self-cleaning. Since water cannot stick, they are immune to ice-formation. And, it turns out, these properties are a result of physical-chemical properties at the nanoscopic scale.

The hydrophobicity of a surface is a property of the contact angle of water to that surface. If less than 90 °, then the surface is hydrophilic. Beyond about 140 °, the surface is defined as superhydrophobic. The three stars listed above can reach a contact angle of 170 ° meaning that the contact area is only 0,6 % of the overall surface area of the droplet.

A surface that is hydrophobic has an astonishing number of properties. Besides the obvious one of water pouring off, bacteria, fungi, algae and other pathogens cannot get a grip either. Dust doesn't settle. This is not to say that purely chemical approaches to creating 'non-stick' surfaces don't work. Polytetrafluoroethylene (PTFE, aka Teflon) is a synthetic fluoropolymer which is highly hydrophobic, just not superhydrophobic.

Even with a more limited repertoire, PTFE is used throughout the aerospace and computer industry as an insulator, as well as in bearings. Gore-Tex incorporates PTFE for waterproofing. Most non-stick frying pans are coated in PTFE. And the medical industry uses PTFE in everything from bypass stenotic arteries, to dental fillings, and in wound-care to prevent chafing.

The surfaces of superhydrophobic materials exhibit patterns and structures at multiple scales – not simply a regular and constant set of ridges or grooves. Such hierarchical structures can manipulate the hydrophobic response and even reverse it, rendering the surface hydrophilic.

Morpho wings or lotus leaves are extremely fragile but, being organic, can also heal. The difficulty in creating synthetic surfaces with similar properties is that they are damaged over time. Abrasion caused simply by water-runoff can be sufficient to destroy surface efficacy.

There are a number of different ways in which superhydrophobic properties can be imparted on surfaces. The first is straight-out chemical bonding to create a new coating over the original surface. P2i, based in the UK, has developed a fluoropolymer coating system which is now used by Samsung, amongst others, to waterproof mobile phones.

They use chemical vapour deposition. The phones are placed in a vacuum chamber under low pressure, and a plasma pulse is used to 'activate' the surfaces to be coated (ie, allow them to become charged). The fluoropolymer gas is introduced where it forms covalent bonds with the surface. A pulsed radio frequency plasma polymerises the coating to form the layer.

Obviously, such a surface will not stand abrasion, but the parts of a phone you want to waterproof are on the inside. These surfaces are not 'permanent' and P2i imagines that their coating system will be incorporated in devices that they hope will become as ubiquitous as a microwave oven. P2i have also used their technique to coat air filter media for the oil industry where Teflon (PTFE, the original fluoropolymer coating) is normally used.

Simply put, though, this approach is too expensive. On high-margin goods like phones, fine, but how about if all you want to do is get the last drops of premier tomato sauce out the bottle?

Professor Kripa Varanasi and his team at MIT have developed a liquid-impregnated surface which can be coated onto the inside of pipes and bottles. Their coating creates a permanent liquid layer against a porous solid coating over the original surface. They have a YouTube video of tomato sauce pouring out of a bottle that has a voodoo-like look.

The problem with these sorts of additive coatings is that they have a very short life-span and don't handle abrasion or temperature variation without degrading. The applications where superhydrophobic surfaces would be of greatest value are industrial. Think aircraft wings that don't ice-up (the cause of numerous disasters), turbine blades with improved longevity and resistance to abrasion, ship hulls that don't foul and so improve fuel economy and speed, hospital medical devices which are intrinsically sterile and prevent bacterial growth, solar panels which are uniformly black at any angle and low maintenance.

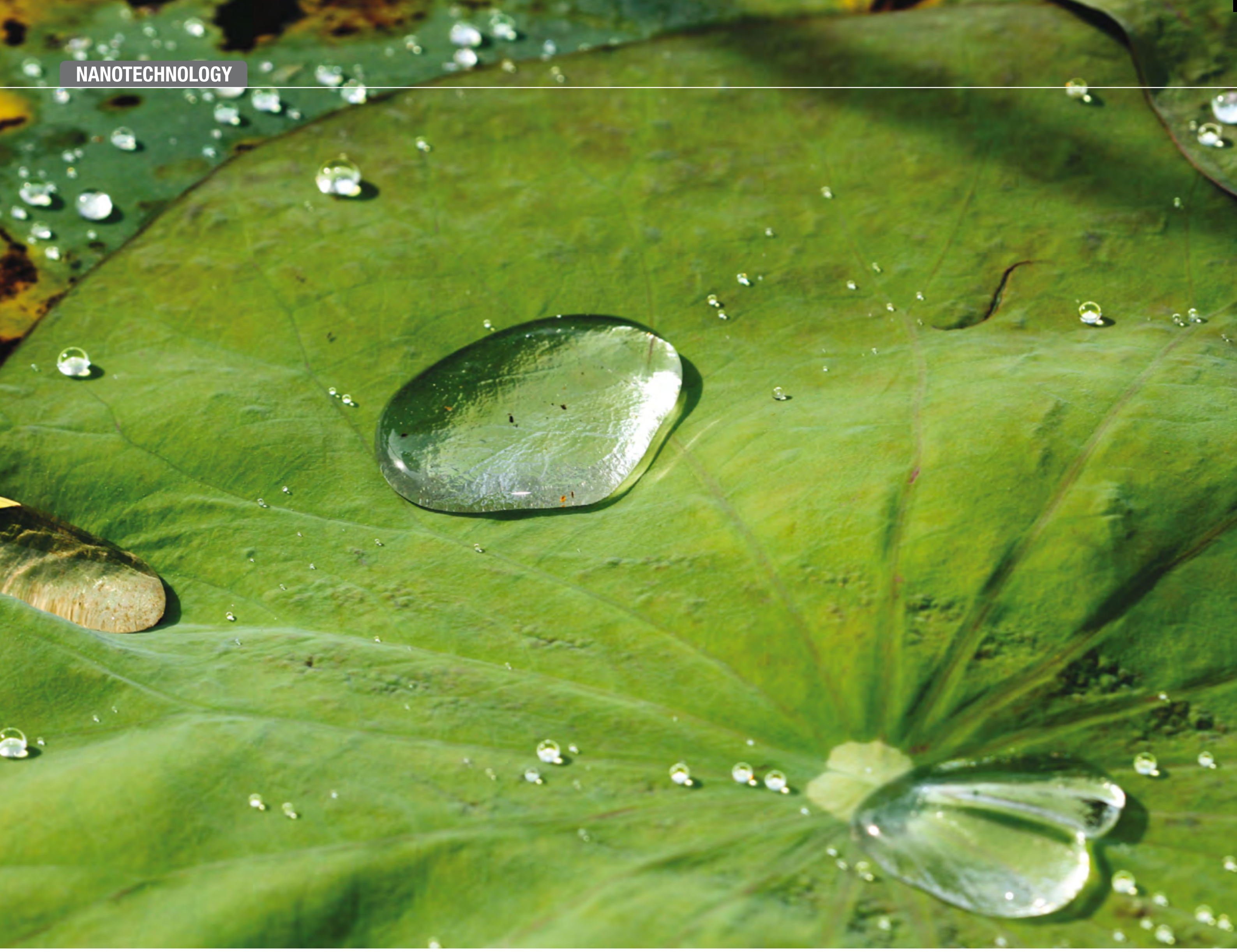
Cornell University and Rensselaer Polytechnic Institute are using the electrochemical process of anodisation to create nanoscale pores. These, they believe, change the electrical charge and surface energy of metal surfaces, which then repels bacterial cells and prevents thin-film formation.

In "Alumina surfaces with nanoscale topography reduce attachment and biofilm formation by *Escherichia coli* and *Listeria spp*", Guoping Feng, *et al*, present their research. Importantly, the approach is low-cost and results in a 'generally recognised as safe' material. The pore sizes they achieve are in the range of 15 to 25 nm.

"It's probably one of the lowest-cost possibilities to manufacture a nanostructure on a metallic surface," said Carmen Moraru, associate professor of food science and one of the paper's senior authors. "The food industry makes products with low profit margins. Unless a technology is affordable it doesn't stand the chance of being practically applied."

The benefit here is also that metal surfaces (rather than coatings) are more robust and so using them in marine biofouling environments is possible.

Some of these applications are already available. Anodic



alumina (or hard-anodized aluminium) cookware is widely used. These, though, use much higher pore sizes but demonstrate the much greater resilience to abrasion and regular use of this material.

Try and imagine the impact of such materials in healthcare, where – while single-use surgical tools can be discarded – life-support equipment is repeatedly sterilised but still contains nooks and crannies where bacteria hide.

Not all surfaces can be treated with the chemical immersion required for anodisation. Professor Chunlei Guo and his team at the University of Rochester have been working with femtosecond laser bursts to etch hierarchical structures onto surfaces. Guo, and his colleague Anatoliy Vorobyev, are building on earlier work that used laser-patterning to turn metals black. They are creating surfaces that are both superhydrophobic and optically highly-absorbant.

Guo says that "the structures created by our laser on the metals are intrinsically part of the material surface." They won't rub off and they are resistant to abrasion.

This is not yet suitable for industrial use as it takes an hour to pattern a 25,4 mm^2 metal sample, however, the idea that femtosecond lasers can be used to etch such patterns means they can be easily applied to surfaces after fabrication. They could even be used on non-metallic materials.

These non-coating approaches are important for another reason: they don't require toxic chemical coatings. By their nature, as they wear off, coatings leach toxins into the environment. Laser-etched surfaces don't.

The opportunities are endless and governments around the world are sponsoring research at an ever-increasing rate. P2i is a spin-out of research funded by the UK government. As usual, the early work will be slow and expensive, but the opportunities for better solar panels, more fuel efficient vehicles, and self-cleaning clothes are endless.

That isn't to say that there won't be silliness too. 'Ultra-Ever Dry' is a xylene and acetone-based coating which is painted onto surfaces (do so in a well-ventilated room, it's toxic).

Numerous internet memes exist where people demonstrate the effect of coating toilets, keyboards, or ice-trays in the paint. Nissan recently coated one of their economy cars in the stuff and took it for a spin to demonstrate a car that may never need cleaning (subject to periodic recoatings). The material isn't transparent so don't expect to use it on the windscreen.

I like the idea of easy-cleaning cookware, cutlery and crockery. Or shirts that never need cleaning. But there are other, more serious, considerations. As the global temperature rises and the oceans acidify, the expectation is that algae and bacteria will thrive. That will cause worse biofouling for pipelines and shipping.

What's interesting is that scientists don't fully understand the process by which superhydrophobic surfaces act. But that doesn't really matter to us. As long as it works, and as long as we can prove that they work safely, we will all benefit. ∎

CSIR's biotechnology spin-out company wins prestigious new product award

ReSyn Biosciences, a biotechnology spin-out company from the Council of Scientific and Industrial Research (CSIR), has won a prestigious new product award at the Society for Lab Automation and Screening (SLAS) conference for its range of innovativeMagReSyn® products, which help scientists find disease mechanisms faster.

The SLAS conference and exhibition event was held at the Walter E Washington Convention Centre in Washington, DC, from 7-11 February, 2015.

The new product award is given to companies that design unique and novel technologies based on the potential impact these products are likely to have in the field of automation, screening and drug discovery. "The high-performance products, MagReSyn®, are capable of expediting research, assisting scientists in making discoveries faster, and helping to find the mechanisms of disease. Identifying the cause of a disease is the key component in their eventual diagnosis and treatment," ReSynBiosciences CEO, Dr Justin Jordaan says.

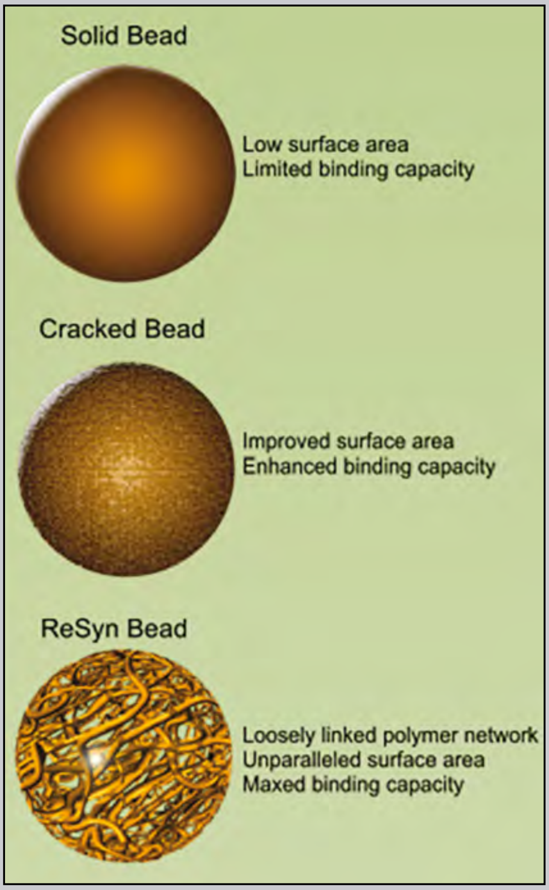
The MagReSyn® products were developed by Jordaan and his team at the CSIR from a proprietary technology platform, which is subject to an international patent application. Jordaan says the MagReSyn® product data demonstrated product quality and utility and was included in the recent international scientific publication by researchers at Cancer Research UK, the Institute of Cancer Research in the United Kingdom, the University of Dundee (Scotland) and Massachusetts Institute of Technology in the United States of America. The products were also used in an automated platform and described as 'excellent' for a process frequently used in discovering the mechanisms of cancer.

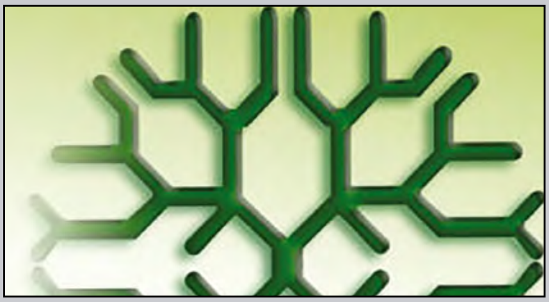
Supporting information was provided in the form of scientific publications and posters prepared in collaboration with international research and industrial partners, where the MagReSyn® products played a key enabling role in automation and screening.

A total of 296 life-sciences companies participated in the SLAS 2015 exhibition, 61 of which submitted products for consideration of a new product award designation, with a total of four awards conferred at this year's event.

"Research is currently underway to expand the range of applications of the technology platform to include the green production of pharmaceutical intermediates and novel research and diagnostic tools. The research continues to be supported by the CSIR through the Biomanufacturing Industry Development Centre Programme," Jordaan says.

For more information contact TendaniTsedu on tel: +27 12 841 3417, email: mtsedu@csir.co.za, or go to www.csir.co.za ▮





Nanoparticle measurement expertise aids development of water pollution tests

LGC (UK) scientists have contributed to a European project to investigate the feasibility of developing water test materials to help measure toxic water pollutants at nanogram-per litre levels. These materials will be useful to the European-wide battle to improve the world's water supplies.

As part of a project with other European National Measurement Institutes, three test materials have been successfully developed for the measurement of polycyclic aromatic hydrocarbons (PAHs), polybrominateddiphenyl ethers (PBDEs) and tributyltin (TBT), which have all been identified as a critical pollutant under the EU Water Framework Directive (WFD) – an EU law introduced to target water pollution.

Under the WFD, all member states must improve the condition of their water supplies, drastically reducing the levels of major pollutants by 2015. Targets were introduced on 22 December 2000, with the aim of protecting, enhancing and restoring the condition of all water in the natural environment.

Despite these targets, the majority of water bodies in the UK and in other EU countries are failing to meet the required targets. Only 27 % of rivers, streams, lakes, estuaries, coastal waters and groundwater in England are currently classified as being of 'good status' under the standards set down by the WFDi.

One of the major barriers is the lack of suitable measurement procedures to allow accurate determination of pollutants at the low levels that the Directive requires. In order to combat this, a feasibility study was launched under the European Metrology Research Programme (EMRP) for the preparation of reference materials for PAHs, PBDEs and TBT in natural waters.

Panayot Petrov, Science Leader in the Inorganic Analysis team within the Science and Innovation division at LGC said: "A requirement of the WFD is that whole, non-filtered waters have to be analysed. This is because suspended particulate matter (SPM) plays a key role in the transport and fate of organic pollutants in the aquatic environment. We used our expertise in nano-particle measurement to characterise the small particles (<450 nm) present in the samples. This provided necessary information about the nature of the model SPMs used."

Three types of ready-to-use water test materials were successfully developed for PAHs, PBDEs and TBT at nanogram-per litre levels. Combining the humic acids with these model suspended particulate matter (SPM) materials represent a step forward in the production of test materials mimicking whole natural water as stipulated in the European Union Water Framework Directive. ▮

Profitability through supply chain excellence – A 'Technology Insight' for specialty chemicals producers

Article supplied by IChemE and Aspentech

Globalisation and the uncertainties of an ever-changing economic landscape have introduced new complexity to the specialty chemicals business. On a daily basis, specialty chemicals producers must navigate multiple variables to determine the most profitable products to produce, when and where to produce them and how to successfully execute against that plan.

Supply chain excellence through software

Specialty chemicals companies who implement supply chain excellence programs report as much as a 10 % increase in margins. This tangible impact on the bottom line demonstrates that supply chain excellence is not an esoteric term, but an actionable initiative that specialty chemicals companies cannot afford to ignore.

Supply chain leaders need to evaluate the critical issues that prevent their supply chain operations from adapting to their business needs. Typical issues include operating in business silos, lack of visibility, and lack of decision support tools, which compounded, significantly hinder the ability for the business to respond quickly to customer demand. It is important for business leaders to identify these challenges in their organisation and to take action to achieve supply chain excellence to successfully navigate market complexity and unlock opportunity.

This article discusses the challenges of effective supply chain operations and decision making, introduces software solutions to transform the Sales & Operations Planning (S&OP) and Scheduling functions, and outlines the benefits and opportunity for specialty chemicals producers to maximise profitability to gain a competitive edge.

This article is published with the kind permmision of IChemE and Aspentech

Challenges facing the specialty chemicals business

Specialty chemicals companies navigate a number of external and internal variables on a daily basis that challenge decision making around forecasting, planning, and scheduling on both short and long-term time horizons. The typical challenges that add complexity and place pressure on operations include:

- **Globalisation** – The rise of multinationals has had a dramatic effect on the industrial sector. For specialty chemicals producers, globalisation has heightened the focus on the supply chain, introduced new complexity and narrowed the margin of error between profit and loss. Producers face the double-edged sword of pursuing new markets (and new opportunities) and opening themselves to new competition. The net result has been a new drive for supply chain excellence.
- **Uncertain demand patterns** – Specialty chemicals producers face uncertain and unpredictable demand patterns with limited visibility of future customer orders. Events, such as the introduction of new products, expiration of patents, the appearance of generics or announcements by regulatory boards, may introduce minor shocks to demand. In turn, the impact on product pricing creates major swings

in both short and long-term demand – distributors may stock pile products prior to price increases or producers may attempt to time price increases at the precise point when distributors require maximum inventory to prevent them from stockpiling at lower prices.

- **Expanded product portfolios** – Specialty chemicals producers continue to differentiate their products in direct response to customer requirements and new market opportunities. Supply chain systems must evolve in parallel to handle various product specs, production scheduling and batch scheduling.
- **Regulatory compliance** – Government regulation has had a profound impact on the chemicals business that has resulted in stricter controls for both finished and unfinished products. Specialty chemicals producers must assure product quality, report precise batch and lot traceability, and deliver tighter product testing and documentation. As part of regulatory compliance, operations such as major and minor cleaning between batches to meet regulatory compliance have a significant impact on plant scheduling and product availability.
- **Hedging behaviour** – To address risk, planners and schedulers often prepare for the worst case scenario by building up safety stock in anticipation of uncertain future demand. Known as hedging, this business behaviour ignores the cost of excess capacity and often points to the business' inability to 'catch-up' in the event of equipment failure. Possibly the most damaging and costly part of current planning and scheduling practices, hedging leads to both under production of required product and over production of unwanted product, which results in increased inventory cost and product waste.

In today's business environment, these factors are a continual threat to operational success and impact the business in specific areas.

The measures of supply chain success

For supply chain operations, the typical measures of success include:

- **Customer service** – Customer service is paramount for specialty chemicals producers and it is a standard measure of business performance. There is constant pressure to reduce order lead times to retain customers, as well as pressure to maintain appropriate stock to meet demand.
- **Inventory management** – Inventory is expensive to store and ties up working capital. Companies require the ability to closely monitor inventory levels and track common metrics such as inventory turns and number of days of

demand that the current inventory can cover.

- **Costs** – Costs related to purchase of raw materials, carrying inventory, distribution, and other costs are spread across the supply chain, and therefore make the supply chain a logical place to track cost savings. Each company has its own individual metrics such as best delivered cost or cost of raw material per tonne of product produced. At the plant level, asset utilisation and product yields contribute to operating costs and must be tracked with their own metrics.

Barriers to success

Companies that optimise their supply chain position themselves for success by aligning people and processes through technology. Typical barriers to supply chain agility relate to business alignment, shared information and visibility on assets and lack of effective decision support systems:

- **Lack of alignment** – Siloed processes and work practices not only lead to inefficient workflows and time delays, but most importantly, disrupt operations and result in objectives that run counter to each other. The net result is lack of ability to respond quickly and profitably to unplanned occurrence such as new orders, equipment failure, raw material shortages, labour constraints or other factors. Operational success is dependent on supply chain processes that seamlessly span strategic, tactical and operational levels and operations that connect and align all stakeholder interests.
- **Lack of business visibility** – For many companies, individual spreadsheets are the primary means for tracking data, performing data analysis and presentation reports and graphs. This practice is outdated and leads to the creation of 'islands of automation'. These 'tools' require manual data entry, which leaves them prone to manual error. As they do not represent the overall business, these 'silos of information' cannot consider any broader planning and scheduling operations. The inability to see the larger operational picture results in decisions based on temporary issues and short term strategy inconsistent with the broader business direction.
- **Lack of decision support tools** – Companies also lack specialised decision support systems that provide real-time, operation-wide information to enable the best decisions. Without visibility on assets, access to information, or understanding of the operational plan, producers cannot react or adapt to changes in the market environment. In fact, an overwhelming number of chemical producers again rely on manual spreadsheets as transaction support systems. The result is an environment where Planners do not have the best information to make the more informed operational decision.

A guide for supply chain success

For specialty chemicals producers, the equation is clear: production of differentiated products, efficient inventory management and on-time product delivery at best cost results in exceptional customer service and profitability. By taking the key steps to align their business and achieve these goals using today's sophisticated supply chain software, business leaders can conquer market uncertainties and operate an agile specialty chemicals business.

Essentially, the formula for effective supply chain operations involves:

- Empowering people with information
- Standardising business processes
- Sharing the plan
- Driving business alignment
- Enabling the best operational decision through information and what-if analysis
- Investing in technology

Today's best-of-breed supply chain software offers specialty chemicals companies immediate visibility on the information they need and the opportunity to carry out the full spectrum of 'what if' analyses. These capabilities, in turn, help them to streamline workflows, reduce costs and quickly reach more informed decisions.

Supply chain excellence pays off

Companies that deploy supply chain optimisation software have the potential to realise significant margin improvement of 10 % by:

- Increasing capacity 3 – 5 %
- Improving customer service 5 – 10 %
- Improving first-quality production 5 %
- Reducing costs 4 – 6 %

The latest supply chain software enables companies to optimise trade-offs between customer service, inventory levels and manufacturing costs and accelerate process innovation. A supply chain best practice is to integrate supply planning with scheduling at the operating level to ensure that the supply plan translates to a detailed schedule for execution. This functionality requires application of technology in two business areas – Sales & Operations Planning (S&OP) and Scheduling, which companies can deploy sequentially or as an integrated solution in a single plant or across multiple sites.

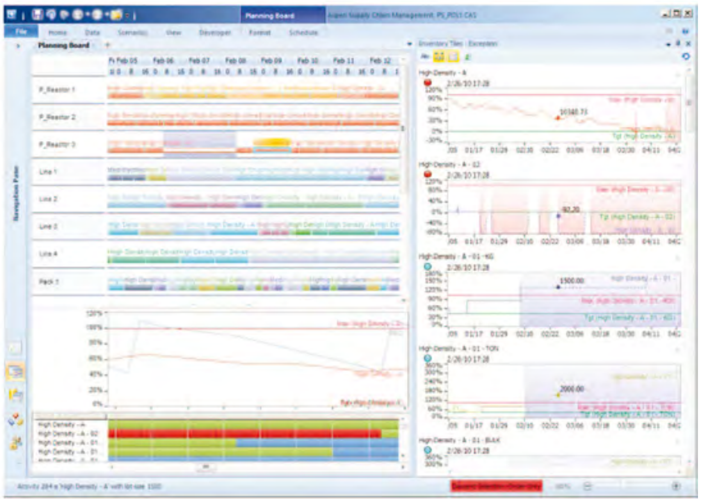
Sales & Operations Planning

While the detailed functional definition and organisation of Sales & Operations Planning varies across companies, a simple working definition can be summarised as the business requirement to match product supply with customer demand as closely as possible at any point in time in order to maximise business profit. In that light, most specialty chemicals companies conduct some degree of Sales & Operations Planning as part of their business process.

Most concerning is when definitions, data and processes vary individually from site to site within the same business unit or organisation. Without a standard Sales & Operations Planning process in place, companies cannot properly align supply with demand and without a supply chain optimisation system, the S&OP process cannot evaluate multiple scenarios, respond quickly to unplanned events or perform insightful analysis and forecasting.

Companies that pursue supply chain excellence follow a formal S&OP process with a high level of sophistication powered by best-of-breed software. Two critical components of an effective S&OP system are first, a demand forecasting capability to identify and forecast demand and second, a planning system to generate a plan to meet that forecasted demand.

Spreadsheets are widely recognised as inadequate for managing complex supply chains. They are typically customised to fit the constraints of each plant and are prone to errors and labour-intensive data gathering.



The interactive Planning Board in Aspen Plant Scheduler provides an easy way to visualise and make changes to the schedule as well as view inventory levels for multiple products simultaneously.

S&OP Case Study – ¤15B specialty chemicals producer in Europe

A €15 billion specialty chemicals producer based in Europe wanted to ensure execution of reliable and cost efficient delivery of their products in Central Europe. The company also needed to remove bottlenecks in the production and distribution processes and to simultaneously optimise:

- Storage and transport capacities
- Logistics (mode of transportation, route, vehicle utilisation, etc.)
- Sourcing from shipping points

Additionally, the company needed to meet regulatory compliance requirements to track CO_2 positions across ten European countries against annual emissions limits.

This supply chain transformation was not an easy task considering the complexity of their supply chain network, which includes more than 30 sites, hundreds of resources, thousands of ship-to locations and a multitude of raw material suppliers. The company did not have a global reporting system, asset visibility or standard supply chain business processes across the organisation. In fact, each country operated completely independent of one another, tracking operations on desktop spreadsheets. To unify operations, the company turned to Aspen Supply Chain Planner, a software application that supports the S&OP process in the aspenONE Supply Chain Management suite to achieve the following:

Optimise across 10 business units
Facilitate decision-making based on economics
Increase the transparency of their business processes
Perform both short-term (weekly/monthly) and strategic long-term (1-5 years) planning.

Through Aspen Supply Chain Planner, this specialty chemicals producer easily determines alternative supply paths across the network and dynamically selects optimal product source locations, based on physical constraints and emissions limitations. By optimising their supply chain to determine the lowest cost for each customer and by improving work processes, data management and reporting visibility, this specialty chemicals producer estimates that it will attain €20 million in annual benefits.

Scheduling Case Study – NOVA Chemicals

NOVA Chemicals, a plastics and chemicals producer with manufacturing sites strategically located throughout Canada and the United States, wanted to standardise their supply chain operations – processes and underlying technology – for their polyethylene business. Due to fragmented business processes, lack of automation and scheduling models that were customised for each plant site, NOVA Chemicals was forced to manage their supply chain in a largely manual fashion, making it difficult to react to any type of business change. The company lacked the ability to evaluate the impact or to determine the best course of action for events, such as price changes, shutdowns, raw material constraints or weather-related factors. Furthermore, the lack of uniformity between models broke down synergies between groups and made change management very difficult.

By committing to a new, standard set of business processes for all parts of the polyethylene business, NOVA was able to migrate to six standard aspenONE Supply Chain Management applications with a single design throughout. The new business processes and technology were automated and integrated, enabling NOVA Chemicals to react quickly to changing business conditions, reduce overall IT ownership and model maintenance and improve data sharing and collaboration to increase their scheduling horizon by 100%.

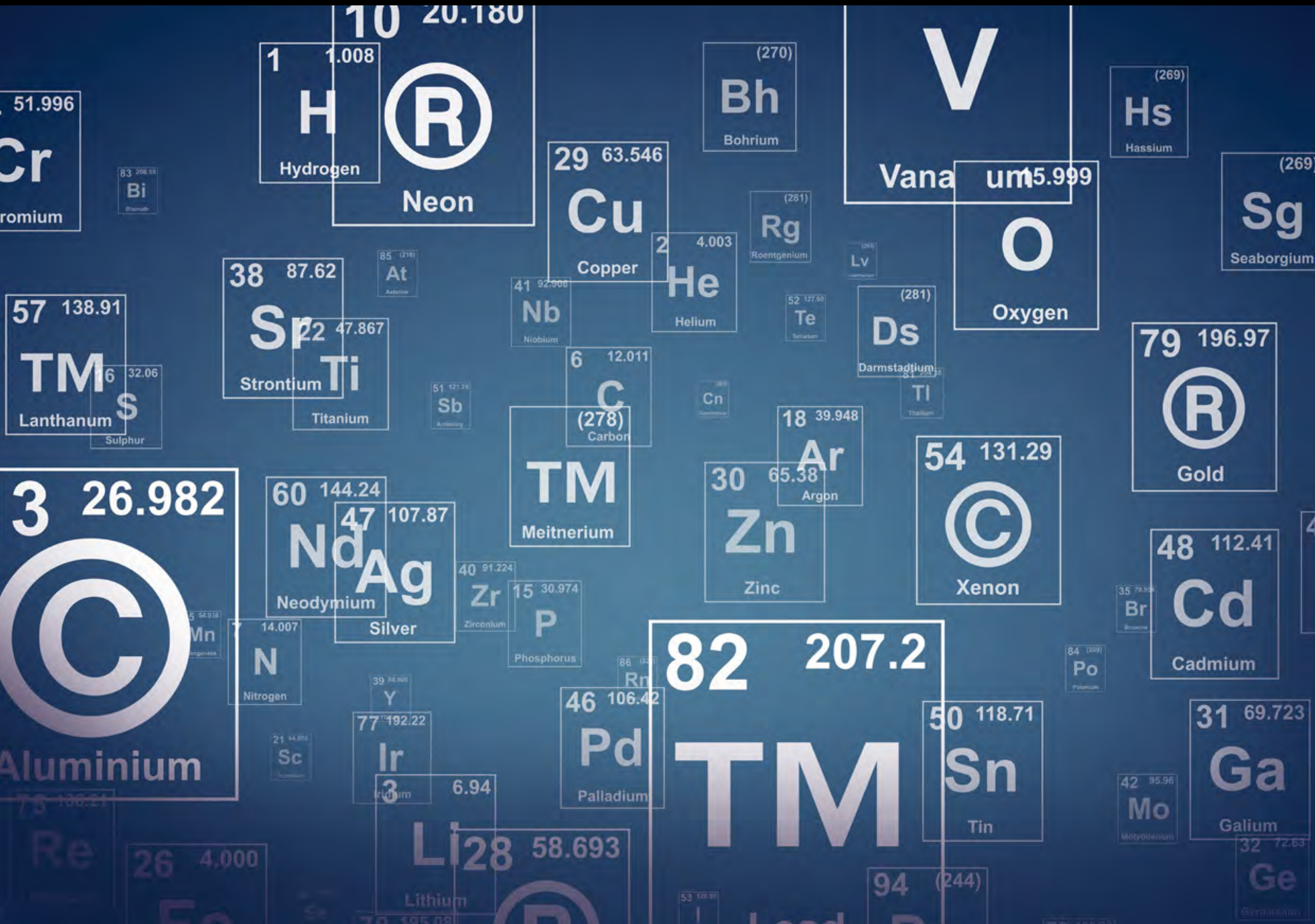
"Due to forward visibility, the scheduling horizon doubled, increasing from 90 days to 180 days. This gave the schedulers better raw material visibility and a better product wheel."

Zoran Stojecevski, Systems Analyst and Developer, NOVA Chemicals

In every supply chain there are activities that must be initiated in anticipation of future demand. The specific activities vary with the business, but generally include finished goods production, semi-finished goods production or raw materials purchasing. To maximise performance, these activities must be planned with the best available information. Improvements in forecasting and demand planning can reduce the need to carry excess safety stock or have spare capacity sit idle. In a fully integrated supply chain, production operations should be closely linked with demand management, so a company's operational plan can adapt as quickly as demand changes.

Generating an accurate demand forecast is a critical first step in the S&OP process, as it is the demand signal that

ARE YOU NEGLECTING A VITAL ELEMENT IN YOUR R&D PROCESS?



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drives all other functions, such as planning and scheduling. The process of developing accurate and consistent projections of market demand and continuously updating these projections as circumstances change is known as demand management, and can include activities such as:

- Consolidating the shipment data for various market segments
- Generating forecasts
- Reconciling forecasts with firm orders
- Collaborating with sales, marketing and customers to refine the forecast
- Tracking forecast accuracy
- Other processes that are essential for developing a sound business plan.

Best-of-breed software uses this demand forecast to generate an optimal plan that factors in labour and equipment, raw materials or feedstock, inbound/outbound transportation, storage capacity and other variables. The role of supply chain planning software in the S&OP process is to focus on business-wide supply and inventory planning, and specifies 'where to make what' based on customer demand. It involves allocating production across various plants while minimising transportation and operating costs.

The best supply chain software provides web-based S&OP analytics for enterprise-wide reporting and access to data and analysis during the planning process. Additionally, the latest software features easy-to-use software interfaces with streamlined workflows to help users visually navigate operational complexity. Combined, these capabilities allow users to attain visibility into their current situation by combining data from their ERP and production systems, as well as results from their planning and scheduling tools for a complete picture of their supply chain.

Many leading specialty chemicals companies have adopted aspenONE® Supply Chain Management to address inefficiencies in end-to-end processes, to drive first quality production, to minimise inventory and distribution costs, and to allow rapid innovation to meet customer requirements.

Plant scheduling

Together with S&OP, Scheduling is the other critical business component of an effective supply chain management system. Schedulers face the similarly complex task of translating the product plan into an execution plan at the plant level. In this area, companies require supply chain systems that can support the high level of business and manufacturing agility required to handle sudden changes to the schedule.

Specialty chemicals manufacturers have a diverse set of multi-stage operations that must simultaneously consider all manufacturing constraints. Timing of these multi-stage operations is an essential element in meeting customer demand and keeping work-in-process inventory at acceptable levels. As always, the detail is crucial. Best-in-class chemical companies are making sure the details are modelled by their decisions support tools. Decision support software provides visibility into the following key areas:

- **Shared resources** – Resources that can be used by more than one asset (such as people, pipes, tanks, warehouse space, clean-in-place and emissions) must be recognised to avoid bringing production to a halt.

- **Production sequence optimisation** – Optimisation of complex setups and transitions based on an unlimited number of properties or attributes, such as product family and raw materials consumed.
- **Time-dependent properties** – Specialty chemicals companies in particular often have shelf life constraints where Schedulers need to have forward visibility into materials that must be used before they expire in order to minimise product loss.
- **Product blending** – Blending optimisation is vital. Perfecting the combination of raw materials with the right properties to get on-spec finished product, taking into account the physical and equipment handling constraints that are associated with blending problems.

With complex and detailed modelling of the production process, there is the danger of going too far into the realm of highly customised scheduling solutions at each plant. Business leaders should resist the temptation to pursue highly customised and difficult to maintain models. The focus should be on scheduling solutions that are standardised, yet scalable and flexible enough to capture the unique requirements of a particular business.

The bottom line of supply chain excellence

Specialty chemicals companies today face numerous uncertainties and constantly navigate internal and external business variables – but sophisticated software systems are available to drive supply chain excellence and to align people and processes. By building S&OP and scheduling operations grounded in the latest supply chain optimisation software, companies can make the best operational decisions, respond to market fluctuations, absorb disruptions and execute against the plan. The tangible benefits are clear – improve margin improvement 4 – 20 %, improve customer service 5 – 10 %, improve first-quality production 5 % and reduce costs 4 – 6 %. Conversely, the cost of lost opportunity may never be known. Through leading-edge supply chain software, specialty chemicals manufacturers can optimise performance, align processes and empower decision makers to maximise profit and gain the competitive advantage. ▮

For more information on how to achieve supply chain management excellence, go to www.aspentech.com

Labelling solutions from cab for chemicals, food, agriculture and manufacturing

Barcode printer manufacturer cab is setting new standards in developing and manufacturing devices and systems for product labelling and product marking.

This German-based company boasts sales and service subsidiaries in seven countries and more than 500 partners in over 80 countries. Technical sales manager for southern Africa, Rudie Buys, affirms the company's support for the region's customers. "cab provides on-the-spot support for our customers in chemical, food, agricultural and manufacturing industries, who rely on our high quality standards," he stated.

On June 1, 2015 a new global system will be adopted for labelling in the chemical industry, known as the Globally Harmonized System (GHS) of Chemical Labelling. This initiative is a system developed by the United Nations (UN) to strengthen international efforts concerning environmentally sound management of chemicals.

The USA Occupational Safety & Health Administration's new labelling requirements are expected to have the greatest impact on internationally-based chemical manufacturers, with few mandatory changes proposed for other general chemical storage. HCS targets chemical manufacturers and importers to ensure their chemical containers will display a label similar to those now used in Europe and many other Globally Harmonised System (GHS) adopters, beginning June 1, 2015.

The GHS-inspired standards will require chemical manufacturers and exporters to label chemical containers with (1) a harmonised signal word (2) GHS pictogram(s) (3) a hazard statement for each hazard class and category and (4) a precautionary statement.

cab's sales manager for the southern Africa region, Julian Power,

confirmed that cab has the technology to help customers switch to the new GHS standards. "Our XC series label printers meet the conditions for the Classification and Labelling Inventory according to GHS", he pointed out.

"In addition, our two-colour printing in one pass is another first for cab," Power continued. "While most companies rely on pre-printed or partly pre-printed labels, we can provide a solution that allows full variable data printing with all the attached benefits.

"This is especially popular because of the low cost per print and the ability to print high quality variable information as well as bar codes. What this means is that a customer can keep blank labels in stock and print only as needed, with batch and sequential numbering".

For more information contact Julian Power at julian@gw.co.za, or tel: +27 11 886 0307. ∎

Secure supply of industrial gas supports broad range of industrial processes

Industrial gas continues to play a pivotal role in the growth of Eastern Cape industry, evidenced by Air Products South Africa's supply to the local market for the past six months of uninterrupted supply of industrial gases.

The industrial gas company was commenting on its contribution to Eastern Cape industry following the launch of its R300 million air separation unit (ASU) in the Coega Industrial Development Zone (IDZ) in November last year.

As the first to market in the Eastern Cape, Air Products is able to deliver security of supply of liquid oxygen and nitrogen, meeting the needs of local industry and offering improved levels of customer service, according to Pierre Fourie, Sales Manager: Eastern Cape for Air Products.

"Our air separation unit supplies liquid oxygen and liquid nitrogen in bulk by road tankers across the Eastern Cape. We also supply the full range of industrial and specialty gases. Depending on volume requirements and specific applications, gases are supplied in cylinders, mini-tanks, maxi-tanks and CryoEase," he says.

"As gas is a vital part of virtually every industrial process, the importance of security of supply cannot be overstated. We are able to match current market demand and have capacity to scale up production in line with growing demand in the region."

The company's identified markets for growth, including automotive and component manufacturing and fabrication, food and beverage, agro-processing and their related value chains, were well aligned with the sectors prioritised for growth in the Eastern Cape's provincial industrial development strategy.

"Liquid oxygen and nitrogen play a key role in the metals processing sector for cutting and laser applications. Metals processing supports diverse industries, including the manufacture of renewable energy components – another key sector where the Eastern Cape is driving industrial growth," continued Fourie.

Air Products distributes liquid nitrogen and liquid oxygen by its newly-upgraded fleet of road tankers across the Eastern Cape, and provides on-site back-up storage for critical customers.

The Coega ASU represents the latest developments in air separation technology in order to deliver optimal energy efficiency and maximum product output capacity, at a reasonable cost of production.

"Our supply chain efficiencies, developments in air separation technology and growing customer base are complementing Air Products' long-standing footprint in the region," commented Arthi Govender – Market Research and Strategy Manager. "We believe that through our investment in Coega, we have not only proven our commitment to our customers in the Eastern Cape region, but we have also established our gas as pivotal to a multitude of industrial processes.

The quality of our technology, coupled with our long-term security of supply will make a positive contribution to economic growth of the region for many years to come," she concluded.

For more information contact Kendal Hunt on tel: +27 11 462 6188 or email kendal@kendalhunt.co.za ∎

Air Products South Africa produces 110 tons per day of liquid oxygen and nitrogen for supply to diverse customers in the Eastern Cape.

Budding chemical engineer

Well, as a confirmed feminist, I would agree with those who say it's never too early to set girls on a career path – such as, for example – little two-year-old Angela, seen here carefully paging through and looking with real interest at all the illustrations in the January 2015 issue of 'Chemical Technology'. It is certainly heartwarming for someone who holds reading in very high esteem, to see a child taking such interest and care with a magazine and a bonus that the publication is 'Chemical', which has been my 'baby' for over 14 years now!

As Angela's grandmother, who sent in the photo, commented, it really is little wonder that she is drawn to this subject matter, as her granddad, father, mother and aunt are all chemical engineers!

This delightful positive feedback was most inspirational to our editorial staff, so, thank you, Thea Buys, for thinking of us and good luck for Angela's future career! ∎

Glynnis Koch, Editor

Dutch compounder cuts labour and improves productivity with Flexicon bulk bag dischargers

An investment in bulk bag dischargers and flexible screw conveyors by compounder, Trinseo Netherlands BV, is increasing productivity, worker safety and plant cleanliness. The company, which runs eight compounding lines in a 5 000 m² plant and employs 80, installed two Bulk-Out™ BFC-X Bulk Bag Discharging systems with integral flexible screw conveyors from Flexicon (Europe) Ltd. One system unloads and conveys talc used to improve the mechanical properties of polypropylene compounds; the other unloads and transports an impact modifier in polycarbonate/ABS formulations.

The bulk bag dischargers replace manual unloading, explained Ron Drabbe, senior improvement specialist at Trinseo Netherlands. The equipment promotes complete evacuation of bulk bags and conveying of material to blending hoppers on compounding extruders.

Bag handling was labour intensive

Each bulk bag weighs 600 kg. Unloading a bag previously required three workers, said Drabbe. Two would mechanically hoist a bag above a hopper while a third, working from a platform atop the hopper, connected the bag to a discharge unit and dislodged trapped residue by hand. Non-free-flowing talc was especially prone to lodging in corners of the bags. Apart from the risk of injury in handling bulk bags and climbing up and down platforms, "unloading generated dust, which settled on the plant floor," he continued.

Each bulk bag discharger frame includes a cantilevered I-beam with an electric hoist and trolley, allowing a single worker to raise and position a bulk bag above the unit's receiving hopper. Because the discharger is automatic and dust-free, Ron Drabbe explained, Trinseo Netherlands can discharge as many bulk bags as are needed, both rapidly and safely.

Bulk bag dischargers ease operation

A cross-shaped bag-lifting frame attaches to the straps on each corner of the bag, and the electric hoist lifts the bag into place on the discharger frame. The operator pulls the bag's outlet spout through a Power Cincher™ flow-control valve whose elliptically-contoured bars close concentrically around the spout, preventing product leakage. The clean side of the bag spout attaches to the clean side of the discharger by means of a Spout-Lock™ clamp ring, which is mounted atop a Tele-Tube™ telescoping tube that maintains constant downward tension on the bag as it empties and elongates, promoting material flow through the bag spout.

Pneumatically-actuated Flow-Flexer™ flow-promotion devices raise and lower opposite bottom sides of the bag, forming a 'V' shape to promote total discharge into the hopper. The hopper is vented to a Bag-Vac™ dust collector that vacuums displaced air and dust from the sealed system as talc or impact modifer discharge from the bag, improving plant cleanliness, noted Drabbe.

Conveyor maintains talc quality

As material enters the hopper, a flexible screw conveyor, 10,5 m long and 114 mm in diameter, transports talc or GRC at a 45 ° incline to an inlet hopper for blending with other additives and resins prior to compounding. The conveyor's flexible stainless steel screw has specialised geometry to handle non-free-flowing materials.

One benefit of this particular screw design is its ability to convey talc consistently regardless of its moisture content. Drabbe said that the density of talc often decreases when it is conveyed because ambient air reduces its moisture content.

A programmable logic controller governs operation of the two dischargers and conveyors.

For more information contact Flexicon Africa on tel: +27 41 453 1871 or email sales@flexicon.co.za ∎

Automated, safe, and dust-free, the Flexicon discharger is equipped with an integral flexible screw conveyor.

The operator connects the spout to a Spout-Lock™ clamp ring, which is mounted atop a Tele-Tube™ telescoping tube.

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website: www saiche.co.za

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Re-launch of Western Cape Branch

Just over two years ago, The Western Cape Branch had ceased to exist, but has been recently re-constituted under the chairmanship of Hamied Mazema, a once branch chairman and past longstanding committee member. A committee was formed out of volunteers and local members who were invited to participate in re-establishing a presence in the Western Cape. This area is an important industrial hub where many chemical engineers reside and where there are three tertiary institutions that teach chemical engineering.

This was further confirmed by the widespread and unanimous support for the initiative across the spectrum of academia and industry. The present committee consists of: Hamied Mazema (Chairperson), Prof Eugene Cairncross (ex-CPUT), Ashleen Marshall (CPUT), Dr Adeniyi Isafiade (UCT), Adri Uys (UCT), Ronald Gunda (City of Cape Town) and Adrian Rudolph (CSIR).

On the 22nd January 2015 the Western Cape Branch had the honour of a very special and magnanimous re-launch, at which the President of IChemE and his team were in Cape Town and ran a very successful workshop on “Chemical Engineering Matters”. The programme, by all standards, was well patronised with over 50 persons attending.

Proceedings commenced with the chairman’s address welcoming the distinguished guests and all attendees. This was followed with an address by Dawie Van Vuuren, President of SAIChE-IChemE, who elaborated on the SAIChE-IChemE collaboration. Thereafter, Neil Atkinson (IChemE) expounded on the ubiquitous nature of chemical process engineering and, in doing so, set the tone for the workshop.

The unique format of the workshop was very productive and stimulating with the audience participating in contributing to the various vistas of “Chemical Engineering Matters” that were presented by IChemE President, Geoff Maitland, and facilitated by Neil Atkinson and Alana Collis, both of IChemE.

At 21:20 the chairman closed the event by thanking everyone for attending and for making the event such a memorable and resounding success. Thereafter everyone gathered for another round of refreshments and snacks whilst networking. In summary, the event was enjoyable, interesting, stimulating and a resounding success: a given, attested to by the fact that the event surpassed the set closure time by almost one-and-a-half hours. ▮

Written by Hamied Mazema

Left to right: (C= W Cape Committee and M= Member). Eugene Cairncross (C), Hamied Mazema (C-Chair),Geoff Maitland (President, IChemE), Philip Lloyd (M), Ronald Gunda (C), Neil Atkinson (IChemE), Adrian Rudolph (C), Alana Collis (IChemE).

(Left to Right) Hamied Mazema (Chair; 80s and present), Geoff Maitland (President, IChemE), Philip Lloyd (Ex-Chair 70s).

(Left to Right) Manoj Chhiba (attendee), Attendee, Geoff Maitland (President IChemE), Hamied Mazema (Chair).

IChemE visits UKZN

On the 21st January 2015 the Discipline of Chemical Engineering at the UKZN hosted a visit by Dr Alana Collis, Senior Technical Policy Officer of IChemE.The discussion focused on the challenges facing chemical engineers in South Africa and the role that IChemE could play in supporting and facilitating engagement of stakeholders in the region on some of the most pertinent issues involving the profession.

After meeting with the major research groups in the department, Alana proceeded with an interactive presentation based around five questions:

- What does chemical engineering look like in your country /region / sector / industry / company right now?
- What challenges do you face?
- What opportunities can you see?
- What actions would you prioritise?
- What can IChemE do to support you, your colleagues and your employer?

She highlighted the existence of special interest groups within the IChemE membership and encouraged all to take advantage of this platform to promote research and create networks. Comments from the audience were invited. The visit was rounded off by a tour of the research and training facilities at the Discipline. ▮

Written by: David Lokhat

Professor Randhir Rawatlal, Head of Chemical Engineering at UKZN and Dr Alana Collis, Technical Policy Manager at IChemE.

etc

Chemical Engineering Matters

It was clear from the outset that the detailed thinking set out in IChemE's *Roadmap for 21st Century Chemical Engineering* would need to be the subject of ongoing review. Nonetheless, a member consultation in 2011 revealed continuing support for the roadmap and the position statements that it embraced.

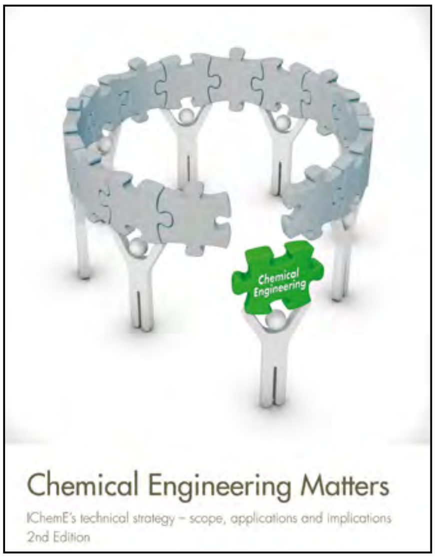
Further dialogue with members in the first part of 2012 refined the institution's thinking on technical strategy matters. A new focus on potential chemical engineering solutions in four key challenge areas – energy, water, food and nutrition, and health and wellbeing – was agreed, coupled with a stronger emphasis on external influences, including the wider economy and public attitudes to science.

The report that has emerged, *Chemical Engineering Matters*, has moved away from the classical roadmap approach in favour of a more open-ended look at the options for progress. This report is an exploration of possibilities and a vivid illustration of the versatility and wide-ranging application of chemical process solutions to human challenges. It positions the discipline as a vital piece of the jigsaw that is the quest for sustainable living in the 21st century.

At the core of the report, the reader will find four vista diagrams – one for each challenge area. The diagrams attempt to capture the current status and some specific challenges under each heading and propose some options for action by chemical engineers and others. External factors are also addressed in the context of the challenges. The vistas represent the beginning of a process, rather than an end. They are intended to provoke debate and stimulate target setting. Initiated by Ian Shott, the institution's technical vice president at that time, the report *A Roadmap for 21st Century Chemical Engineering* addressed the question: "What does society need; what are the desirable outcomes and how can chemical engineers work in partnership with others to make it happen?"

The report acknowledged that this was a tough question. Nonetheless, it asserted that chemical engineers must offer credible answers if the profession is to be taken seriously by decision makers, opinion formers and an informed and increasingly demanding public. At the roadmap's core were 20 position statements, underpinned by a series of action plans describing an extensive range of projects and initiatives that required IChemE support. The sustainability challenge was clearly stated and the work also acknowledged that there was no 'one-size fits-all' solution. A commitment was given to allocate resources to support the action plans and to publish regular updates. The roadmap was re-evaluated and IChemE is working with members around the world to demonstrate that chemical engineering matters.

Through the vistas, *Chemical Engineering Matters* has identified a clear set of global challenges that can be addressed by the application of sound chemical engineering principles. The solutions and work programmes for the institution will vary in different locations and will require versatile partnerships with other stakeholders to secure delivery in developed, emerging and nascent economies around the world. In addition to the vistas, the report also describes IChemE's current thinking in three fundamental underpinning areas: safety and



risk, education and training, and research and development. Readers will also find a discussion on the external influences that shape the environment in which the modern chemical engineer must operate.

Some key conclusions are reached and set out in the form of eight areas of action for IChemE's leadership and staff team to pursue. These actions span the four challenge areas along with the fundamental issues and the externalities. Broad in scope, the actions will guide policy development and work programmes in the years ahead.

Over the course of modern history, chemical engineering has never stood still and chemical engineers are not noted for inaction. This proactive, problem-solving approach will continue in the future. Given the scale of the challenges facing humanity, IChemE clearly recognises that doing nothing is not an option. ▮

Source: IChemE

SUDOKU NO. 103

Complete the grid so that every row across, every column down and every 3x3 box is filled with the numbers 1 to 9. That's all there is to it! No mathematics are involved. The grid has numbers, but nothing has to add up to anything else. You solve the puzzle with reasoning and logic. For an introduction to Sudoku see http://en.wikipedia.org/wiki/Sudoku

	9				1			
		2				4		
				3		2	6	
	4							
	6	3				7		
	1		3	2				6
		5		4	6		7	
						8		2
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Solution for SUDOKU 102

2	6	3	4	5	7	9	8	1
1	4	7	9	2	8	6	5	3
5	8	9	6	3	1	7	4	2
7	5	8	1	4	3	2	9	6
6	9	1	5	8	2	3	7	4
3	2	4	7	6	9	5	1	8
4	1	5	2	9	6	8	3	7
8	7	2	3	1	5	4	6	9
9	3	6	8	7	4	1	2	5

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FLEXICON™ Manual Dumping Stations allow dust-free dumping of bulk material from bags and other containers. Automatic reverse-pulse filter cleaning allows continuous, efficient operation. Available with integral bag compactors for total dust containment.

UNLOAD

BULK-OUT™ Bulk Bag Dischargers unload free- and non-free-flowing solids from bulk bags automatically. Allows untying, discharging, retying and collapsing of bulk bags—all dust-free. Available with weigh batching controls.

USDA ACCEPTED

CONDITION

BLOCK-BUSTER™ Bulk Bag Conditioners loosen materials that have solidified during storage and shipment. Variable height turntable positions bag for hydraulic rams with contoured conditioning plates to press bag on all sides at all heights.

FILL

SWING-DOWN™, REAR-POST and TWIN-CENTREPOST™ Bulk Bag Fillers can fill one bulk bag per week or 20 per hour at the lowest cost per bag. Numerous performance options. Available to industrial or sanitary standards.

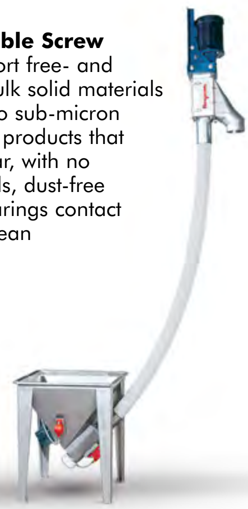
USDA ACCEPTED

CONVEY

FLEXICON™ Flexible Screw Conveyors transport free- and non-free-flowing bulk solid materials from large pellets to sub-micron powders, including products that pack, cake or smear, with no separation of blends, dust-free at low cost. No bearings contact material. Easy to clean quickly, thoroughly.

USDA ACCEPTED

3-A CERTIFIED



CONVEY

PNEUMATI-CON™ Pneumatic Conveying Systems move a broad range of bulk materials over short or long distances, between single or multiple inlet and discharge points in low to high capacities. Available as dilute-phase vacuum or positive pressure systems, fully integrated with your process.

TIP

TIP-TITE™ Container Tippers dump bulk material from drums (shown), boxes or other containers into vessels up to 3 metres high. Dust-tight (shown) or open chute models improve efficiency and safety of an age-old task.

SUCCEED

The FLEXICON™ Lifetime Performance Guarantee* assures you of a successful result, whether you purchase one piece of equipment or an engineered, automated plant-wide system. From initial testing in large-scale laboratories, to single-source project management, to after-sale support by a worldwide network of factory experts, you can trust your process—and your reputation—to Flexicon.

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*See full guarantee for details.

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