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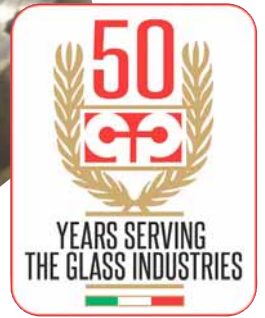
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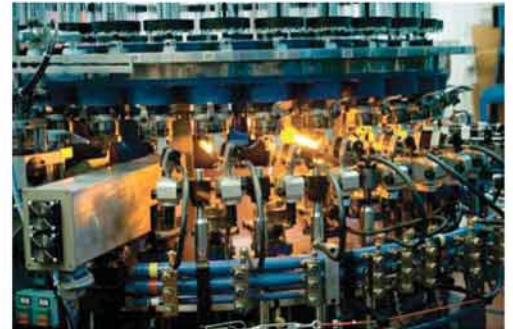
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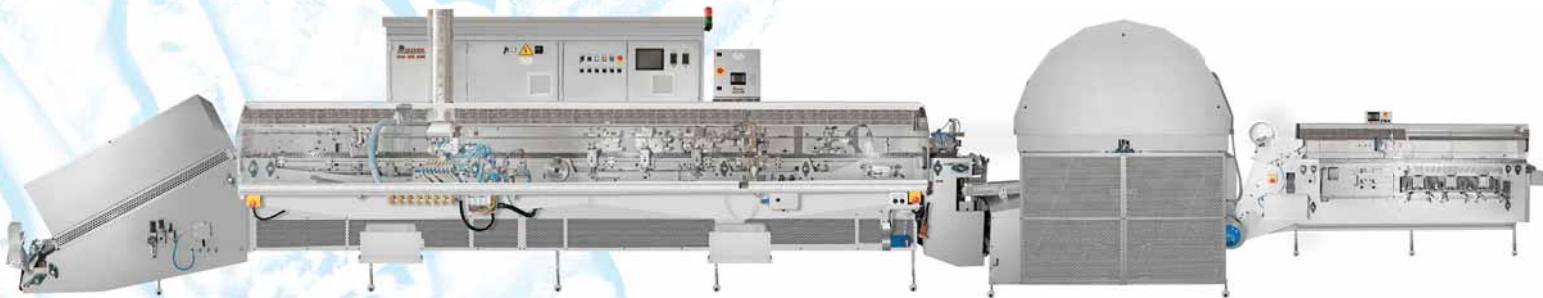
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LATTIMER

IMPORTANT MACHINERY INVESTMENTS

UK precision machinist **Lattimer** is targeting growth in the global glass container manufacturing industry after investing more than GBP 1million in new machinery.

The Southport manufacturer, which has a twin facility in Vineland, New Jersey, US, has recharged its Southport factory, with new machinery and a series of upgrades to existing equipment. According to Lattimer managing director Mark Hailwood, the business, which makes more than 20,000 component parts – primarily for the global glass container manufacturing industry – is looking to make further investments throughout 2014.

The company said it will be promoting its super-charged operation to target customers worldwide including factory operators and OEMs (original equipment manufacturers) for the glass container industry.

New additions to the factory floor include milling, turning, grinding and mill-turning machines. “We work in an industry which constantly demands new and innovative engineering solutions,” said Hailwood. “This investment of more than GBP 1 million will expand Lattimer’s capacity to produce an even greater range of products to help customers drive perfor-

mance and slash costs. “Lattimer supplies to manufacturers working on a massive scale, with machines operating 24 hours, seven days a week. Machine failure, of even a short period, can cost tens of thousands of pounds in lost production.”

The investment comes weeks after the Southport manufacturer announced strong overseas growth in Southeast Asia, following high profile deals in the Philippines and Indonesia.



BEATSON CLARK US DEBUT AT BREWEXPO AMERICA

Leading UK glass manufacturer **Beatson Clark** will be making its US debut at **BrewExpo America**, the largest brewing trade show in the United States, at the Colorado Convention Center in Denver on 9 and 10 April.

Beatson Clark, which produces high-quality bottles for a number of major UK breweries including Samuel Smiths, the Meantime Brewing Company and Thornbridge, will be exhibiting its unique range of bespoke bottles in a bid to win more brewing clients in the United States.

In 2013, Beatson Clark teamed up with the award-winning Brooklyn Brewery in New York to produce premium bespoke bottles for its collection of beers. “The American craft beer sector is a very crowded marketplace and it’s essential that brands have stand-out appeal on shelf,” said Lynn Sidebottom, Sales and Marketing Director at Beatson Clark. BrewExpo America, in association with the Craft Brewers Conference, is presented by the Brewers Association. It is the only event that serves both packaging breweries and brewpubs.

The event is the leading trade show for craft brewers and exhibitors to build business relationships. This year it is expected to attract over 7,000 visitors.

SERBIAN GLASS

INAUGURATION OF NEW FURNACE



Serbian Glass Factory has opened a new EUR 20 million furnace for the production of glass containers in all colours.

The company’s L5 production line has a capacity of 230 tonnes/day and was opened by Serbian President Tomislav Nikolic and Cvetan Vasilev, President of the Supervisory Board and majority shareholder of Corporate Commercial Bank’ Sofia.

The nominal capacity of the L5 furnace, including the four production lines, allows for the production of 180 million bottles and jars per year.

It brings the total amount invested in the site by majority shareholder - the international consortium of the ‘Glas Industry’ – to exceed EUR 105 million over the past 20 months.

For construction of the furnace and relevant production lines, refractory materials, machines and equipment were supplied by companies including Sorg, RHI, MSK and *Bucher Emhart Glass*.

Work on the site included additional civil engineering and architectural works and a transport bridge and elevator for the transportation of finished goods to the 6,000 sq.m. warehouse.

This provides direct transport of finished goods from the production lines to the warehouse through an enclosed area, protecting finished goods from the weather.



KEY SALES AND MARKETING APPOINTMENTS

Two recent appointments at **IRIS Inspection Machines** will contribute positively to the company's continued business growth and development plans. The inspection solutions specialist has named two more multi-lingual sales and marketing experts, who will help IRIS maximize global customer service.

Eloy Garza joins as Sales Area Manager for North and Latin America, Portugal, Spain and Italy.

Fluent in Spanish, Italian, French and English, he studied engineering in Mexico and has worked in Chicago, Edmonton, Lugano, Barcelona and Turin. With more than 10 years' experience in the industry, Eloy's primary role is to reinforce existing business relationships and establish new ones.

Géraud Picard d'Estelan is responsible for marketing and communications at IRIS, supporting the international sales team. Géraud speaks French,

IRIS

English and German and has recently completed his first successful project of benchmarking industrial equipment.

A subsidiary of the Wisetec Group, IRIS Inspection Machines was established to provide turnkey inspection solutions for mass-produced glass containers of any shape or colour, including wine, beer, liquor and Champagne bottles, pharmaceuticals and food containers. A team of dedicated Research and Development engineers has evolved a range of equipment to match the industry's demanding requirements and satisfy the inspection needs of key

international customers. The company has based its development on a long-term partnership with glassmakers in the field of glass defects detection, as well as on an exceptional knowhow in the most innovative vision technologies. The success of IRIS is due not only to the exceptional efficiency of its Evolution machines range but also to the excellent support provided by engineers worldwide. Thanks to a network of international agents and technical support service centres, IRIS is able to support customers throughout Asia, Europe, the Americas, Africa and Australia.



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INTERFA- CE BETWE- EN SYRINGE AND DEVICE

The development of autoinjectors generally involves the integration of a pre-filled glass syringe into a plastic drug delivery device – a major challenge due to the different tolerances of both materials.

Gerresheimer has now filed a patent application for its *Gx G-Fix* standard adapter for precise and reliable positioning of syringes and needle shields. Drug delivery devices play an increasingly important role in the market for pharmaceutical products. A rising number of patients suffering from chronic diseases such as rheumatism, arthritis or Parkinson inject their drug themselves with the help of autoinjectors. Self-administering drugs in this way obviates the need for regular visits to the doctor, is more comfortable, and relieves the health care sector. Most autoinjectors contain two main modules: the injector itself and the pre-filled syringe. Both modules are



combined in one assembly, which is specified by the pharmaceutical company and supplied to the market in one piece. This approach is important as medical technology products are subject to high quality standards and must be reliable. In practice, however, the production of autoinjectors has to deal with the tolerance requirements of two entirely different materials: the device is made of plastic while the pre-filled syringe is made of glass. Gerresheimer, a leading international partner of the pharmaceutical and healthcare industry developed a solution that allows an easy integration of syringes in drug delivery devices and has now applied for a patent. “Gerresheimer’s Plastics & Devices Division is the expert for glass and polymer products,” Andreas Schütte, Member of the Board of Gerresheimer and Head of the company’s Plastics & Devices Division explains. “When we developed Gx G-Fix, we pooled our comprehensive intelligence in the area of pre-filled glass syringes and polymer-based drug delivery devices and created an interface that works without complex two-component injection molded parts or sophisticated assembly processes.” Attached to the syringe shoulder, the plastic standard adapter provides a precisely defined interface to the device.

In the auto injector,

Gx G-Fix has several functions. First, the adapter connects the syringe with the device. Before, the high dimensional tolerance of the glass syringe allows only marginal control of the injection needle’s position in the front opening of the autoinjector. As Gx G-Fix is specifically adapted to the autoinjector, it allows accurate needle positioning and significantly higher control of the injection process.

Second, the syringe is well protected from breaking. Conventional products coupled the syringe with the finger flange. When triggered, the structurally sensitive flange is subjected to a lot of pressure and can easily break. With Gx G-Fix, however, attaching the syringe at the sturdier shoulder has minimized the risk of breakage substantially. Moreover, Gx G-Fix allows a precisely defined distance to the rigid needle shield (RNS). As most autoinjectors are equipped with long 1ml syringes, tolerances often result in a repositioning of the RNS either towards the front or towards the rear, which means that RNS removal requires autoinjector caps with a complex design. This problem can be solved by using a variation of the adapter that connects with the RNS. With a clearly defined position, RNS removal no longer requires a specific design of the injector cap.

The Gx G-Fix is assembled as part of the ready-to-fill syringe processing

at the syringe manufacturer’s facility. Device integration and RNS positioning with Gx G-Fix can be used individually or in combination. Plastic syringes can also be easily fitted with the adapter. Autoinjectors with Gx G-Fix are therefore suitable for plastic and glass syringes and can therefore be used for a variety of drugs. This does not require any changes to the customer’s filling station. Gx® is a registered trademark of the Gerresheimer Group. G-Fix™ is a trademark of Gerresheimer.

STRONG RE- SULTS FOR FINANCIAL YEAR 2013

Gerresheimer brought financial year 2013 to a successful close. “2013 was a rewarding year for us. We met all the targets we set ourselves. At the beginning of financial year 2014, we sharpened our organization’s customer focus. We are investing in highly promising growth projects, further improvements in quality and the internationalization of our business. These are important steps in setting the course for our future,” said Uwe Röhrhoff, Chief Executive Officer of Gerresheimer AG. Gerresheimer increased revenues in financial year 2013 (1 December 2012 to 30 November 2013) by 3.8% to EUR 1,265.9 million. At constant exchange rates, this corresponds to growth of 5.8%. Business with the pharma industry once more showed strong





growth and broad cyclical resilience. Revenue gains were likewise generated with cosmetics packaging. Sales volumes were solely down in the area of laboratory glassware due to weak market demand in North America. Gerresheimer generates some 83% of revenues with products for the pharma and healthcare industry. The company increased adjusted EBITDA by 4.1% in financial year 2013 to EUR 249.8 million. At constant exchange rates and including EUR 7.5 million in other operating income, this corresponds to EBITDA of EUR 254.0 million. The adjusted EBITDA margin came to 19.7%, as in the prior year. Net income went up by 0.3% to EUR 68.5 million. Adjusted net income climbed 17.2% to EUR 103.5 million. Earnings per share stayed at EUR 1.98. Adjusted earnings per share amounted to EUR 3.08, an increase of 17.6%.

Gerresheimer's capital expenditure in financial year 2013 was EUR 119.1 million (2012: EUR 118.9 million). The company is notably further expanding production capacity for drug delivery systems such as prefillable glass syringes, insulin pens and asthma inhalers. A second focus is on growth in emerging markets.

In December 2012, Gerresheimer took over Triveni in India, a leading maker of plastic pharmaceutical packaging products. The third focus of capital expenditure is on further improving product

and production process quality.

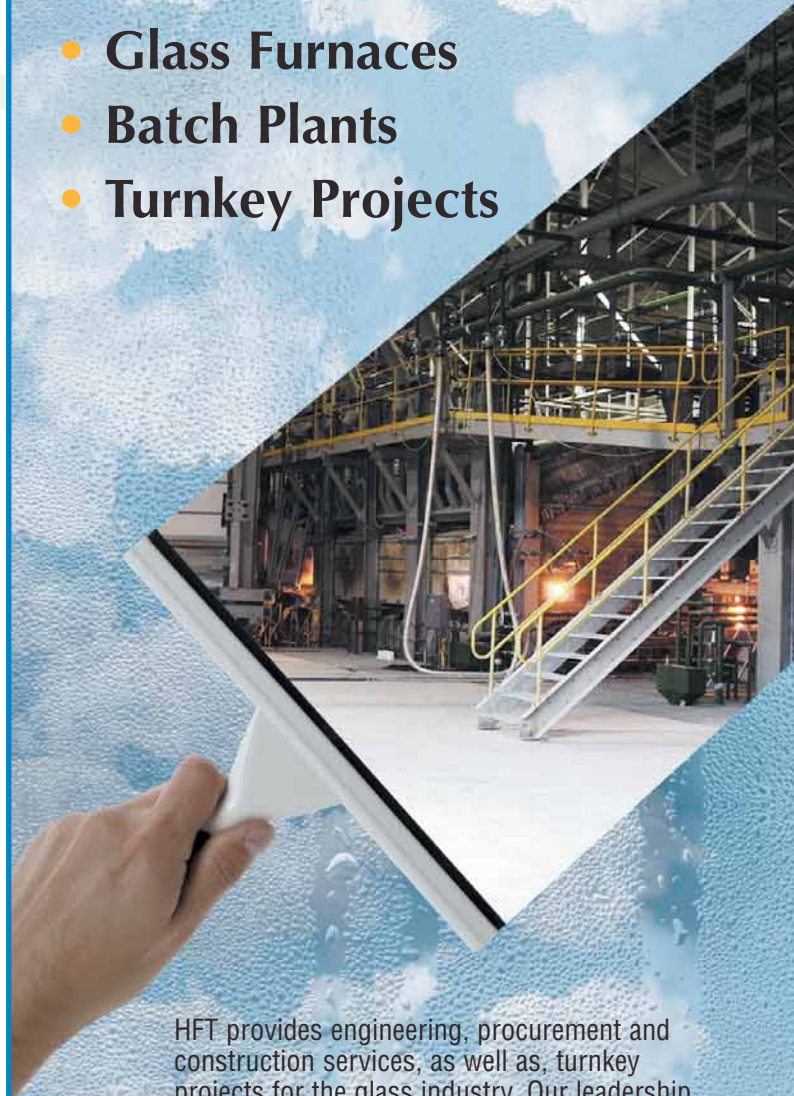
The company currently anticipates revenue growth of 4% to 6% at constant exchange rates for financial year 2014. Adjusted EBITDA at constant exchange rates is expected to be between EUR 250 million and EUR 265 million. Capital expenditure in financial year 2014 will be on a par with the past financial year, meaning around 9% to 10% of revenues.

"Our ongoing high level of investment in capacity expansion, new products, continuous quality improvement and production locations in emerging markets is the key to our success. 2014 is going to be a highly promising and interesting year for us in which we are aiming at further organic growth. Customer demand for our reliable, high-quality pharmaceutical packaging products and drug delivery systems continues to grow. We will once again make selective additions in 2014 in the USA, India, China and Europe, and we have already launched projects to that end," said Uwe Röhrhoff.

At the Annual General Meeting on April 30, 2014, the Management Board and Supervisory Board of Gerresheimer AG will be proposing that a dividend of EUR 0.70 per share be paid out for financial year 2013 (prior year: EUR 0.65 per share). This represents a payout ratio of almost 23% of adjusted net income after non-controlling interests.

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COKE BOTTLE WEIGHT REDUCED BELOW THE 200G MARK

Ardagh has cut the weight of a 330ml Coca Cola bottle to below the 200g level for the first time. The new 190g bottle is the result of a series of improvements, which have seen the 330ml version of the contour bottle reduced in weight from 240g in 2005 to its current weight.

During the process, Ardagh was able to retain all the bottle's trademark dimensions, and maintain quality and strength while improving environmental performance. The lightweighting project also involves 330ml Sprite and Fanta bottles, in addition to the smaller sized 200ml Coca Cola bottle, which is sometimes referred to as the 'mixer' bottle. The 200ml container has had its weight reduced in three stages during the same timeframe, from 170g in 2002 to its current weight of 140g.

Carsten Berkau, Design Manager for Glass Europe at Ardagh Group, stated: "Lightweighting is an ongoing process through well-established design and manufacturing techniques. "Our task is to keep the brand shape, while determining the stress points and the optimum weight of a glass bottle. State of the art technology ensures that when we are challenged, we can respond with even greater precision."

Ardagh is also working

with Coca Cola on other sustainability projects with a view to reducing energy and CO2 emissions. The installation of heat exchangers in a pilot project at Ardagh's Dongen glass plant in the Netherlands transfers recovered energy in the form of hot water from the glass plant to Coca Cola's nearby bottling plant.

TRIPLE SUCCESS IN WORLDSTAR AWARDS

The announcement of the 2013/14 Worldstar Awards has marked an outstanding start to the New Year for Ardagh Group and the teams who produced three of the winners – Absolut Unique, Nemo and Ringo – which all received international recognition by the World Packaging Organisation.

Absolut Unique has gained worldwide acclaim as a daring concept to create nearly four million uniquely designed and decorated stunning special edition glass bottles for one of the world's leading vodka brands. The Nemo can for Bonduelle has been described as "a real game changer in metal packaging", representing the future of food packaging. RinGo® with its ring free construction and 20% material reduction offers real sustainability benefits to the paints and coatings market and improved ease of use for the consumer.

The Worldstar Awards are recognised for showcasing

the best of the best in new packaging developments on a global stage. They are selected from those packages which have already won their national competition. All three Ardagh Group packs impressed the expert panel of judges with their originality, attention to detail and functional superiority. "Winning a Worldstar award is a major achievement within the international packaging sector, so gaining three awards in the same year for products from both our glass and metal businesses demonstrates Ardagh's commitment to creating brand building packaging for our customers," says Niall Wall, CEO Ardagh Group.

ACQUISITION OF VERALLIA NORTH AMERICA

Ardagh Group announces that it has priced the following transactions, totaling USD 1.53 billion, to finance the acquisition of **Verallia North America** (VNA) as follows:

- USD 700 million Senior Secured Term Loan B at a coupon

of LIBOR plus 3.00% (together with a 1.00% LIBOR floor, this financing has a current interest cost of 4.00%);

- USD 415 million Senior Unsecured Notes due 2019 at a coupon of 6.25%;
- USD 415 million Senior Unsecured Notes due 2021 at a coupon of 6.75%.

Ardagh is very pleased with the continued support it has received from debt investors and the current financings, at an average cost of 5.4%, will substantially reduce the interest cost of funding the acquisition of VNA, as compared to the original financings priced in January 2013.

Ardagh expects to complete the acquisition of VNA by 30 April 2014. Following completion of the VNA acquisition, Ardagh will operate 101 facilities globally, employing 19,500 staff and reinforce its position as a global leader in packaging solutions, producing metal and glass packaging for most of the world's leading food, beverage and consumer care brands.

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INVENSYS EUROTHERM NOW ALSO SUPPLIES SPECIAL GLASS INDUSTRY THERMOCOUPLES

The extremely high temperatures and challenging atmospheric conditions involved in glass melting, fining and conditioning processes require the application of special thermocouple technology. These thermocouples need to be capable of accurate measurement whilst demonstrating the minimum in temperature drift over time. This long-term

stability is a key factor in a glass manufacturer's ability to control and operate processes to the limits of acceptable glass quality whilst achieving the best in energy efficiency. Furthermore, if thermocouple technology is applied to measure and protect critical areas of the furnace, such as the crown against overheating, it is imperative that these sen-

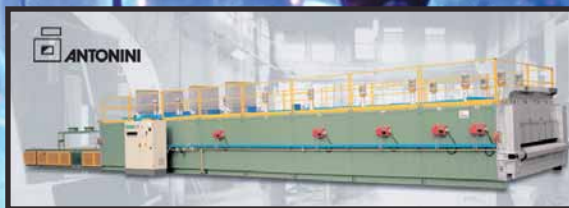
sors are both reliable and robust over long periods of time. **Invensys Eurotherm** designs, supplies, maintains and services a broad range of glass customer specified high temperature thermocouples around the globe.

In fact almost all is possible; thermocouples with single/double and triple type S-R and B element(s), thermo element wire diameters from 0.3 to 0.5mm. Protection thimbles made from pure

Pt (ZGR/ODS/FKS-stabilized), PtRh90/10% and PtRh 80/20 as well as precious metal coating by Pt and PtRh (ACT). Diameter of precious metal thimbles from 6mm up to 12mm or even more. Wall thicknesses starting from 0.2mm. Length and dimension according to customer's needs and demands. Invensys Eurotherm says it can recycle scrap, old Pt-PtRh tubes and thermo-element wires.

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FERRO CORPORATION

CORPORATE GOVERNANCE PLANS ANNOUNCED

Ferro Corporation has announced that its Board of Directors has voted to recommend that shareholders approve the declassification of the Board and other governance practices in furtherance of the company's continuing commitment to serve the long-term interests of all Ferro shareholders. The Board also announced its intention to appoint Peter T. Thomas, the company's President and Chief Executive Officer, to the additional role of Chairman of the Board. At the company's 2014 Annual Meeting, the company will propose a conditional amendment to its Code of Regulations to declassify its Board of Directors and a conditional amendment to its Eleventh Amended Articles of Incorporation to eliminate cumulative voting in the election of directors. If both amendments are approved by Ferro

shareholders, the declassification would be implemented via a phased-in approach. Under this approach, the director nominees of the class standing for election at the 2014 Annual Meeting would be elected to one-year terms and the directors in the two remaining classes would serve out their three-year terms until the 2015 or 2016, as applicable. The amended Code of Regulations would provide that directors elected at and after the 2014 Annual Meeting would serve for one-year terms. Each of the above proposals is conditioned on the approval of the other, and neither proposal will take effect unless shareholders approve both proposals at the 2014 Annual Meeting. The company will also take action to amend its Code of Regulations to eliminate provisions containing voting or participation requirements that

are greater than a simple majority standard. The Board has decided that, at the organizational meeting of the Board of Directors immediately following the 2014 Annual Meeting, the company's President and Chief Executive Officer, Peter T. Thomas, will be appointed to the additional role of Chairman of the Board. In connection, William B. Lawrence has agreed that, if re-elected at the 2014 Annual Meeting, he will step down from his position as Chairman of the Board. Lawrence commented, "Peter Thomas has demonstrated extraordinary leadership and commitment to shareholders since his appointment as Interim President and Chief Executive Officer in November 2012. Those qualities were essential to the Board's decision to name him President and Chief Executive Officer in April 2013 and they underlie the Board's decision to name him Chairman. Peter has led Ferro's execution of the value creation strategy for more than fifteen months and set a clear vision for

the company's future. We look forward to the additional contributions he can make as Chairman of the Board." Thomas said, "I appreciate the expression of confidence in my leadership reflected by the Board's decision. It is a privilege to lead this company and its employees on our mission to bring value to our shareholders. I especially want to thank our Chairman, Bill Lawrence, for his leadership of the Board since November 2012 and his unwavering support of me and our value creation strategy. I look forward to Bill's continued support after I assume the role of Chairman." The Board has also agreed to appoint Gregory E. Hyland as Lead Director and as Chair of the Board's Governance & Nomination Committee. Mr. Hyland has been a member of the Ferro Board since 2009 and a member of the Board's Governance & Nomination Committee since 2010. Hyland is Chairman, President and Chief Executive Officer of Mueller Water Products, Inc.



2014 SIL VERSION OUT NOW

VERTECH'

The 2014 version of SIL has just been released by **Vertech'**, the leading company for software solutions dedicated to the glass manufacturing industry. SIL is a modular system providing the essential tools for controlling the entire production process of a glassmaking factory, from forming machines to the palletizers, including quality controls in the laboratories and now on raw materials as well. Vertech' invests about 25%

of its turnover in the development of new functionality and improvements every year, forward-thinking developments, responding to customers' requirements and adding new inspection machines available on the market to the list of the equipment communicating with the SIL solution. The 2014 version of SIL presents a new dashboard for operators, enabling visibility at a glance of key performance indicators, the management of pallet quality resorting, as well as many improvements focused on communication between the users in production, laboratory, mould shop and elsewhere. Vertech' will present the new version on live demo at 2014 trade fairs including *China Glass*, *Mir Stekla* and *glasstec*.

↓

SUCCESSFUL START-UP FOR SECOND E-MOC MACHINE AT STOELZLE CZESTOCHOWA

BOTTERO

The installation of the second **Bottero E-MOC** - TG 4 1/4 machine in the **Stoelzle** plant of Czestochowa was extremely successful.

Stoelzle Czestochowa has almost three-years' experience with Bottero E-MOC technology, which enables to manufacture articles that were first produced in double gob now in triple gob, at almost the same

cycle speed.

The Polish glassworks, which is part of the prestigious Stoelzle Glass Group based in Austria, is specialized in the production of top of the range liquor bottles, including large quantities of flask bottles suitable for TG production as well as round and non-round larger double-gob containers.

E-MOC technology has

satisfied these requirements thanks to the efficiency of its cooling system which allows high speed productions without affecting quality, particularly when it comes to flat panels. The 360° cooling potential of the E-MOC is the base for high quality production at speeds considerably higher than those of a traditional machine manufacturing the same

container, and in general the resulting quality is higher.

With the strength of three years experience, when the decision was made to add a fifth production line to the furnace built in 2011, Stoelzle Czestochowa had no hesitation: it had to be another Bottero E-MOC machine. With over 500 sections installed all over the world, the E-MOC is proving to be the winning choice project after project, where high speed, high efficiency and high quality are the essential requirements to be competitive on the market.

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GOLDEN ANNIVERSARY

golden anniversary

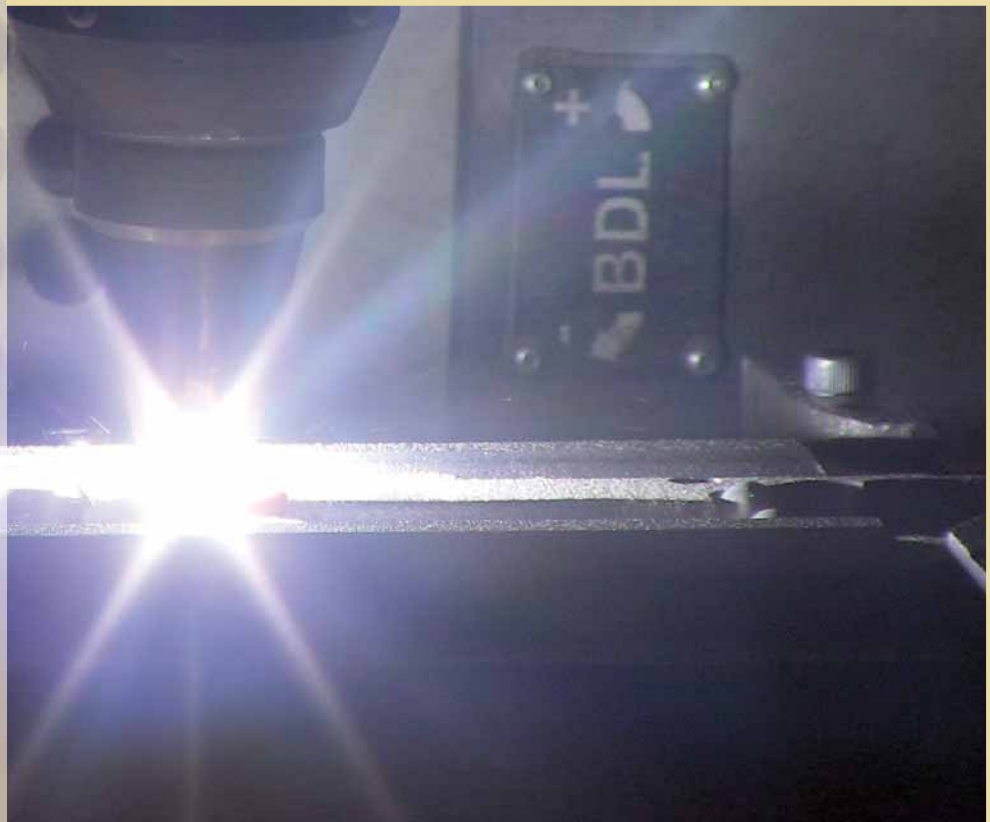


1964-2014

Peregó:

50 YEARS OF EXPERIENCE IN HIGH- QUALITY MOULD MANUFACTURE

During a recent visit to Perego, one of Italy's 'Master' mould manufacturers, we had the chance to speak to Giancarlo and Leonardo Perego, who spoke to us about the recent and important developments and investments this company is undergoing in this important 50th anniversary.



THE ORIGINS OF THE COMPANY

Leonardo Perego:

In the 1960s, when my father set the company up, and having a glassmaking background (he worked at Ivisc – Industria Vetraria San Cristoforo – now known as Bormioli, for 17 years, where he was involved in the design and creation of moulds), he created his own company.

Giancarlo Perego told us as that time all glassworks had their own in-house workshop to create and take care of the moulds. "When I started in my own company I was the person who bought the cast iron as well as designing the moulds."

And then in 1964, Perego started up in a very small workshop. In

GOLDEN ANNIVERSARY

golden anniversary





1967, the first part of the premises where we are now were being built. And in 1968 the company moved here to Via Marchesina, just outside Milan. At that time there were 12-13 people working for the company. All these people working for us at that time (14-18 years old) worked for us until they retired! And some of their sons and daughters are working for us now.

And Giancarlo Perego highlighted the fact that, as he said: "I could not have done anything without these people."

In 1978, we literally doubled the size of the premises here in 1978, and then in 2000 we opened the new premises next to these, and in we inaugurated the company in Croatia, and this year, in 2014, we are inaugurating our new premises. These new premises have been built on the area of the old premises (which we pulled down), and they are ready to move into.

Glass Machinery Plants & Accessories (GMP&A):

Did you stop production while the old buildings were being pulled down?

Leonardo:

No. Because the new workshop has been built 'around' the old building. So this means that we pulled the old building down only when the new one was ready.

The new building also includes offices and in the future we will decide which part of our office department to move there – probably connected to production. But in reality, we are not speaking about transferring or moving but just 'completed'. This means that nothing is taken away from Italy, but is added to the other part.

GMP&A:

Is this because there is higher demand from other countries?

Leonardo:

Not really. It is because Italy is slowly becoming more and more compressed. We now have 80 employees and we will soon be less, due to retirement and so on. So we have decided to move everything that is 'new' to the new building.

Giancarlo:

However, we still have an excess of employees due to the level of technology that we use.



TECHNOLOGY, PERSONNEL AND EXPANSION

GMP&A:

Let's take a look at the technology level used and how it has developed in the workshop.

Leonardo:

I can give you some figures: 2010 – 97 employees, about 2,500 moulds. 2013 – 82 employees, about (more than) 4,000 moulds. All made here in Milan with the new technology that we have installed.

In these three years, 15 people have left the company (mostly from production) and, at the same time, the company decided to invest in technology, spending 2-3 million Euro and increasing its production by 80 per cent. In the six-month period from March to September 2013, we actually had record figure in terms of production. We are now slowing down investments because the market (in Italy) – with regards to costs – does not guarantee payback on these investments.

The company now employs 82 people in Italy and about 40 people at its international unit in Croatia. This independent company was

set up in 2001, when Perego took over an existing company, and the share capital of the company is owned entirely by Giancarlo Perego Spa here in Milan.

We now have high hopes for Croatia. Our unit there was set up as a company dedicated to mould accessories. And we would like to point out that it does not depend in any way on sub-contractors – it is highly independent, with the majority of production processes carried out either in-house or controlled directly by us.

GMP&A:

How would you define the croatian unit?

Leonardo:

The correct definition of the company is that it is a production unit. We order the raw materials and send them to Croatia, they make the accessories, which then return to us here, and we send them out to the clients as per the orders that are received by the company in Croatia.

And we must underline here that the production in Croatia is not intended to substitute the production here in Italy, it is in

addition to it to make the company more competitive in the newer and emerging market areas.

GOING BACK TO MOULD MAKING

Leonardo:

And the news of this year is that as of 2014 the company in Croatia will be manufacturing moulds in addition to accessories. We expect to have the unit up and running, and production started by spring this year. We must say, however, that the company was already involved in mould manufacturing but when we took it over we converted it to the production of accessories. This means that we don't need to 'teach' the people working there to make moulds, but just to 'update' their know-how.

And all this is also thanks to the two smaller shareholders of the company (with a 17 per cent share), two brothers of the Spiljak family, whose father was the original owner of the company and friend of Giancarlo Perego. They are, in fact, enabling the company to run really well thanks to their will and interest in what they do.



So the new building over there is now ready and waiting for the machinery to be installed. And if we may say so, it is a really state-of-the-art building and workplace, with all the 'mod cons' that today's workplaces have.

This will enable us to enter the markets that at present, with production costs here in Italy, we cannot work with. Croatia has lower costs than Italy, not only with regards to labour costs, but also everything else connected, such as electricity, tax, and, of course, the fact that it is closer to the countries and markets we want to start working with. And working in Croatia also provides a series of benefits, such as reimbursements of parts of investments and tax deductions and rebates of course.

GMP&A:

Does this mean that Perego will increase its turnover or have these investments been made purely to 'stay alive' in this market?

Giancarlo:

Today we can surely say that the investments made here in

Italy and in Croatia have certainly been made to enable the company to stay active but also to increase its turnover, as well as to continue our positive outlook for the future. We must also be ready to work with each and every market and follow the developments of these markets. This means expansion and larger market areas to work with. In fact, we do not need to go and look for new clients as we are already receiving contacts and requests from a lot of companies in those areas and, in order to satisfy these requests at acceptable prices for these lower-priced markets, we are starting to make moulds in Croatia too.

Leonardo:

This means that we are celebrating our 50th anniversary in the best way possible with these new developments and, of course, with great pride in the achievements we have made in these years.

And these investments made by the company are also satisfying and comforting for our employees who see that even if this crisis period we are still investing and

growing – both in technologies and in production volumes.

The important advantage that Perego gains from these investments is that the company is entirely independent with regards to the entire production process of its moulds and accessories – everything is done in-house. This includes metallization (90 per cent), thermal treatment, polishing.

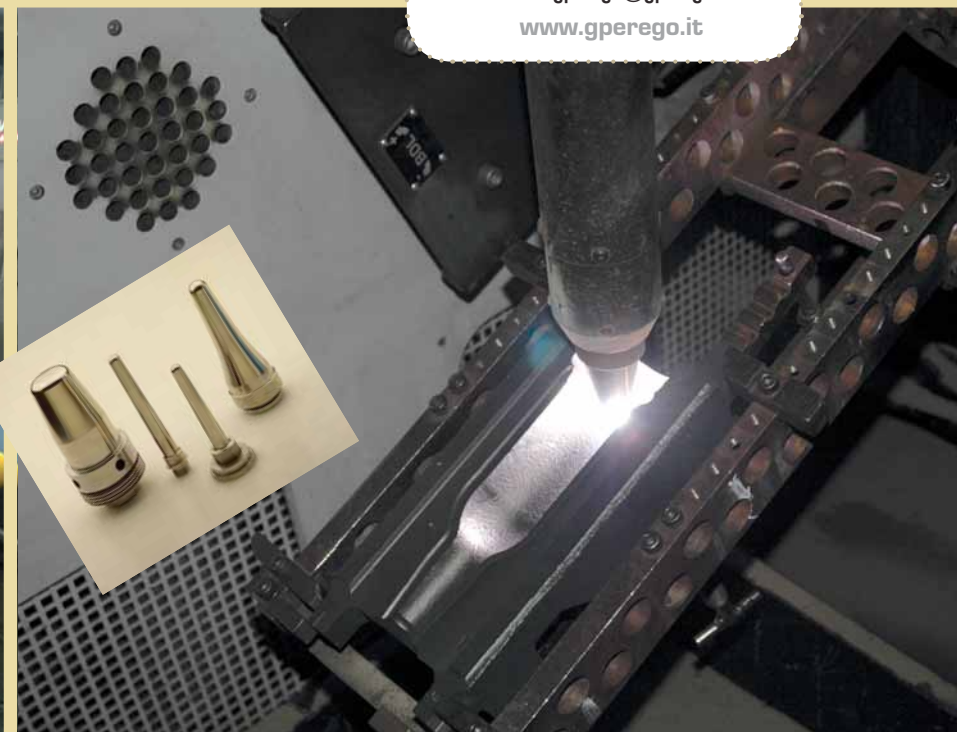
And even if today's markets are requesting more and more low-cost moulds, we at Perego are still working to manufacture the highest quality products using all our experience. ■



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Vertech' PROPOSES ITS PLANT PERFORMANCE MANAGEMENT SOLUTION



In this article, Philippe Bierry and Ulas Topal from Vertech', the French specialist for production monitoring systems dedicated to the glass container industry, explain the long term evolution of the SIL system.

The 2014 SIL version has just been released by Vertech', the French specialist for production monitoring systems dedicated to the glass container industry.

"The new functionalities and improvements will delight our customers," says Ulas Topal, Sales Director at Vertech', "as major evolutions are developed in close relation with our customers to respond to their requirements and projects."

"We invest about 25 per cent of our turnover in developments every year," confirms Jonathan Souillot, in charge of R&D.

"Last year, the major evolution available for operators was the picture of the defects rejected by inspection machines and the solution dedicated to the mould shop. In the 2014 SIL version, a new dashboard displays an 'at a glance' view of main key performance indicators and offers direct access to detailed information. The new release proposes many improvements focused on communications between the users, as standard of reaction sent from the lab to operators in production, or information about events sent directly on the LED dis-

plays for operators on line."

A SUCCESS STORY

The company was born in 1995 thanks to a simple idea: from highly specialized software created in Saint-Gobain laboratories, the goal was to develop the specific market of production monitoring worldwide.

The SIL (standing for System of Information on Line) first dedicated to counting articles, quickly evolved to a complete monitoring system connected to all inspection equipment, on line or in the lab, from the IS machine to the palletizers.



The Vertech' team

During Vertech's first years, Philippe Bierry, General Manager, surrounded himself with highly qualified engineers, for most of them still working in the company today. "Our staff is the main asset of the company. Engineers and project managers working in Vertech' have a double expertise in software development and glass manufacturing practice. They perform developments, make the installations on site and train the users in the plant. They all speak two or three languages."

After a few years of expansion, the SIL system was installed in France, Italy, Germany and the United States. Eighteen years later, glass plants in Asia, India, Russia, Central and South America and Africa are supplied with the SIL solution. With more than 500 lines equipped worldwide, Vertech' has gained expertise in glass production, a high knowledge of the standard practices in glass plants, and experience in customer-tailored software applications.

IMPORTANT EXPANSION

In the last three years, Vertech' has taken to a new step as several engineers and a new salesman dedicated to Europe have joined the company. To face development, Philippe Bierry decided to invest in a new building on the industrial campus of Chalon-sur-Saone, allowing to welcome customers and propose training sessions in a more adapted and pleasant environment. That is the reason why 2013 was such a busy year for the company, when it moved to these new prem-

PRODUCTION SOFTWARE

SIL solution, for each and every process of the production chain

ises and renewed its professional image.

Vertech' now employs 33 people, divided in four different locations worldwide: in addition to the French head office, an office was created in 2000 in Turin, Italy - now managed by Andrea Borgno with two engineers for support – dedicated to the Italian market, with long term customers always volunteers for pilot projects. A subsidiary was also set up in Fisher, Indiana, United States, in 2005 by Benoit Delacourt, for the US market. It is now managed by Fabio Castro, who is also in charge of South America, with an engineer for support.

Last year, a fourth office was opened in Mexico by Ludovic Dugenest, for the Mexican market and on-site support in America. Offices and subsidiary are essential to our local customers for a close follow up, availability of sales and technical staff, they also have a stock of spare parts in case of hardware emergency.

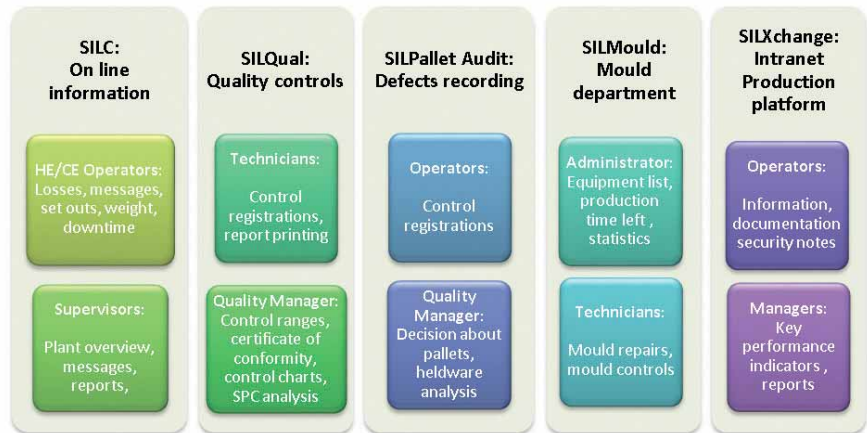
A team of agents are also expanding customer service and creating close relationships with long-distance customers. In China, Techimport has been a great support for Vertech over the last few years for creating relationships and fulfilling the needs of the Chinese market.

More recently, Sigmatrade (Iran) and Glatec (South Korea) have signed with Vertech for their experience in the glass industry.

A SOLUTION TO GLASSMAKERS' REQUESTS

What makes the success of SIL solution worldwide?

Production management software is dedicated to increasing plant performances. Benefits



generated are exponential compared to the cost of the solution itself. The introduction of a MES (Manufacturing Execution System) in a glass plant is the ultimate step between production equipment level and the general management level. It is the corner stone to pilot plant management with secure data and more efficiency. As a matter of fact, the SIL system is often compared to a car dashboard by Philippe Bierry: "A production monitoring system is a tool concentrating all production data and displaying key performance indicators in real time, a management dashboard to pilot the plant. But it is also a reporting tool performing analyses and a quality tool ensuring traceability on several years."

The modular architecture of the SIL and its flexibility enable Vertech' to adapt it to the technical particularities of each plant and to answer precisely to their needs. Information collected from inspection machines and events are stored in the SIL database. The new modules developed over the last few years have made SIL the solution for each and every key process in the production chain, such as: follow-up of performances on production lines, management of quality controls on lines or in the lab – with SPC analysis capabilities – , final product control capabilities and resorting in the plant or at sub contractors,

management of mould set performance, usage, changes, defects or damages, complete production data analysis through a comprehensive reporting tool, intranet production portal providing a personalized and secured access to general plant information as well as performance indicators (KPI) through web technology...

"Technical evolutions are essential to our solution; we have, however, placed even greater emphasis on customer service in the last few years," Philippe Bierry says.

CUSTOMER SERVICES

Vertech' has, over the years, developed a comprehensive range of services, such as IT consultancy, automation to quality procedure, commissioning of installation projects, training for Managers and Operators on site, offering complete turnkey installations if necessary.

SIL solution has been translated into 14 languages, technical documentation is available and maintained in English, French, German, Spanish, Italian, Russian, Chinese, and now in Turkish.

Customer support and maintenance of the system

Since Ulas Topal joined Vertech' in 2010, maintenance contracts have been added to global service offer and are now a standard reference for Vertech's customers.

Maintenance consists in an annual subscription allowing upgrade of the system when the plant decides it, annually or when a new piece of inspection equipment is installed in the plant and requires connection to the SIL system.

Technical support is managed by Julien Reynaud, a very experienced technician with 15 years within the company, supported by a hotline service available 24/7/365 with a dedicated phone number. A remote access connection allows our team to make diagnosis and assist users in very short periods of time.

Additionally, an annual audit of the system is proposed to the plant to check the performance of the system and refresh training when necessary.

VERTECH' COMMITMENTS AND PERSPECTIVES

Quality certification

In 2006, the company committed itself to quality certification in order to organize its own development and structure products and services with one unique goal in mind: customer satisfaction. ISO 9001 certification was obtained and renewed in 2009 and in 2012.

Vertech' has established a process of control and validation of every hardware and software platform prepared in the company to be sent to a plant for installation.

For four years, the software provider has been proposing an annual version of the SIL solution, through an annual catalogue, in order to present a secure and uniform version, providing more visibility of the new functionalities and easier upgrade for glass manufacturer groups who wish to have the same version in each plant.

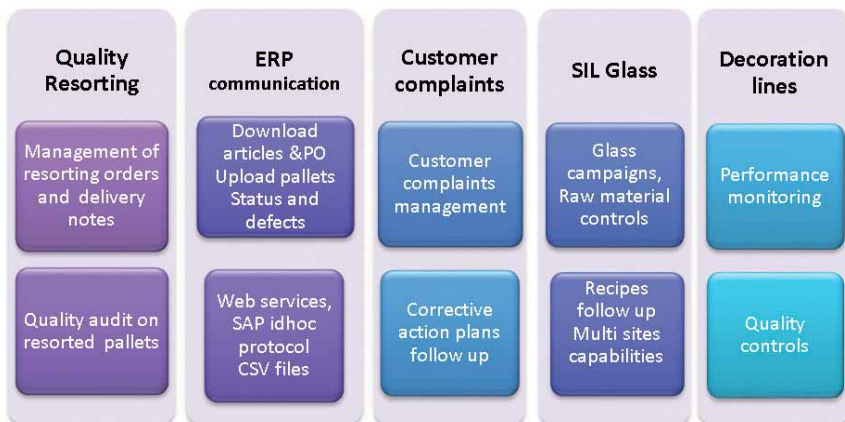
PERSPECTIVES

Most of SIL customers are glass manufacturers from the

food and beverage industry or pharmaceuticals and cosmetics industry, some are in tableware. Currently, the SIL is being adapted to the glass tubes industry, offering new perspectives of development also for production lines of glass containers made out of tubes. New perspectives are also offered inside the container glass plants, out of the traditional field of installation for the SIL (from IS to palletizers): a module is already available for the management of glass components, raw materials and glass campaigns. Moreover, decoration lines were equipped with the SIL recently for the performance monitoring and the management of quality controls. Additionally, the requirements of the manufacturers for connecting external systems or integrating the solution to global ERP systems or even making the SIL their internal intranet platform represent real perspectives for the SIL. ■

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SIL solution: new modules



O-I

CONFIDENCE IN GROWING INDONESIAN AND SOUTHEAST ASIA MARKETS

Owens-Illinois, Inc. (O-I) has announced it is making a significant investment in its Jakarta plant, and introducing an innovative technology called narrow neck press and blow (NNPB), enabling efficient lightweight bottle production.

An existing production line was also recently upgraded to increase speed and capacity, allowing the company to continue to serve Indonesia's leading food, beverage and pharmaceutical brands, as well as the ever-expanding South-east Asia market. O-I Jakarta's President Director, Joseph Haddad, says O-I's investment is a direct result of growing customer demand and the company's confidence in the growth prospects that exist for South-east Asia-based manufacturers. "The Indonesian and Southeast Asian markets represent major opportunities for our Jakarta plant, which has supplied Indonesia's food, beverage and pharmaceutical markets with quality glass containers for the past 40 years, and is set to play an integral role in achieving O-I's growth targets," said Haddad. "O-I's 2013 Asia Pacific volume gains, were driven by strong growth in Southeast Asia, a trend we expect to continue," he

added.

To better align its operations with this predicted growth, O-I Jakarta is currently installing narrow neck press and blow (NNPB) technology, which ensures consistent and precise glass wall thickness, helping to reduce bottle weight whilst maintaining design profiles and glass strength. The lightweight bottle production process is also more sustainable because it uses less glass during production. It also requires fewer raw materials, and results in lower CO2 emissions.

"The advantage of being part of a multi-national business such as ours is that we can access a range of regional and global resources. We have a great deal of expertise in lightweighting containers, and we have colleagues from around the world who are working with our team in Indonesia to equip them with the skills and knowledge they need to successfully manage NNPB production," said Haddad.

O-I's NNPB technology has been used by many of the world's high-profile beverage companies to deliver significant environmental benefits. One example is O-I's award-winning Australian Lean+Green® lightweight wine bottle range, which has been adopted by over 75 Australian wine brands since its launch in 2009.

In addition to its own production, O-I Jakarta



has the ability to access its regional footprint to support further local growth and ensure security of supply.

"Our regional footprint gives us the ability to source glass containers that we don't currently produce locally, and offer our Indonesian customers an extensive product portfolio," said Haddad.

"In addition to providing the latest innovations in glass bottle production, we also offer local customers valuable insights into various markets around the world. We recently hosted a major Indonesian customer in Australia to provide it with a detailed look at the local beverage industry, including a range of perspectives on glass filling set-up, techniques, distribution and marketing," said Haddad. O-I Jakarta also encourages its customers to access additional services to support new product development. For instance, O-I Jakarta works with its regional design team to help customers develop unique glass packaging designs that differentiate their brands. They also ensure that designs are suited to manufacture, and meet customer filling-line and secondary-packaging requirements.

BOARD OF DIRECTORS APPOINTS NEW MEMBER

O-I has appointed Carol

Williams to the O-I Board of Directors. Ms. Williams is a special advisor to the CEO at Dow Chemical Company, a diversified chemical company with revenues in 2012 of USD 56.8 billion. Prior to her current role, which began on 1 January 2014, she served as Dow's executive vice president of manufacturing and engineering, supply chain and environmental, health & safety operations.

During Williams' 34-year history at Dow, she moved through a number of management positions in R&D before becoming operations leader and then vice president for the North American chlor-alkali assets business. She was named senior vice president of basic chemicals in 2009 and president of chemicals & energy in 2010 before assuming her executive vice president role.

Williams, who holds a bachelor's degree in chemical engineering from Carnegie Mellon University in Pittsburgh, Pa., also serves on Dow Chemical's Executive Leadership Committee and Strategy Board.

Williams is also a board member for Atlanta based, Zep Inc., a leading producer of maintenance and cleaning chemical solutions. Her appointment to O-I's Board of Directors is effective 20 February 2014.

VERSAFLOW CARAFE USED BY DUTCH COMPANY

'sLandsBeste is the first





Dutch company to use the *VersaFlow Carafe* for its sauces, a bottle designed by O-I.

VersaFlow Carafes have a pouring spout that allows consumers pouring of liquids in a cleaner, precise and esthetical way. Wyno Vermeulen, co-owner of 'sLandsBeste: "Our products are natural, traditionally-made and of high quality. We deliberately chose a glass container. By using the VersaFlow Carafe, we are also strengthening our brand identity and we can stand out even more distinctively on the shelf." According to O-I, VersaFlow allows for a clean and precise dosage of

liquids directly from the container. No dripping, no rims, no spots, so the container can be used even at distinguished meals without decanting. VersaFlow responds to the growing demand of consumers for functionality and their increased emotional connection with glass packaging. Moreover, for brands it means competitive advantages by being different.

"Brands can develop completely new packaging concepts and have additional options regarding the brand experience," said Steffi Lenz, Innovation Project Manager at O-I.

ASL OYNA

CONSTRUCTION OF NEW GLASSMAKING FURNACE

Asl Oyna open joint stock company, one of the leading producers of glassware in Central Asia, will build its second glass-making furnace at a cost of USD 12.5 million in 2014-2016.

The project will allow it to produce an additional 80 million units of glassware a year.

Asl Oyna OJSC launched production of glassware products for EUR 22 million in October 2009.

Germany's *HEYE International GmbH* supplied equipment to Asl Oyna. The firm will produce 150 tonnes of glass mass a day and 126 million units of finished glassware products a year.

Asl Oyna is able to make various glassware goods from flint and coloured glass.



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CORNING MUSEUM OF GLASS

ACQUISITION OF MONUMENTAL WORK BY LIZA LOU

Continuous Mile (2006-08) is a monumental sculpture composed of 4.5 million, glossy, black glass beads woven onto a mile-long cotton rope that is coiled and stacked. Standing about three feet high and stretching nearly five feet in diameter, the sculpture took Lou two years to make with a team of beadworkers from several townships in KwaZulu-Natal, South Africa. Conceived as a work about work, Continuous Mile is exquisitely made and manifests the social concerns that run throughout the artist's work. "We look forward to inaugurating our new North Wing galleries with Liza Lou's large-scale work," said Karol Wight, executive director of **The Corning Museum of Glass**. "The new galleri-

es will be devoted to the display and interpretation of contemporary art in glass and we look forward to highlighting artists like Liza Lou, who are pushing the boundaries of how glass is used in art today."

"Liza Lou has redefined beading by removing it from a decorative context," said Tina Oldknow, curator of modern glass at The Corning Museum of Glass. "Trained as a painter, Lou used coloured lines of beads like brushstrokes to decorate the surfaces of her early sculptures and installations. In her more recent work, such as Continuous Mile, the bead no longer decorates the surface, but actually creates sculptural form."

Lou creates meticulously beaded works

that reference recurring themes, such as labour, confinement, wonder, and human endurance. Lou emerged as a presence in the art world in 1996 with Kitchen (1991-96), a nearly life-size reproduction of a kitchen entirely covered in beads, which was featured in an exhibition at the New Museum in New York. The work is an over-the-top commentary on women's work, popular culture and nostalgia, complete with a perfectly beaded crumpled bag of potato chips, a spilled soft drink, and a sink full of dishes in water.

Examples of her other work include Security Fence (2005) is a full-scale, silver beaded enclosure of chain-link and razor wire that can neither be entered nor exited. Untitled 10 (2011-2012) is one of a series of monochromatic beaded paintings in the tradition of American minimalist painters such as Agnes Martin, Sol LeWitt, and Robert Ryman.

Awarded a MacArthur "genius grant" in 2002, Lou, who is also based in Los Angeles, opened a second studio in Durban, South Africa in 2005. Working with a team of Zulu women in downtown Durban, Lou has deve-

loped an economically sustainable project, while creating extraordinary artworks that she could not realize on her own. Her works are represented in international museum collections including The Whitney Museum of American Art, New York; The Cleveland Museum of Art, Ohio; The Metropolitan Museum of Art, New York; Fondation Cartier pour l'art contemporain, Paris, France; François Pinault Foundation, Palazzo Grassi, Venice, Italy; Deste Foundation for Contemporary Art, Athens, Greece; La Fundación/ Colección Jumex, Mexico City, Mexico; Fundación Privada Sorigué, Lleida, Spain; and the Honart Museum, Teheran, Iran. The Corning Museum of Glass is currently adding a North Wing, designed by Thomas Phifer, which will open in late 2014. The 100,000-square-foot North Wing addition will include one of the world's largest facilities for glassblowing demonstrations and live glass design sessions and a new 26,000-square-foot contemporary art gallery building. The galleries will feature a simple, white interior with massive curvilinear concrete walls. Continuous Mile will be presented in the open architectural space along with other large-scale works. The building will be the largest space anywhere dedicated to the presentation of contemporary art in glass.



NOT LIKE THE OTHERS IN GLASS



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Libbey Inc. has reported results for the full year and fourth quarter-ended 31 December 2013, presenting its results with an additional reporting segment. The US Sourcing segment includes US sales of sourced ceramic dinnerware, metal tableware, hollowware, and serveware. Libbey will now report financial results for the Americas; Europe, the Middle East and Africa (EMEA); US Sourcing; and Other. The addition of US Sourcing reflects the increasing importance of this segment where sales grew 11.5% during the fourth quarter of 2013 and 8.4% for the full year. Sales for the fourth quarter were USD 221.0 million, compared to USD 219.1 million for the fourth quarter of 2012, an increase of 0.9% (0.1% excluding currency fluctuation).

Gross profit for the fourth quarter was USD 47.7 million, compared to USD 44.6 million for the fourth quarter of 2012, an increase of 7.1%.

Adjusted gross profit for the quarter was USD 53.8 million, compared to USD 45.5 million in the prior-year quarter. A 24.3% adjusted gross profit margin was achieved during the fourth quarter of 2013, compared to 20.8% in the fourth quarter of 2012 and was the highest fourth quarter adjusted gross profit margin percentage since 2000.

The adjusted EBITDA margin was 17.0%, compared to 13.6% in the prior-year fourth quarter. "Fourth quarter revenues

LIBBEY

RESULTS FOR FULL YEAR AND 4Q 2013

were in line with our expectations and, along with the benefits of our much improved cost platform, allowed us to achieve a 25.9% increase in adjusted EBITDA, compared to the fourth quarter of 2012. We remain on track with our longer-term goals, including increasing profitability, increasing cash generation and reducing leverage. Our restructuring initiatives over the last two years have strengthened our cost position considerably, and we are now focused on maintaining the hard won margin increase and profitably growing our business," said Stephanie A. Streeter, chief executive officer of Libbey Inc. Streeter continued, "We look forward to a stronger sales environment in 2014 and the opportunity to better leverage our global capabilities."

Sales in the Americas segment were USD 154.1 million, compared to USD 156.3 million in the fourth quarter of 2012, a decrease of 1.4%. This was comprised of a 1.9% increase in sales in the company's foodservice channel, a decrease of 10.0% in retail and a 9.9% increase in the business-to-business channel. Sales in the EMEA segment increased 8.2% (3.4% excluding currency impact) to USD 38.7 million, compared to USD 35.8 million in the fourth quarter of 2012. Sales in US Sourcing

were USD 19.8 million in the fourth quarter of 2013, compared to USD 17.7 million in the prior-year quarter, as sales of World Tableware and Syracuse China flatware and dinnerware increased 11.5%.

Sales in Other were USD 8.5 million, compared to USD 9.2 million in the prior-year quarter. This decrease was the result of an 8.4% decrease in sales (10.7% excluding currency impact) in the Asia Pacific region.

Earnings before interest and income taxes (EBIT) increased to USD 23.9 million in the fourth quarter of 2013, compared to USD 13.6 million for the fourth quarter of 2012.

Adjusted EBITDA of USD 37.6 million (see Tables 1 and 3) was USD 7.7 million more than the USD 29.9 million reported in the prior-year quarter, an increase of 25.9%. The primary factors contributing to the improvement in adjusted EBITDA from the prior-year quarter include higher capacity utilization, adjusted for the furnace malfunction in Toledo, and lower labour and benefit costs partially offset by increased energy costs and higher direct material costs.

Interest expense decreased by USD 0.9 million to USD 7.7 million, compared to USD 8.6 million in the year-ago period, primarily driven by lower debt.

Libbey's effective tax rate was 42.5% for the quarter-ended 31 December 2013, compared to 67.7% for the quarter-ended December 31, 2012. The effective tax rate was influenced by foreign jurisdictions with differing statutory rates, the impact of tax legislation in certain foreign jurisdictions, accruals related to uncertain tax positions, foreign withholding tax and other activity in jurisdictions with recorded valuation allowances.

Sales for the full year 2013 were USD 818.8 million, compared to USD 825.3 million for 2012, a decrease of 0.8% (1.8% excluding currency fluctuation).

Net income for 2013 grew to USD 28.5 million, compared to net income of USD 7.0 million during the full year 2012. EBIT increased to USD 73.7 million during 2013, compared to USD 50.4 million for 2012.

Adjusted EBITDA was an all-time record USD 134.4 million, compared to USD 132.4 million for the year ending 31 December 2012.

The adjusted EBITDA margin for the full year 2013 grew to 16.4%, which was the highest percentage in a full year since 2002, from 16.0% in 2012.

Sales in the Americas segment were USD 560.8 million, compared to USD 580.7 million in 2012, a decrease of

3.4% (4.0% excluding currency fluctuation). This was comprised of a 0.8% decrease in sales in our foodservice channel, a decrease of 7.7% in retail and a 0.2% increase in the business-to-business channel.

Sales in the EMEA segment increased 8.7% (5.4% excluding currency impact) to USD 146.5 million, compared to USD 134.8 million in 2012.

Sales in US Sourcing were USD 78.3 million in 2013, compared to USD 72.2 million in 2012, an increase of 8.4% in sales of World Tableware and Syracuse China flatware and dinnerware products. Sales in Other were USD 33.2 million, compared to USD 37.5 million in the prior-year period. This decrease was the result of an 11.5% decrease in sales (13.0% excluding currency impact) in the Asia Pacific region.

Interest expense in 2013 decreased by USD 5.7 million to USD 32.0 million, compared to USD 37.7 million in 2012, primarily driven by lower interest rates.

Libbey's effective tax rate was 31.8% for the year-ended 31 December 2013, compared to 45.0% for the year-ended 31 December 2012. The effective tax rate was influenced by foreign jurisdictions with differing statutory rates, the impact of tax legislation in certain foreign jurisdictions, accruals related to uncertain tax positions, foreign withholding tax and other activity in jurisdictions with recorded valuation

allowances.

Libbey continued to strengthen its balance sheet as it realized a net reduction in debt outstanding of USD 10.2 million during the fourth quarter, primarily as the result of debt repayment in China. Libbey reported that it had available capacity of USD 70.5 million under its ABL credit facility as of 31 December 2013, with no loans currently outstanding. The company also had cash on hand of USD 42.2 million at 31 December 2013. As of 31 December 2013, working capital,

defined as inventories and accounts receivable excluding a USD 5.0 million receivable in insurance claims less accounts payable, was USD 173.1 million, compared to USD 172.7 million at 31 December 2012. Working capital remained flat with the prior year, as the result of higher inventories and receivables offset by higher accounts payable. Sherry Buck, chief financial officer, added, "We continued to make progress on our financial goals, as outlined in our Libbey 2015 strategy, in adjusted EBITDA mar-

gins, leverage ratio and Return on Invested Capital (ROIC). We have a strong foundation to further increase our adjusted EBITDA margins in 2014 as we realize the benefits of our North American capacity realignment." Libbey reported that Hard Rock International recently named Libbey as its 2013 Culinary Partner of the Year. This award is presented to the outstanding vendor partner among all of the equipment and supplies, small wares and food companies Hard Rock works with globally.

LUBISOL ENGINEERING

EARLY DETECTION OF HOT SPOTS AND RAT HOLES IN SILICA CROWNS

Rat holes are caused by condensation corrosion in loose joints of silica crowns. Regardless of the improved quality of the silica bricks they are still a problem for the glass industry worldwide.

The experience of **Lubisol** shows that the early detection of hot spots in the crown may help in the early detection of rat holes enabling an easy early hot repair.

Condensation corrosion in the silica crown is a very slow process taking at least 6-12 months before the hot spot is converted into a rat hole. The regular inspection of the crown by measuring the cold face temperatures in different areas of the crown may help for early detection of the hot spots. The recommended inspection period is once per month. The cold face temperatures of silica crowns with standard light silica insulation are usually between 180 and 220°C. In cases when this temperature becomes 250-300°C this may be an early indication for a hot spot formation. By removing the thermal insulation in this area one can make a hot repair by patching the crown with Lubisol S-Seal and this will stop the corrosion process. The action is easy and simple and this may reduce to a great extent the formation and further enlargement of the rat hole.

Lubisol had promoted this simple method among its clients with great success. In all cases the regular monthly inspections and reports have contributed for achieving a long service life of the silica crowns where such inspections have been regularly applied.



SORG AND GLASS SERVICE JOIN FORCES TO PROMOTE ES III



Sorg joins forces with **Glass Service, Inc.** (Czech Republic) to promote the industry standard for advanced model based expert control systems for melters and forehearths. Glass Service is the unrivalled leader in this field with over 15 years of experience with various glass types. Sorg is the recognized leader in supplying furnaces and conditioning systems.

Effective immediately, Sorg will not only act as a reseller of *ES III*™ but also develop projects independently of Glass Service. In other words, Sorg customers will no longer have to work with multiple parties to set up communications between their underlying control system and ES III, but benefit from a convenient one-stop-shop solution instead.

Sorg will place special emphasis on integrating ES III

into the highly successful line of *Sorg 340S* forehearths to give them more of a product characteristic. As a tightly embedded option, ES III will make day-to-day forehearth operations even easier.

On the other hand, Sorg's global sales force and presence will enable Glass Service to expand their installed base even quicker.

Both parties see this as a 'win-win-win' situation offering substantial benefits for Sorg, Glass Service and their customers.

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BOTTLE DECORATION GAINING POPULARITY

DANCO DÉCOR

One of the recent projects of Ukrainian **DanCo Decor** has been the decoration of corporate bottles of vodka. The decoration was made in compliance with the corporate identity of the customer, Danco Company. After applying the chemical frosting technology, the glass became matt and opaque. Then design elements - logo and company name - were screen printed on the bottle. The contrast between the frosted glass and bright ceramic colours creates

an outstanding image and helps to emphasize the unique style of the customer. According to Sergey Danilov, director of DanCo Decor Company, bottle decoration for souvenirs and corporate production is gaining popularity. "Good-looking and high-quality decoration of glass products (bottles, cups, glasses, shot glasses) with the logo and name of the company presents an opportunity to make a name for a company or remind of its goods and services.

This is a useful gift that looks equally good in the office and in an informal

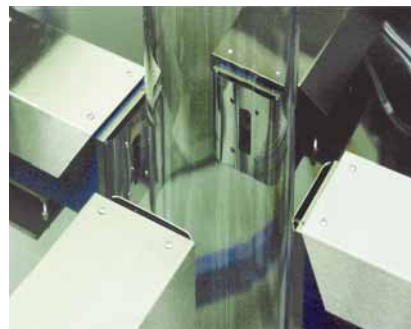
atmosphere, during family gatherings, celebrations and feasts."

ZIPPE OPENS SINGAPORE OFFICE

Zippe has announced that it has opened a new sales and service office in Singapore, managed by Woon Fu Choo, previously of Siemens Singapore. Choo studied Mechanical Engineering, but also has considerable experience thanks to his years at Siemens, in particular in the area of control technology. As the Business Deve-

lopment Director Asia Pacific, he will be cooperating closely with Zippe representatives in the ASEAN Region and will be an important contact person for customers on site, in particular in the area of process automation. Choo speaks English, Mandarin (as well as other Chinese dialects) and Malayan.

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China Glass 2014
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Heye International: HIGH-SPEED PRODUCTION OF HIGH QUALITY CONTAINERS

Heye International gives us its idea on the IS-machine evolution which responds to important requirements. We find out about how this German manufacturer deals with these requirements and with its developments in machinery and technology, all finalized to ensure production and quality, but also the safety of operators involved.



HEYE SPEEDLINE: EVOLUTION IN IS-MACHINES

Heye sees four major requirements in the IS-Machine segment: high safety in every respect, optimum cleanliness and user-friendliness, all this at high quality and speed. Safety and clean design are two factors that belong together, because staff and equipment both need to be protected. Machine downtimes decrease, quality of the products and profit increase. Integrated control features provide permanent information on the state of the equipment. This reduces the number of errors, avoids time-wasting troubleshooting and useless exchange of components.

Last but not least, top quality machines ensure high speed – for many years. Important to mention: Heye focussed on making an evolution – not a revolution – to ensure that plants can still use existing mechanisms and variables.

In the past, the variety of possible options within the machine led to a variety of individually customized solutions. By functional integration the modular concept of the SpeedLine contributes in implementing the most important options in one common structure.

With this background Heye has decided to design a new machine concept to be well prepared for the future. An excellent example of functional integration is the machine bed. It is not only the backbone of the machine; all air distributors and tanks are integrated. That means an optimally prepared bed also for retrofitting Heye Process Control and proportional valves.

Let's have a closer look into the different features and technical solutions, to see how market requirements have been implemented.

Dr. Benedikt Felgenhauer
Manager Machine Technology
HEYE INTERNATIONAL

Wilfried Seidensticker
Product Manager Hot End
HEYE INTERNATIONAL

MACHINERY DEVELOPMENTS

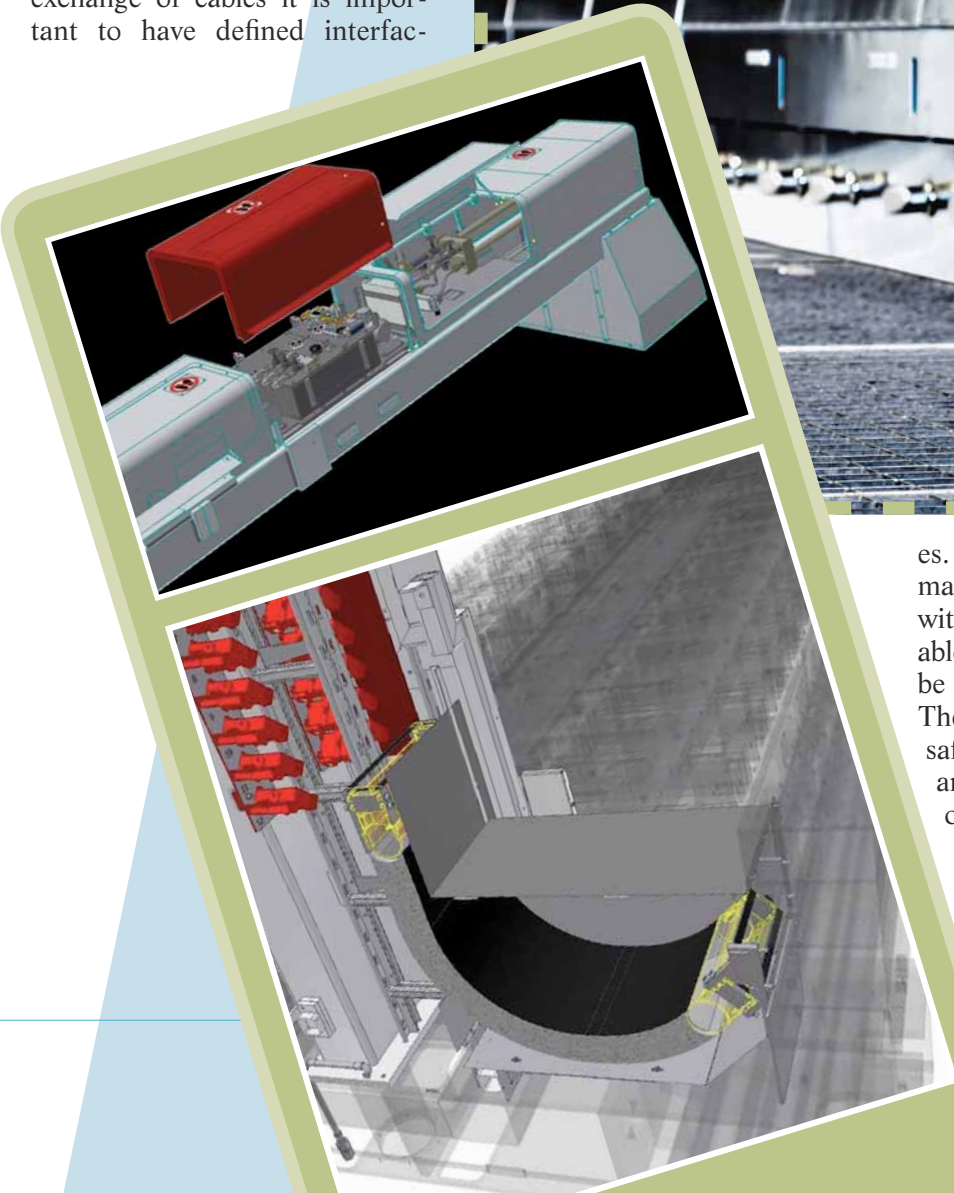
HIGH SAFETY AND USABILITY

Safety and usability come hand-in-hand. Good usability reduces the risk of potentially dangerous human errors. High safety is, for example, a result of the integrated cable channels in the machine bed.

The development of integrated cable ways on the blank and blow mould side is very important for the increasing number of servo- and control electronics. Thus, the cables are protected in an optimum way against mechanical influences and hot glass, and risk of fire is eliminated.

Besides the optimum protection of the cables, the structured cable ways also enable to carry out cabling during the machine assembly phase in the Heye workshop.

For installation at customer premises on site and for a later exchange of cables it is important to have defined interfac-



es. Another feature is that the machine conveyor is equipped with a rail system so that a movable heat protected ladder can be moved along the sections. Thereby, the operator can work safely on the blow mould side and the machine can be kept in operation.

CLEAR INTERFACES

One important interface is the connector board in the uprights for connecting



the servo- and valve block cables. For installation at a later date or a section-wise exchange, Heye has designed cut-outs from the bottom of the cable duct into the cellar. It is therefore possible to lay the cables section-wise into a separate duct underneath the bed.

Defined interfaces for air and water underneath the machine bed allow precise planning of medium supply and quicker installation during commissioning.

USABILITY THROUGH EASY CONTROL OF THE PROCESS

The upright was redesigned due to the increasing amount of servo- and control technology. Furthermore, the development of the housing has been executed in such a way that all components can be accommodated and the streamlined design could be maintained. Besides the integration of various control cabinets, the housing also contains a human machine interface (HMI)

in order to control all important functions and to make settings. This HMI ensures quick access to the most important information. Thanks to the introduction of new monitoring functions the information does not only cover the Heye servo components but also a query and adjustment possibility for operating pressures, optional dead plate monitoring and a central messaging system.

Monitoring of the valves for functions such as final blow is an important step towards process monitoring, preventive maintenance and job safety. The operator is not at risk when accessing difficult areas in order to control the pressure functions. The pressure check can be carried out without losses resulting from switching-off the section. However, monitoring not only involves whether the valve works but also how exactly.

All valves are electrically controlled so that extensive cascade via the valve block is omitted. In its place, the structure contains cable ducts that guide the cables to the upright. The adapter plates are prepared for the use of proportional valves.

CLEAN DESIGN

HACCP is the abbreviation for the Hazard Analysis and Critical Control Points concept and is required by all major fillers. This is a preventive system that ensures both, food and consumer safety. Beside a high quality article, clean design also means that the equipment can be cleaned in an optimal way. This reduces the time needed for repairs and maintenance. Cleanliness increases the lifetime of equipment.

For the new design the individual air distributors of the cross structure were grouped together. Thus, a clear and clean design resulted which is not only easy to clean but also offers the operator

MACHINERY DEVELOPMENTS

a clear view through the entire machine from the blow to the blank side. Process air can be fed directly into the beam via the upright by means of flange plates. This means that external piping is no longer needed.

The streamlined design continues on the blank side. By arranging the injectors above the valve block the air pipes are no longer crossed by the injector rack and its pipework underneath the block. Furthermore, the new injector generation is now arranged compactly in the operator's field of vision. Additionally, rapid interchangeability and exactly pre-adjusted capacity matching with lubrication point size are ensured.

In the machine area, conveyor functions have been integrated on a large scale. Conveyor cooling, cable ways and dead plate cooling are now installed in the conveyor body, whereby the cables are optimally protected and guided the shortest possible way.

For better cleaning and as protection against dirt and heat, the pushers are surrounded by casings, also offering the option of active pusher cooling by the machine conveyor body via the cable channel. By directly positioning the pusher socket at the machine conveyor in front of each section, the pusher can be exchanged very easily as it is possible to remove the plug to uplift the unit with the cable tail.

The dead plate position for each cavity can optionally be monitored by an infrared sensor underneath the dead plate over the whole cycle run of a section. If heat radiation is abnormal or does not exist at a given time, a failure in glass handling or demoulding has occurred. In that case the following gobs for this section will be rejected. This minimizes downtimes and avoids wasteful maintenance.

Beside the bed, manifolds and conveyor, the scoop beam is an

additional example of functional integration. Both hollow profiles are used to guide compressed and blast air, while the cable duct is embedded in between.

There are modules for scoop cooling and pneumatics on the profiles. The modules are optimally protected against environmental influences by easy to remove hoods, while still being easy to reach by means of flaps.

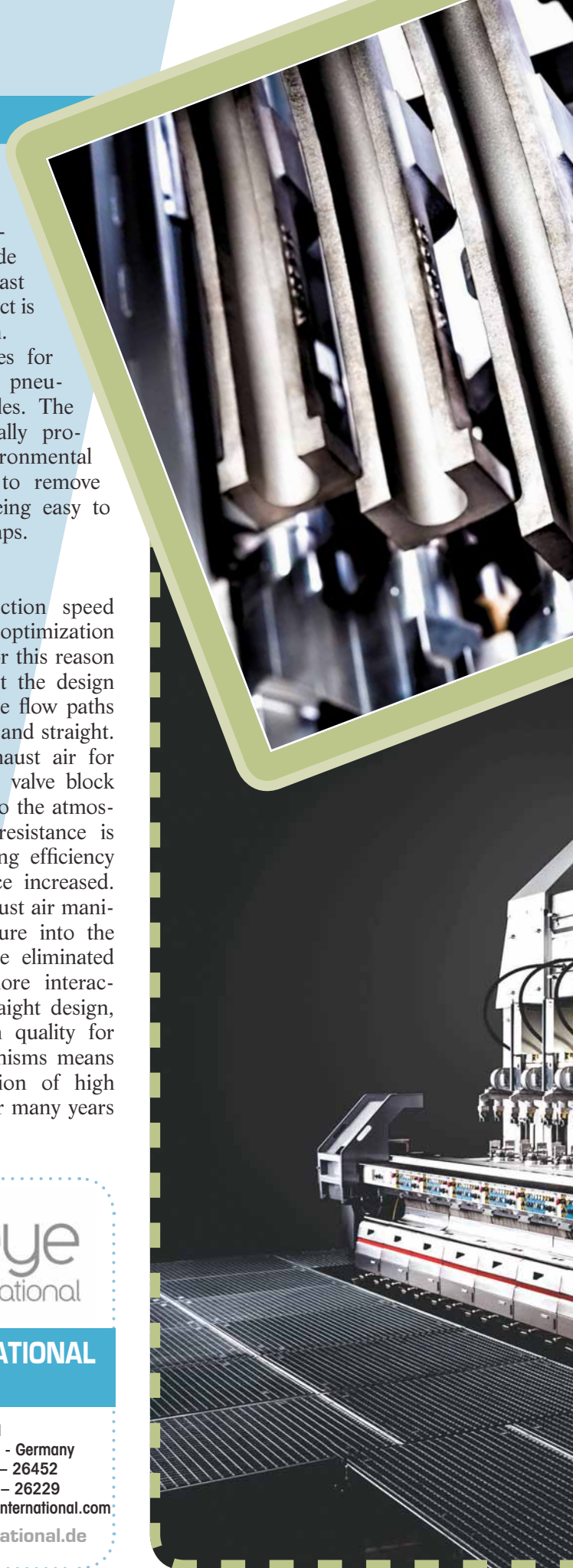
HIGH SPEED

Increasing production speed also requested an optimization of the flow paths. For this reason – when carrying out the design of the new bed – the flow paths were kept very short and straight. In addition, the exhaust air for plunger cooling and valve block is guided directly into the atmosphere. Thus, flow resistance is decreased and cooling efficiency of the plunger hence increased. By omitting the exhaust air manifold the back pressure into the valve block could be eliminated as there are no more interactions possible. A straight design, combined with high quality for all parts and mechanisms means high-speed production of high quality containers for many years to come. ■



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GMBH**

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Malaysia Glass Association (Persatuan Kaca Malaysia)



Thai Plate Glass Industry Association



Vietnam Glass Association



Busellato Glass Moulds,
in partnership with Empakglass:

INNOVATION,
TECHNOLOGY AND
IMAGINATION
- TOGETHER

MOULD RESEARCH AND DEVELOPMENT

From a workshop for the repair and maintenance of glass moulds, to the creation of par excellence moulds for the most complex glass containers, this is the story of Busellato Glass Moulds. The company, in fact, is a synonym of innovation and technology. It first began as a mould repair and maintenance workshop, and then, in the 1990s, it started with automatic metallization, being the first mould manufacturer to weld bronze automatically.

With the second generation of the family already in charge, the company's expansion and activities are continuing to develop at a fast pace. Today's challenge is to take this specialist mould manufacturer to satisfy even the most diverse and difficult requests – from 5-millilitre to 13-litre capacities.

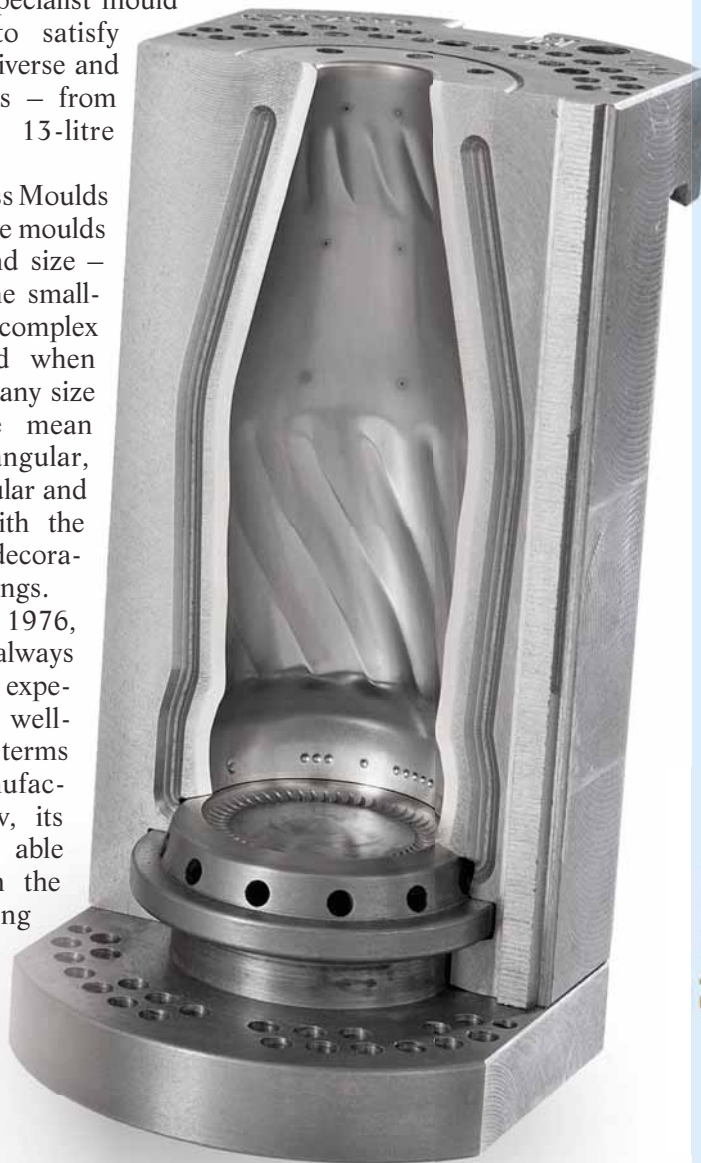
Busellato Glass Moulds is able to produce moulds of any shape and size – ranging from the smallest and most complex containers. And when we speak about any size and shape we mean it: round, triangular, square, rectangular and so on – all with the most complex decoration and engravings.

Founded in 1976, the company always has always had experienced and well-trained staff in terms of mould manufacturing and now, its technicians are able to comply with the most demanding

customers' needs. Today, the company occupies 3,200 square meters of production area and 1,100 of office space. Moreover, to respond to clients' growing demands in terms of cost saving and quality control, an area dedicated to mould maintenance has been implemented and is fully operational.

METALLIZATION

With the research for more enhanced metallization processes and characteristics in mind, detailed studies were conducted regarding the metallization techniques and materials used for glass-contact surfaces in moulds. This enabled Busellato to develop



The story of Busellato Glass Moulds is really no different from many Italian companies, and is based on long-term and family traditions. Thanks to its continuous growth and development, the company has taken another step forward thanks to an important partnership with EmpakGlass, a unique service provider for the glass industry.





specific know-how in this area, allowing it to detect and correct defects, even in post-production phases.

Created for the NNPB and P&B processes, this innovative coating has a solid track record of good and robust results. This is noticeable not only in moulds but also in all the accessories such as: neck rings and guide rings, plungers and cooling tube, blowheads, vertiflow plates, funnels, take out tongs, thimbles...

Thanks to the results of the

study, ideal parameters for HVOF (High Velocity Oxy Fuel) technology have been defined, with considerable advantages both in terms of finishing and durability of the moulds.

INNOVATIVE COATING

One particular development that the company is proud of is the Busellato Innovative coating. This coating, **designed in cooperation with the nanotechnology research laboratory VENETO NANOTECH**, was created to grant basic advantages in mould utilization, such as:

- highly increased swabbing cycles;
- longer lifetime of moulds;
- more polished container items;
- diminished need to add glass weight;
- less waste;
- less maintenance;
- less pollution.

On top of all that, in order to provide its customers with support even before the mould design of the project to mass production – as well as including it – Busellato Glass Moulds benefits from the cooperation with its business partner EmpakGlass.

PARTNERSHIP WITH EMPAKGLASS

EmpakGlass is really a unique service provider. Technical and

commercial solutions for the global glass industry that this Portuguese company can supply include: strategy consulting, new markets, costing systems, technical projects, technical analysis and solutions, quality management, manufacturing support and much more.

EmpakGlass staff has profound experience from working in globally leading companies such as Bucher Emhart Glass, Sorg and Crown, Cork & Seal, with knowledge of the most frequently spoken languages.

EmpakGlass technical approach

In an analysis of the current situation of the glass container markets and future prospects for this industry, EmpakGlass sees continuous growth of global business complexity plus an always present pressure on costs, environmental requirements and innovation demands. This requires continuous adaptation of new strategies and production methods.

The industry trend maintains its consolidation track, but many new glassmakers are still appearing, providing new opportunities but challenges as well. Globally divided production processes require more and new reliable providers being flexible and capable to fill high global demands.



MOULD RESEARCH AND DEVELOPMENT

For example, for a typical global project: a liquor glass bottle ordered in Spain, moulds from Italy, produced in Tunisia, decorated in Poland, filled in France and sold in the US (and all OTIF - On Time In Full Delivery).

In this harsh and demanding business environment choosing the right strategic partners is the key success factor.

EmpakGlass combines the power of technology with knowledge and experience, granting its customers competitive advantages in the container glass industry. The company's integrated approach, offering technical and commercial solutions, results in a much diversified customer base:

- glassmakers undergoing important technical and/or commercial evolution;
- multinational brands (glass fillers);
- glass distributors (glass sellers);
- hardware & software suppliers for the glass industry;
- other service companies (insurances,...)

This diversified customer base does not only increase EmpakGlass' knowledge base of the complete glass business from different

angles; it is also an asset for customers.

DRIFT Approach - Do It Right the First Time!

The service needs of customers vary from individual projects to PSA (Performance Support Agreements) programmes. And by using any entry point from the list below, running a defined isolated programme or ordering complete support packages, Hop-On-Hop-off or the complete tour, customers are in control all the way. Some entry points to EmpakGlass:

- strategy and costing systems;
 - marketing;
 - new customers and new business support;
 - product design and product optimization;
 - mould design;
 - batch and furnace;
 - manufacturing and IS support;
 - quality control and cold end;
 - optimization and training;
 - risk analysis and claims;
 - forming software development;
 - mould shop management software;
 - batch and furnace software.
- EmpakGlass backs its techni-

cal activities with the continuous development and upgrading of its own Forming Software Simulator as well as other technical software.

Thanks to the common philosophy that both Busellato Moulds and EmpakGlass have in terms of providing their customers a solid and integrated approach backed up on the latest technology, establishing a partnership was quite a natural step. ■

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Glass insulators:

THE 'POWER' OF TOUGHENED GLASS

In this article we take a look at a highly specialized use of toughened glass – insulators for power lines – presenting the products and production methods and technology used in this sector.

Insulators were first manufactured in the 1800s when the first telegraph and telephone circuits were put in place. Glass insulators were then produced in the 1850s for use with telegraph lines and, as technology developed, so did the technology regarding insulators, which were needed for telephone lines, electric power lines, and other applications.

TOUGHENING THE GLASS

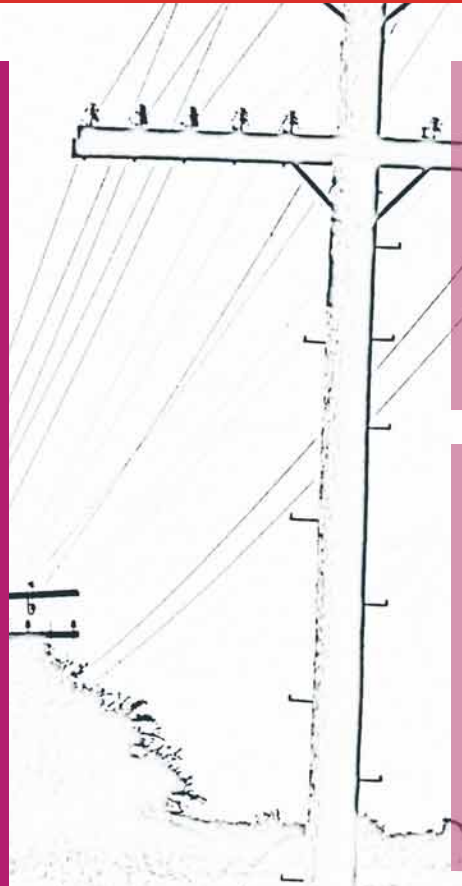
The production of rigid insulators for electrical applications

was made possible thanks to the annealing treatment of glass, during which internal tensions created during fabrication are eliminated. In this process the temperature is raised sufficiently to relieve tensions but not enough to cause deformation. Then follows a slow cooling process to avoid the appearance of temperature gradients that could create new tensions. This treatment improves the glass properties and above all its mechanical characteristics.

Tempering consists in a thermal treatment given to the glass,

with a first equilibrium stage to homogenize temperature and a second stage where the outside of the pieces are rapidly cooled in order to create surface compression and internal tension. This provides the glass with many advantages and improved resistance to mechanical and thermal strains.

The tempering process gives the glass a great structural resistance, but at the same time demands a very high level of quality, during both fabrication and the inspection stages to prevent



SPECIAL APPLICATIONS

defects, in order to ensure that the insulators are reliable for the function they have to perform.

GENERAL CHARACTERISTICS AND PERFORMANCE

Toughened glass insulators have a great resistance due to the thermal treatment they receive. But besides this property there are many other advantages such as their resistance to ageing, even when submitted to great mechanical stress.

On the other hand, their dielectric resistance is very high on account of the glass homogene-

- a toughened glass dielectric, with the appropriate characteristics and form for the conditions of the environment in which they have to work;

- a malleable cast iron cap, hot dip galvanized;

- a forged steel pin, hot dip galvanized.

The cap and pin are joined to the glass disc with special aluminous cement with the adequate properties to support the thermo-mechanical strains during manufacture and use.

Finally, the cap of the insulator is provided with a locking device (split pin) made from



ity, which makes them practically proof against perforation.

Moreover, toughened glass insulators possess another very important advantage consisting in the fact that a whole glass insulator is always a 'healthy' insulator, which facilitates the inspection of the electrical lines. In case of breakage of a glass disc, the glass shatters into small pieces but the mechanical resistance of the resulting insulator 'stump' is practically the same as unbroken insulator. The string of insulators therefore keeps most of its original mechanical properties until such time as the defective insulator can be substituted.

SUSPENSIONS INSULATORS

Components

Suspensions insulators are made up of the following elements:

stainless steel or phosphorous bronze ensuring a positive coupling between the string elements.

Moreover, the pins of those insulators for use in direct current or high pollution applications can be protected, if required, with a sacrificial zinc sleeve.

The cap of insulators with clevis and tongue coupling is provided with a forged steel bolt with a split pin.

Range of use

Suspension insulators must comply with a series of national and international standards: IEC, ANSI, BS, NF, UTE, UNE, DIN, etc. Each standard is subdivided into four insulator groups, classified according to the different forms of the glass disc as required by different environment conditions. These four groups are:

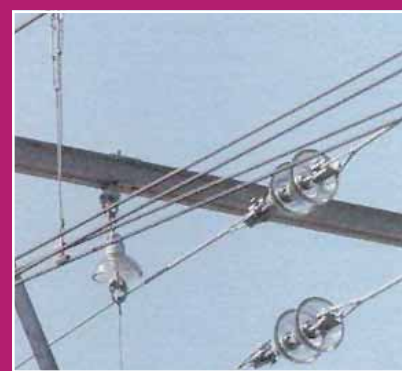
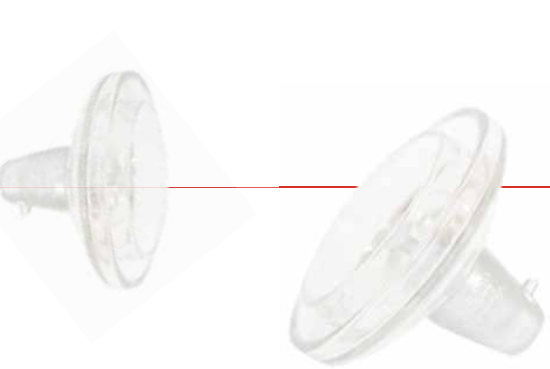
- standard insulators – They

are most common and used on low pollution lines.

- anti-pollution insulators. With two recommended different forms for middle and high pollution zones. Their greater creepage distance allows to reduce the effects of pollution without increasing the length of the string.

- aerodynamics insulators. These insulators are highly recommendable in desert applications. Due to their wholly flat dielectric profile, the absence of ribs makes difficult the build-up of deposits on the dielectric due to the clearing action of wind and rain. They may also be used in areas subjected to critical industrial pollution (or combined industrial and desert pollution).

- spherical insulators. As with aerodynamic insulators, the lack of ribs on the piece of glass hinders accumulation of residues on



the dielectric, facilitating the rain and wind clearing effects.

Finally, within each subdivision, a large range of mechanical resistances exists for each standard and insulator form, going from 40 to 300 kN and fully covering the different requirements and possibilities of electrical lines.

Dimensional, electrical and mechanical characteristics

Both the guaranteed mechanical and electrical values for each insulator are those recommended by IEC, BS and ANSI standards.

Similarly, the dimensional values (such as diameter, spacing, coupling standards, creepage distance, etc.) are in conformity rigorously with the specified standard.

HVDC TOUGHENED GLASS INSULATORS

Specific stress conditions

HVDC by nature is creating a set of conditions quite remarkable and different from traditional AC lines. The unidirectional E field is a main source of ionic effects on dielectric materials. While IEC (1) is describing in detail the testing parameters and performance expectations of ceramic DC insulators (either glass or porcelain)

it is not so the case for composite DC application which is not covered by any standard. The question needs to be asked, however, if highly strategic lines such as DC can afford to take the risk of unknown performance, with organic inherently ageing materials, compared to the safety net provided by stable and inert products, such as toughened glass, largely supported by decades of service.

Over the years, manufacturers' have set up special materials and designs for HVDC, from the dielectric itself to the end fittings. For toughened glass, the current design has largely integrated the evolutions of the last 50 years field experience

Originally, standard glass or porcelain was used for HVDC. As a result of ionic migration and the associated specific stress effect, several problems occurred leading to punctures and outages on lines with standard porcelain, or shattering of glass shells at levels higher than expected during the first years.

Toughened glass, however, never led to the magnitude of problems encountered with porcelain since a shattered unit does not generate any operational

interruption or disturbance.

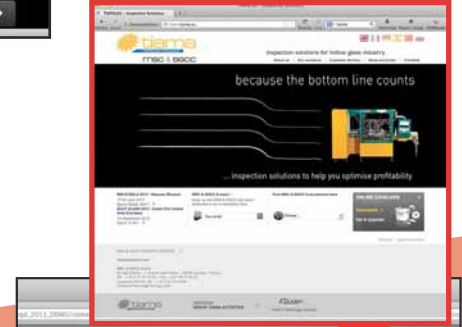
The specific action of ionic migration corresponds to the migration of ions in the glassy phase of the dielectric material under the unidirectional DC voltage. This glassy phase exist in both glass and porcelain. Under the ionic effect of DC voltage, there is a formation of a depletion layer where Na^+ alkali cations have moved. This migration through the silica network which forms the frame of glassy materials depends on the resistivity of the material itself. Ionic conductivity depends mainly on temperature, but is also a function of the amount and type of alkali present in the dielectric (5).

A second effect of this migration, is a possible ionic accumulation in areas of structural heterogeneity.

The second generation of DC glass, HRTG special glass composition has been designed around better protection against corrosion and above all, much higher resistivity. This special chemistry of glass locks the ions through a much lower ionic conductivity in order to stop migration under DC voltage. Given this 'immunity' against ionic stress, the adverse effects described above and seen in the earlier applications have been eliminated. Additionally, special process treatments in glass moulding have led to a much higher purity of glass, and therefore a lower impact to DC ionic accumulation. ■



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PSR: GLASS TEMPERATURE MEASUREMENT IN FOREHEARTHS AND DISTRIBUTORS

The function of the feeder forehearth is to provide gobs of glass to the forming machine at a constant, uniform temperature suitable for the particular forming process, at a constant weight and shape and at the required speed of the forming machine. The most important physical parameter for the forming process is the glass viscosity and as this varies on a logarithmic scale with glass temperature (small changes in temperature producing large changes in viscosity), precise forehearth temperature control

is essential if consistent feeder operation and efficient glassware production are to be maintained.

The actual gob temperature is normally controlled indirectly by controlling the equalizing section temperature of the forehearth and measuring the gob temperature periodically with a portable infrared pyrometer. Some companies install thermocouples in the feeder spout but these temperature readings are significantly affected by the location of the thermocouple and the feeder tube rotation direction and speed. Although the gob temperature is of prime

Precise forehearth and distributor temperature control is essential if consistent feeder operation and efficient glassware production are to be maintained.

To control the glass temperature it must be accurately measured.

Here we describe and compare the temperature sensors recommended and used in our forehearth and distributor systems.



Fig. 1 - A feeder forehearth providing gobs to the forming machine

importance, many glass companies still do not measure this at all and rely entirely on the measurement and control of the equalizing section temperature.

The uniformity of the gob temperature can be evaluated on a qualitative basis by observing the formation of the gob preferably with the feeder tube stopped from rotating. This assumes that all the feeder expendable refractory parts have been correctly selected and installed and that the feeder mechanism has been correctly adjusted and is operating correctly. If the gob does not develop straight from the orifice and curls to one side this indicates that the gob is cold on the side to which the gob curls. If the gob curls towards the forehearth then the bottom glass is too cold and the rear cooling sections need increasing in temperature.

If the gob curls away from the forehearth then the bottom temperature is too high and the rear cooling sections need to be reduced in temperature.

Before the development and widespread use of suitable permanently installed tri-level (triplex) thermocouples, these

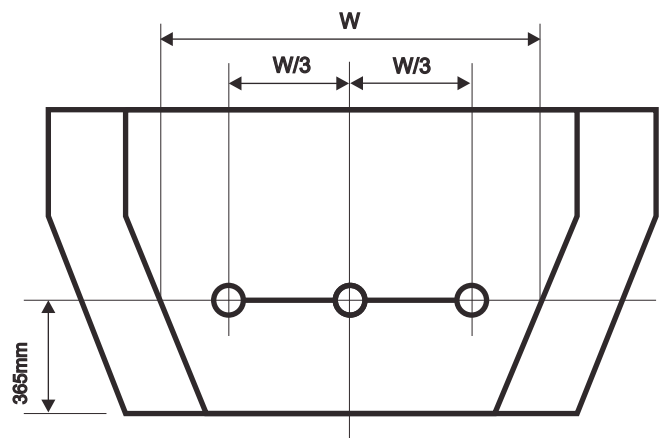
observations were used for setting up the forehearth zone temperatures.

The use of temporary portable tri-level thermocouples at job changes alongside these observations eventually lead to the use of permanently installed tri-level thermocouples.

TRI-LEVEL THERMOCOUPLES

The thermal homogeneity of the glass entering the spout can be used as a quantitative guide to the uniformity of the gob temperature. This is evaluated by installing three tri-level (triplex) thermocouples through the equalizing section superstructure across the spout entrance. These thermocouples have three hot junctions located at one inch (25 millimetres) off the channel bottom (Lower), in the middle of the glass stream (Middle) and one inch (25 millimetres) below the glass surface (Upper).

They are normally arranged in a nine-point grid with one on the centre line of the forehearth



PSR standard thermocouple positions

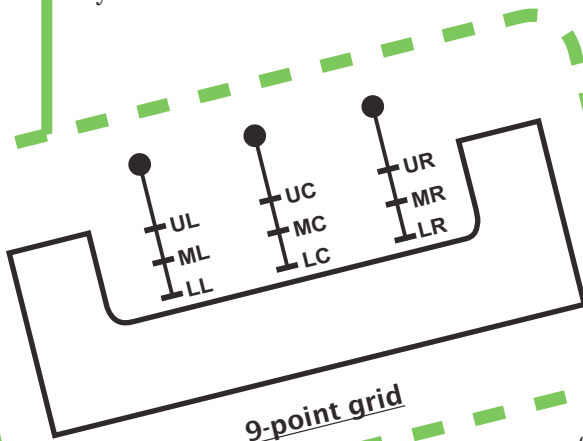
and one on either side (Left and Right) at a distance equal to a third of the channel width from the centre line. The thermocouples should be as close to the spout entrance as possible but not so close that their readings are readily affected by changes in the direction and speed of rotation of the feeder tube or rotors. They should be located between burner positions to prevent possible damage to the side thermocouple sheaths by flame impingement, with a peephole positioned to allow viewing of the thermocouples. The thermocouples are typically located 14.3/8 inches (365 millimetres) back from the spout entrance.

The spread of temperatures

TEMPERATURE SENSORS

over the nine-point grid can be expressed mathematically as a percentage thermal homogeneity efficiency figure as adopted by several glass companies. In comparing these thermal homogeneity figures the location of the thermocouples and the method of calculation must be taken into account.

PSR uses the following 9-point and 5-point thermal homogeneity calculations:



9-point grid

For the 9-point grid, six positive horizontal temperature differences 'ΔH' are calculated from the values

(U.C.–U.L.),
(U.C.–U.R.),
(M.C.–M.L.),
(M.C.–M.R.),
(L.C.–L.L.) and
(L.C.–L.R.)

by subtracting the lowest value from the highest value.

Three positive vertical temperature differences 'ΔV' are calculated from the highest and lowest values of

(U.L., M.L. and L.L.),
(U.C., M.C. and L.C.) and
(U.R., M.R. and L.R.)

by sub-

tracting the lowest value from the highest value.

The 9-point forehearth thermal homogeneity efficiency is then calculated as follows:

9-Point Thermal Homogeneity Efficiency (%) = $[1 - (\Delta H + \Delta V) / M.C.] \times 100$.

The triangular area formed by the Upper Centre (U.C.), Lower Left (L.L.) and Lower Right (L.R.) thermocouple junctions contains the glass primarily used to form the gob and it is considered that these temperatures have a direct bearing on gob temperature distribution and ultimately on the glass distribution in the article being manufactured.

For this reason many glass companies only use the five points within this triangle in the calculation.

This allows the upper and middle sidewall temperatures to be operated at higher temperatures if necessary to increase the lower sidewall temperatures without producing a lower thermal homogeneity efficiency figure.

For the 5-point grid, two positive horizontal temperature differences 'ΔH' are calculated from the values

(L.C. – L.L.) and (L.C. – L.R.) by subtracting the lowest value from the highest value.

One positive vertical temperature difference 'ΔV' is calculated from the highest and lowest values of (U.C., M.C. and L.C.) by subtracting the lowest value from the highest value.

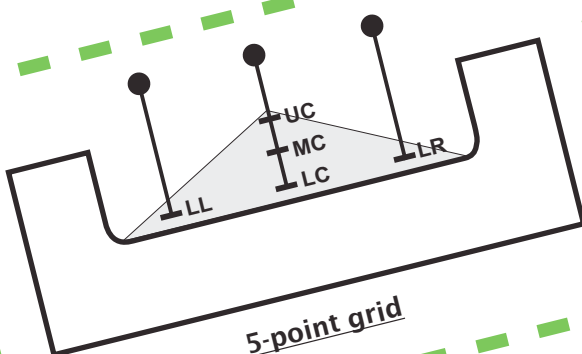
The 5-point forehearth thermal homogeneity efficiency is then calculated

as follows:

5-Point Thermal Homogeneity Efficiency (%) = $[1 - 3 \times (\Delta H + \Delta V) / M.C.] \times 100$.

As in the 5-point calculation there are only two horizontal temperature differences and one vertical temperature difference compared with the six horizontal temperature differences and three vertical temperature differences in the 9 point calculation, the temperature differences are multiplied by 3 to make the typical differences of the 5 points represent the total differences of the 9 points and to make the 9-point and 5-point calculations mathematically equivalent.

Other methods of calculating the forehearth thermal homogeneity efficiency value are used by different companies but we believe that the versions of the calculations described above best represent the glass thermal homogeneity because if all 9 or 5 thermocouple temperatures are the same both thermal homogeneity efficiency values calculate at 100 per cent and values greater than 100 per cent are not possible. Other calculations attaching more importance to the sidewall temperatures being hotter than the centre temperatures can provide thermal homogeneity efficiency values greater than 100 per cent. The logic behind this is that as these temperatures are measured a distance back from the spout the side temperatures will cool faster than the centre line temperatures due to the greater heat losses. So if the side temperatures start off hotter than the centre line temperatures it is more likely that the temperatures across the glass width will be more even when the glass reaches the spout entrance. In some designs the centre line tri-level thermocouple is off-set further back upstream from the side tri-level thermocouples to effectively achieve the same result



5-point grid

but with the objective of having the temperature readings equal and using the original thermal homogeneity efficiency calculation.

These nine or five thermocouple temperatures provide the only quantitative basis for setting up a forehearth and its associated distributor zone set point temperatures with the objective normally of obtaining the best vertical and horizontal glass thermal homogeneity at the spout entrance.

If the feeder tube is rotated too quickly it can result in the formation of a vortex and a resultant build-up of colder stagnant glass on the side to which the tube rotates, particularly if the full flow capacity of the forehearth and spout is not being utilized. Under these circumstances if the direction of rotation of the feeder tube is reversed the lower temperatures will change to the opposite side of the forehearth. The faster the rotation of the feeder tube, the greater the temperature difference will become between the two sides of the forehearth. It is generally recommended that the feeder tube or rotors be rotated as slowly as possible and not faster than about three revolutions per minute.

THERMOCOUPLE DESIGN

Thermocouple suppliers have worked closely with glass companies and forehearth suppliers over many years to develop reliable triplex thermocouple designs. PSR uses a high specification triplex thermocouple design providing long life and long-term accuracy and stability. This basic design has been produced by Engelhard (now BASF) for over 30 years. Although these tri-

plex thermocouples have a high initial cost they are capable of operating for a complete furnace campaign and can be considered as an investment as a high proportion (typically 95 per cent) of the precious metal can be recovered for recycling and the significant scrap value refunded or offset against the purchase of new replacement thermocouples.

Type B thermocouple elements (Platinum– 30 per cent Rhodium +ve conductor and Platinum–6 per cent Rhodium –ve conductor) are used specially manufactured to Tolerance Class 1 which is from 0 to 1100°C ± 1.0°C and from 1100 to 1600°C ± 1 + 0.003 (t–1100)°C.

Normally Type B thermocouples are only manufactured to Tolerance Class 2 which is 600 to 1700°C ± 0.0025t. Type R (Platinum – 13 per cent Rhodium +ve conductor and Platinum –ve conductor) and Type S (Platinum – 10 per cent Rhodium +ve conductor and Platinum –ve conductor) are normally manufactured to Tolerance Class 1. Type B thermocouples have advantages over

commonly used Type R and S thermocouples in that Platinum – Rhodium alloys are used for both conductors and any migration of Rhodium due to evaporation and diffusion at high temperatures does not significantly affect the temperature reading during the life of the thermocouple whereas the pure Platinum conductor of Type R and Type S thermocouples can be contaminated by Rhodium migration to give significant off-set errors even after a short period of operation. Type B thermocouples also generate a much lower EMF voltage with temperature and have a negligible output over the range 0 to 50°C making cold junction compensation and the use of compensating cable less critical. Compensating cable can be supplied which is not as expensive because only high temperature copper-copper cable is required.

Type R and Type S compensating cable required for these thermocouples can also introduce an error unlike

Fig. 2
Tri-level
thermo-
couples
installed
in PSR
forehearth
equalizing
section



TEMPERATURE SENSORS

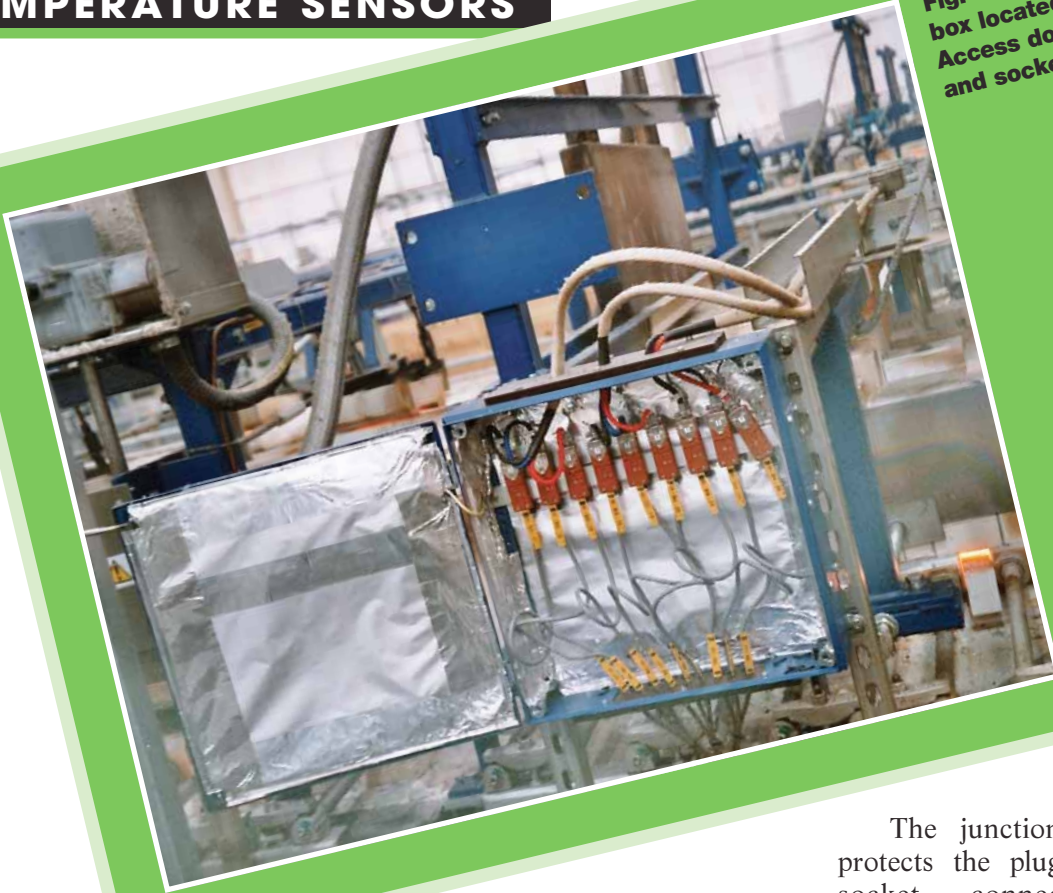


Fig. 3 - Thermocouple junction box located at side of forehearth. Access door is open to show plug and socket connections

the copper-copper cable used with Type B thermocouples. For example Type R and Type S compensating cable up to a temperature of 1000°C and with the connection to the thermocouple between 0 and 100°C has a tolerance of $\pm 2.5^\circ\text{C}$. Type R and Type S thermocouples were popular for use with the older analogue instrumentation due to their higher millivolt output signals which are easier to measure but this is not now a consideration with modern microprocessor based digital instrumentation.

In this thermocouple design there are no connections in the thermocouple head with the precious metal element wires passing directly through the sealed thermocouple head and extending for 2 metres so that the connection to the field wiring can be made in an insulated and sealed junction box in a cooler location at the side of the forehearth.

This connection is made with plugs and sockets which are included with the thermocouple. This avoids any junction errors due to connections in the thermocouple head being at the high ambient temperature directly above the forehearth. The two-metre long precious metal extension leads (not compensating cable) are individually covered in a heat resistant glass fibre sleeve together with an overall glass fibre sleeve covering all three leads.

For junction identification the Upper junction is sleeved in black and is numbered 1 on the plug, the Middle junction is sleeved in blue and is numbered 2 on the plug and the Lower junction is sleeved in red and is numbered 3 on the plug. The numbers are engraved on the plugs to provide a permanent identification. A sealed and insulated junction box is included in our supply together with the necessary thermocouple mounting brackets and insulators.

The junction box protects the plug and socket connections from oxidation and oil contamination due to the relatively high ambient temperature and oily atmosphere around the forehearth. The mounting brackets hold the thermocouples in the correct position and shield the thermocouple heads from the heat from the forehearth superstructure and exhaust flues. The insulators isolate the thermocouples from the forehearth steelwork and mounting bracket to prevent any electrical interference from electric boosting systems.

The thermocouple has a 15-millimetre outside diameter and 10-millimetre inside diameter recrystallized alu-



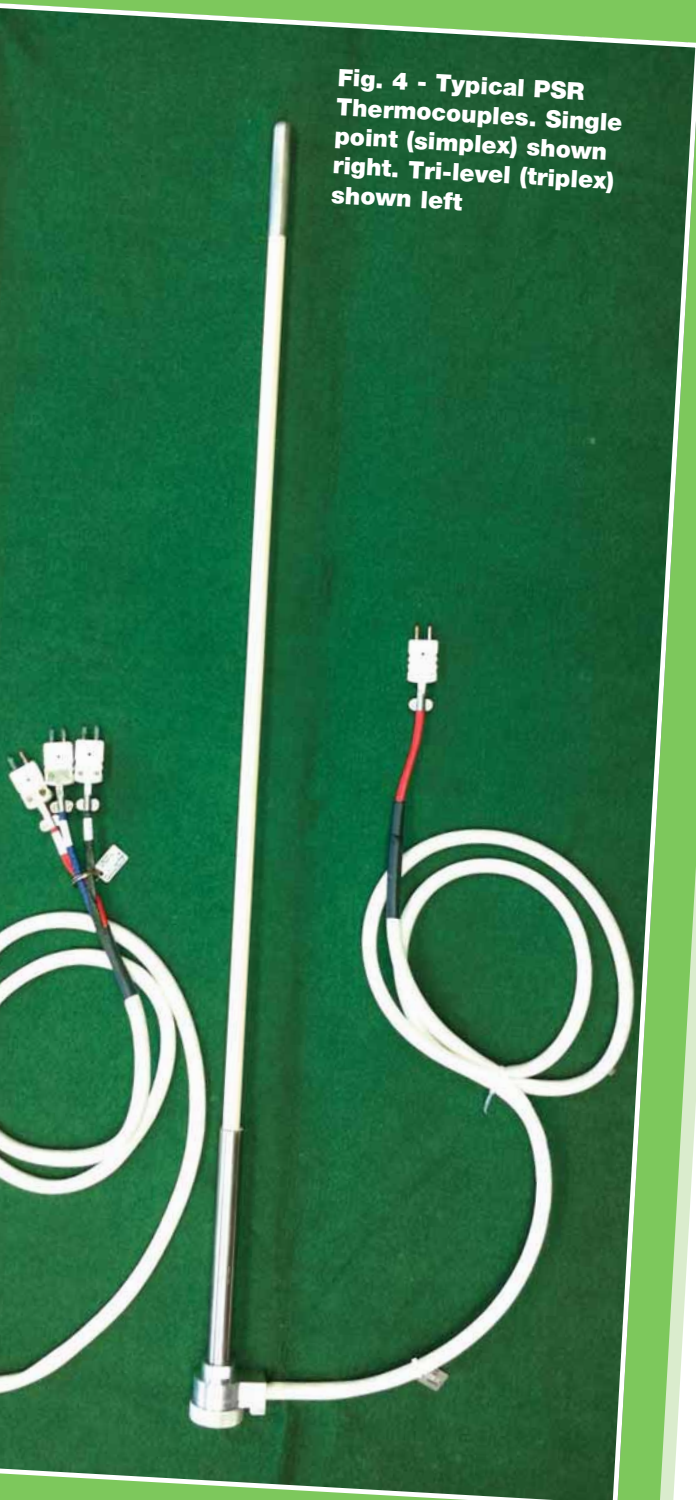


Fig. 4 - Typical PSR Thermocouples. Single point (simplex) shown right. Tri-level (triplex) shown left

mina sheath protected from the glass with an 8-inch (203 millimetres) long, 0.38-millimetre thick Oxide Dispersion Strengthened (ODS) Platinum thimble thickened to 1.00 millimetres at the tip which is cemented and fired on to the

recrystallized alumina sheath.

Unlike normal platinum and platinum-rhodium alloys which are corroded by amber glass and have a relatively short life, the ODS Platinum is suitable for use in all glass types and colours.

The three thermocouple junctions use 0.5 millimetres thick Type B thermocouple wire within single recrystallized alumina twin bore insulators.

The three junctions are normally located 1/2 inch (13 millimetres), 2.1/2 inches (64 millimetres) and 4.1/2 inches (114 millimetres) from the tip of the thermocouple. The thermocouple is normally installed 1/2 inch (13 millimetres) off the channel block base being designed for use in a nominal 6 inches (152 millimetres) glass depth. The thermocouple can be lowered the 1/2 inch (13 millimetres) to the channel base if necessary to accommodate a lower nominal glass depth of 5.1/2 inches (140 millimetres) or even 5 inches (127 millimetres) but other thermocouple junction locations for different glass depths can also be provided. If the thermocouple is to be installed on the channel bottom then the weight of the thermocouple must be support-

ed by the thermocouple bracket to prevent deformation of the thimble over time. The thickened thimble bottom protects against possible erosion due to vibration.

The overall length of our standard triplex thermocouple for installation across the spout entrance in an equalizing section is 36 inches (915 millimetres) excluding the thermocouple head made up of an 8 inches (203 millimetres) long, 22 millimetres outside diameter Inconel backing tube and a 28 inches (711 millimetres) long, 15 millimetres outside diameter, 10 millimetres inside diameter recrystallized alumina sheath. A 40 millimetres diameter access hole is required in the forehearth roof for installation of the thermocouple.

Longer thermocouples are supplied for other locations such as the forehearth entrance. Longer ODS Platinum thimbles are used for greater glass depths.

ADVANCED CONTROL STRATEGIES

The Upper Centre triplex thermocouple junction is used as the control sensor for the equalizing section. This must not be located much more than 1 inch (25 millimetres) below the glass surface, particularly for coloured glasses, otherwise temperature control cycling will occur due to excessive process lag. In our advanced temperature control systems the Middle Centre and Lower Centre junctions are used in secondary Cascade control loops to trim the cooling section set point temperatures, automatically optimizing the centre line vertical glass temperature homogeneity at the spout entrance.

The Lower Left and Lower Right junctions are used in secondary Trim control loops to trim the left and right-hand side firing, automatically optimizing the horizontal glass temperature homogeneity. The secondary Cascade

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temperature sensors

and Trim control loops operating together automatically optimise the overall thermal homogeneity at the spout entrance.

INFRA-RED FIBROPTIC THERMOMETERS

For measurement of forehearth cooling section temperatures and distributor section temperatures including the throat riser PSR normally recommends and uses infra-red fibroptic thermometers.

The Land Fibroptic Model FG supplied by Land Instruments is a popular analogue instrument of which we have supplied many units over the years although for the past 9 years we have used the Infratherm IS 50-LO/GL, a digital instrument supplied by Lumasense Technologies (formerly Impac).

The thermometer consists of an optical head lens mounted in a purge air assembly which is sighted vertically from above the forehearth or distributor roof onto the glass surface through an Inconel sighting tube. The optical head is connected to the thermometer processor unit via a 5-metre long stainless steel coated fibroptic light guide which allows the processor unit to be mounted in a junction box in a cooler location at the side of the forehearth or distributor rather than on top of the forehearth. This allows the processor unit to operate accurately without the need for air or water cooling as was required with the

infra-red pyrometers originally used over 30 years ago. The maximum ambient temperature for the optical head and light guide is 250°C whereas for the processor unit it is 70°C. The purge air assembly protects the optical head objective lens surface from contamination with dust or moisture.

It requires a supply of instrument quality (dry and oil free) compressed air at an approximate volume of 65 to 100 litres per minute (4 to 6 cubic metres per hour) and generates a cone shaped air stream.

The optical head is connected to the purge air assembly with a quick release bayonet connector allowing easy

removal for lens checking and cleaning as well as for viewing down the sighting tube for checking against a portable infra-red thermometer.

A purge air control panel incorporating a pressure regulator, water filter, oil filter, individual flow indicator/regulator rotameter for each fibroptic and low pressure switch for remote alarm monitoring is included in our supply to ensure an adequate supply of purge air to each fibroptic thermometer. A 610 millimetres long Inconel sighting tube is used to allow the optical head to be mounted high on top of the forehearth superstructure steelwork on a special mounting bracket/heat shield to protect the optical head and light guide from the heat exhausted from the combustion and cooling flues. The narrow sighting angle of the thermometer objective lens allows sighting within the 27 millimetres internal diameter Inconel sighting tube and the 40 millimetres diameter access hole in the forehearth roof block to the glass surface. The Inconel sighting tube passes through a 134 millimetres thick fibroptic sighting block above the forehearth roof block to protect the surrounding roof block insulation and enters 25 millimetres into the external face of the roof block to ensure that the sighting block is correctly aligned with the access hole in the roof block. The infrared radia-



Fig. 5 - Fibroptic thermometer, purge air assembly and inconel sighting tube located above the forehearth

Fig. 6 - Processor units for fibroptic thermometers



tion is transmitted through the fibre optic light guide to the processor unit. Transmission through the multi-fibre optic light guide is based on the principle of total internal reflection by the boundary surfaces of the glass fibres which is practically free from any losses.

During installation the light guide must be adequately supported and the bend radius must not be less than 50 millimetres to prevent damage to the glass fibres. The processor unit consists of the infra-red detector and signal processing circuitry.

The infra-red detector is a silicon photovoltaic cell which is very stable with ambient tem-

perature and time. Its spectral response is in the range 0.8 to 1.1 micron which ensures that it is unaffected by changes in the combustion atmosphere in its sighting path as the water vapour and carbon dioxide in the combustion atmosphere radiate at wavelengths outside the sensor's spectral range.

Much earlier Radiamatic pyrometers used extensively in the glass industry over 50 years ago were total radiation pyrometers using thermopile devices which were sensitive to all wavelengths.

These required the use of an air purged refractory sighting tube extending to within a short distance from the glass surface

to avoid false glass temperature readings due to changes in the combustion products in the pyrometer's sighting path.

The fibroptic thermometer has a temperature range of 600 to 1800°C suitable for many applications but for forehearth and distributor temperature measurement a sub-range is set of 1000 to 1400°C. The processor unit requires a 24 Volt DC power supply from the temperature control system and provides a linearized 4 to 20 milliamp signal representing the temperature range 1000 to 1400°C which is suitable for direct input into a temperature control system. It has a test switch which outputs a mid-range signal of 12 milliamps to test the correct connection of the field wiring and configu-

TEMPERATURE SENSORS



Fig. 7 - Purge air control panel for 6 fibroptic thermometers

ration of the control system temperature controllers and indicators.

The signal processing circuitry is digital allowing easy and quick setting up of the instrument using a digital interface to a PC running the configuration software. To complement the instrument a calibration source is available allowing quick and easy checking and adjustment of the thermometers.

The fibroptic thermometer has a modular construction allowing easy replacement of major component parts, in some cases without the need to return the instrument to the manufacturer.

The fibroptic thermometer measures essentially the surface glass temperature (the top 25 millimetres for white flint glass, 5 millimetres for amber glass and 4 millimetres for green glass) and is installed sighting vertically on the glass surface at the end of each control zone.

To obtain a correct temperature measurement of an object with a radiation thermometer it is necessary to set the emissivity value for the object.

The emissivity of an object is a measure of the object's emission and absorption of radiation at a particular wavelength and temperature compared to a perfect black body which has an emissivity of 100 per cent. As the thermometer is sighting at right angles to the glass surface in a totally enclosed forehearth chamber the emissivity setting on the instrument is set at 100 per cent as in this situation the glass approximates to a total black body.

SINGLE POINT THERMOCOUPLES

Some customers prefer to use single point thermocouples rather than fibroptic thermometers in the cooling sections. In this case an equivalent single point (simplex) thermocouple design to the

same high specification as the tri-level (triplex) thermocouple design can be supplied.

The single point thermocouples have a shorter ODS Platinum thimble as the single junction is only installed 1 inch (25 millimetres) into the glass surface but they have a longer overall length as they are mounted in brackets/heat shields high on the superstructure steelwork in the same location as the fibroptics would be installed to protect the thermocouple head from the heat from the combustion and cooling exhausts. A peephole is positioned opposite the thermocouple location to allow correct positioning of the thermocouple in the glass.

The thermocouple is lowered by a colleague whilst being viewed through the peephole. When the thermocouple tip touches the glass surface as indicated by the tip of the thermocouple merging with its own reflection in the glass surface the thermocouple backing tube is marked and then the thermocouple is lowered a

further 1 1/2 inches (38 millimetres) to put the thermocouple junction 1 inch (25 millimetres) into the glass surface.

Some customers also use tri-level (triplex) thermocouples in the cooling sections but whilst these provide additional information to show the temperature gradients through the glass depth along the length of the forehearth this is an expensive option and does not really provide any information that could not be ascertained from the resultant tri-level thermocouple temperatures at the spout entrance.

PSR has used both fibroptic thermometers and single point thermocouples in cooling sections and on balance prefers to use the fibroptic thermometers as they are a non-contact sensor.

Both sensors provide good results and troublefree operation providing that they are installed correctly. Each sensor has its own advantages and disadvantages which are summarized and compared below.

ADVANTAGES AND DISADVANTAGES OF INFRA-RED THERMOMETERS

- Infra-red thermometers provide non-contact temperature measurement and are therefore not damaged by and cannot contaminate the glass. Their readings cannot be affected by electric boosting in the glass.
- Infra-red thermometer sensors are stable and do not deteriorate with time. Their calibration can be checked and re-set if necessary. Good installation and maintenance techniques can provide an almost unlimited lifespan.
- Infra-red thermometers require an instrument quality compressed air supply for purging of the objective lens and a 24 Volt D.C. power supply for the processor unit.
- Infra-red thermometers pro-

vide a high level, linear 4 to 20 milliamp output signal that is less affected by electrical interference than a thermocouple millivolt signal and which can easily be scaled to provide improved signal resolution in a temperature control system.

- Infra-red thermometers have a fast response time reacting to temperature changes much faster than a thermocouple.
- Infra-red thermometers measure essentially the surface glass temperature and cannot measure the temperature at different points throughout the glass depth.
- However, as all heat transfer takes place through the glass surface infra-red thermometers are appropriate for controlling forehearth and distributor zone temperatures.
- Infra-red thermometers can be used in throat riser areas to measure the entrance temperature to the distributor from the furnace providing that no cooling is employed over the throat riser section.
- The measurement of the surface glass temperature is important in cooling sections to ensure that the glass surface is not being overcooled.
- Infra-red thermometers always measure the glass surface temperature irrespective of changes in the furnace glass level.
- Disruption to the glass surface as can occur in the vicinity of stirrers can result in a fluctuation in the temperature measured by an infra-red thermometer due to surface optical effects.

ADVANTAGES AND DISADVANTAGES OF THERMOCOUPLES

- Thermocouples are in contact with the glass and can be corroded and damaged by the glass flow and any foreign materials such as stones pass-

ing through with the glass. The thermocouple sheath needs to be protected with an appropriate platinum thimble to prevent corrosion by the glass and provide an acceptable lifespan.

- Thermocouples can be subject to electrical interference from electric boosting in the glass and need to be isolated from the forehearth and mounting steelwork.
- Thermocouple outputs can deteriorate with time at high temperatures and the thermocouple type should be selected to minimize this affect.
- Thermocouple calibration cannot be practically checked and cannot be re-set. Faulty thermocouples have to be replaced.
- Good thermocouple design and installation can provide a long but finite lifespan.
- The precious metal content of the thermocouples can be recovered for recycling and the significant scrap value refunded or offset against the purchase of new replacement thermocouples.
- Thermocouples require no additional services.
- Thermocouple junctions used for zone temperature measurement and control must be located no more than 1 inch (25 millimetres) below the glass surface otherwise temperature control cycling can occur due to the excessive process lag between changes in the heating or cooling and changes in the measured temperature.
- The glass surface temperature can be significantly different from the temperature 1 inch (25 millimetres) below the glass surface particularly when cooling coloured glasses.
- As the thermocouple junctions are set at a particular distance below the glass surface under specific operating conditions changes in the glass level due

TEMPERATURE SENSORS

to hydraulic head loss along the forehearth at different forehearth throughputs will result in changes in the measurement point location and the measured temperature.

- Similarly changes in the controlled furnace glass level will result in changes in the measurement point location and the measured temperature.
- The furnace glass level must be controlled to ± 0.010 inches (± 0.25 millimetres) or better for successful thermocouple control of forehearths and distributors. Glass level changes in excess of these values will result in temperature upsets due to the measurement points being closer or further away from the glass surface.
- Thermocouples such as tri-level thermocouples having junctions at different levels can measure the glass temperature throughout the glass depth for glass thermal homogeneity evaluation and to provide a basis on which to set up forehearth and distributor zone temperatures.
- Suitable thermocouples with long protection thimbles can be used in heavily cooled distributor throat riser areas to measure the glass temperature entering the distributor from the furnace at glass depths not affected by the cooling which may be some 12 inches (305 millimetres) below the glass surface.

At the beginning of this article we stated that the function of the feeder forehearth is to provide gobs of glass to the forming machine at a constant, uniform temperature suitable for the particular forming process, at a constant weight and shape and at the required speed of the forming machine but that the gob temperature and uniformity is normally controlled indirectly by controlling the equalizing sec-

tion temperature and the glass thermal homogeneity at the spout entrance.

The actual gob temperature not only depends on the glass temperature and thermal homogeneity as measured in the equalizing section at the spout entrance but also on the following factors:

- The levels of substructure and superstructure insulation in the forehearth equalizing section and spout.
- The orifice ring size and insulation.
- The atmospheric conditions around the feeder spout as it determines heat losses.
- The spout firing level. The spout firing is normally manually set at a fixed firing level to compensate for the heat losses at the spout so that the glass is generally neither heated nor allowed to cool greatly from the temperature in the equalizing section.
- The glass depth in the equalizing section and spout which determines the glass residence time and consequent heat loss between the measurement point in the equalizing section and the orifice.
- The forehearth pull which determines the glass residence time and consequent heat loss between the measurement point in the equalizing section and the orifice.
- The gob size and weight.
- The feeder tube direction and speed of rotation as it affects the glass flow into and within the feeder spout.
- The feeder plunger height, stroke and action as it pushes the glass through the orifice.
- The shear mechanism operation in cutting the gobs and shear cooling spray which may locally cool the spout and orifice ring.

As can be seen there are many other factors that determine the gob temperature and as this is the

final opportunity to control the temperature of the glass and hence the viscosity of the glass entering the forming operation we consider that measurement and control of the gob temperature is of prime importance for the forming process and should not be ignored.

CONTINUOUS GOB MEASUREMENT AND CONTROL

Continuous gob temperature measurement and control using infra-red thermometers as well as gob monitoring by thermal imaging has been possible for many years but not widely adopted in the industry. For gob temperature measurement a two colour infra-red thermometer is normally used, measuring at two different wavelengths and comparing the ratio to minimize the affects of shear spray, steam and smoke on the reading and a peak picker is used to hold the maximum temperature and ignore the shearing. These infrared thermometers are generally sighted on the gob at the orifice and measure a similar temperature to a portable infra-red thermometer. However, modern parallel shear mechanisms make it very difficult to view the gob near the orifice ring to accurately measure the gob temperature in this way.

PSR has participated in gob temperature measurement and control trials using the high specification BASF Exactus GT infra-red thermometer. The advanced, high speed BASF Exactus GT infra-red thermometer has such a fast response time (1000 readings per second) that it can not only measure the gob temperature in free fall



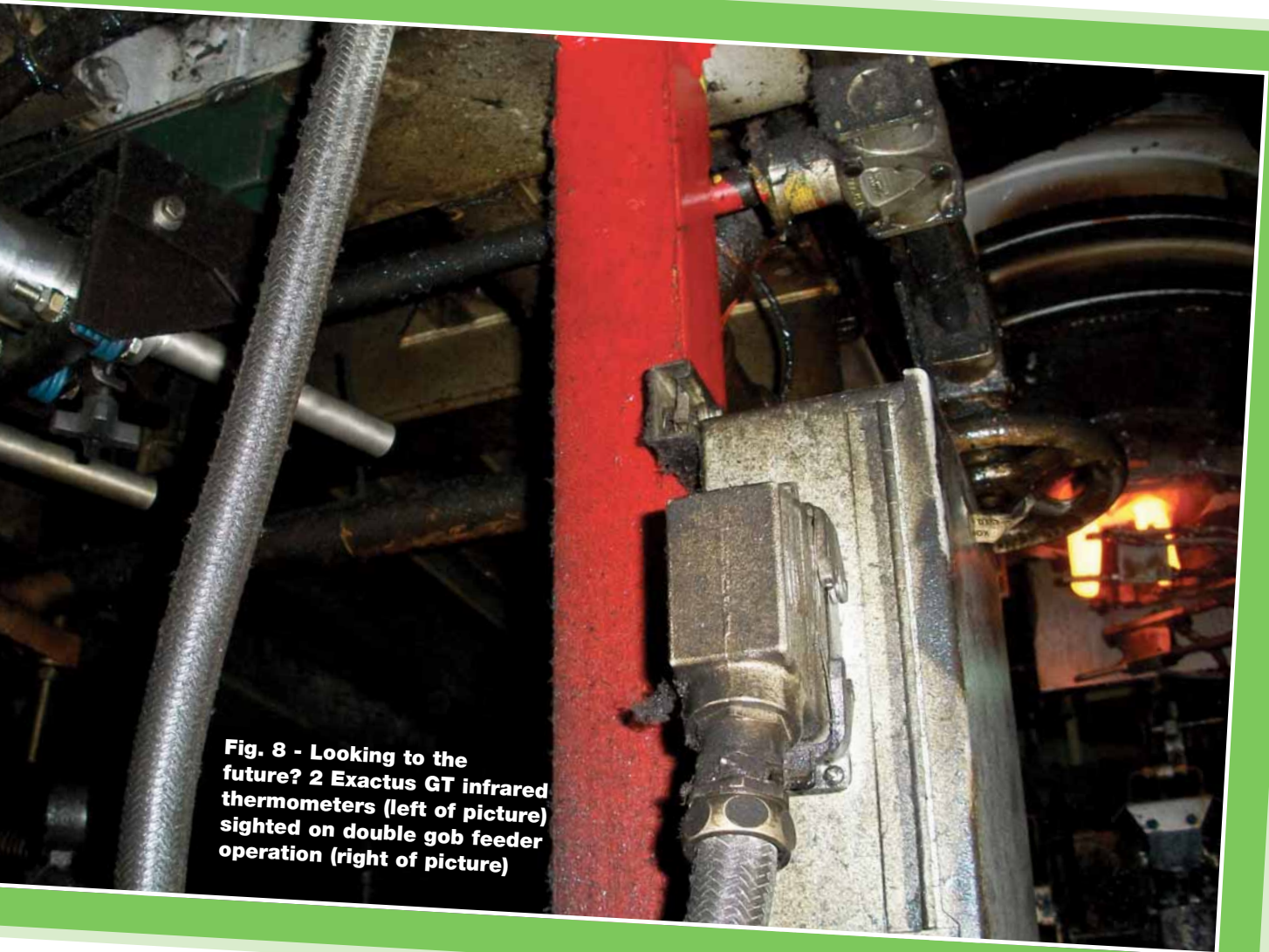


Fig. 8 - Looking to the future? 2 Exactus GT infrared thermometers (left of picture) sighted on double gob feeder operation (right of picture)

below the orifice and provide an accurate single average gob temperature, it can also measure the longitudinal temperature profile of each individual gob and this information can be used to analyse the gob forming process and its subsequent effect on the forming process.

Whilst the gob temperatures observed on our forehearths using our normal temperature control strategies have generally been steady and consistent on multiple gob applications, the implementation of gob temperature measurement and control can still contribute to a significant improvement in the glass condition for the forming process and eliminate an otherwise unknown and uncontrolled

important parameter.

Alongside the gob temperature measurement trials we have also trialled Model-based Predictive Control algorithms provided by Advanced Control Solutions Inc (ACSI) and these applied to our

normal temperature control strategies have proved to be capable of providing improved thermal homogeneity and gob temperature control as well as improved temperature control response at job changes. ■



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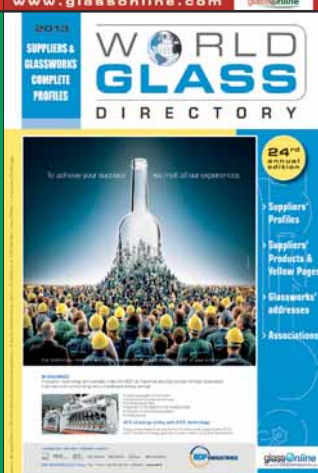
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