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dec 2012

From President's Desk

I am thankful to Messe Dusseldorf GmbH, Germany and Messe Dusseldorf India Private Limited, pioneers in organizing international exhibitions and trade fairs, for the efforts put in by them to bring together companies from different parts of the world in GLASSPEX INDIA 2013. After notable success of GLASSPEX INDIA 2009 and 2011, I hope that GLASSPEX INDIA 2013 will receive good support from the industry in India and other parts of the world.

I am looking forward to a magnificent display of latest technology, by world renowned companies exhibiting their products in the exhibition. Participation by the experts in the Seminar will enable delegates to understand global technological advancements in glass industry. GLASSPEX INDIA 2013 will also be a forum for glass fraternity to come together for closer interaction among themselves.

I extend warm greetings and felicitations to organizers and participants and best wishes for success of the event.

S C Bansal
President AIGMF

and Managing Director, Adarsh Kanch Udyog Pvt. Ltd./
Advance Lamp Component & Table Wares Pvt. Ltd, Firozabad (UP)

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The All India Glass Manufacturers' Federation

BHARAT SOMANY

Chairman
GLASSPEXINDIA 2013 International Conference

Executive Director
Glass Equipment (India) Limited,
The Engineering Unit of HNG & Inds. Ltd.,
Bahadurgarh, Haryana

It is my pleasure to present this special issue of Kanch being brought out on the occasion of GLASSPEX INDIA 2013 International Exhibition and Conference. The issue contains papers to be presented in the Conference in addition to regular matter published in Kanch.

With the cooperation of members we have been successful in securing participation of eminent experts to present papers on various aspects relating to Managing Sustainable Growth and Cost Efficiency in the Glass Industry.

I am sure that the presentations and interaction with speakers will help attendees in updating themselves about technological advancements in the Industry. I sincerely thank all the experts and their organizations / companies for their participation and the delegates who come to attend the conference.

I welcome one and all and hope you find GLASSPEX INDIA 2013 International Exhibition and Conference to be instructive, productive and fruitful.

Bharat Somany
Chairman – Glasspex 2013 International Conference Committee

About The All India Glass Manufacturers' Federation

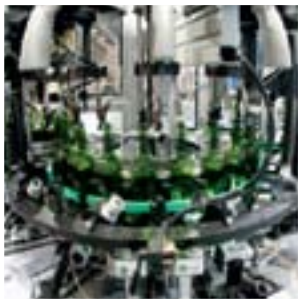
The All India Glass Manufacturers' Federation was founded in 1944. The Federation is made up of five Regional Associations viz. Western India Glass Manufacturers' Association-Mumbai, Eastern India Glass Manufacturers' Association-Kolkata, U.P. Glass Manufacturers' Syndicate-Firozabad, Northern India Glass Manufacturers' Association-Sahibabad, Ghaziabad (UP) and South India Glass Manufacturers' Association-Hyderabad. The Federation was incorporated under the Companies Act, 1956 (No. 1 of 1956) as a Limited Company on 15-6-1970. The main aims & objects of the Federation are:-

a) To encourage, promote and develop the manufacture of glass articles of all kinds and to safeguard and protect the interests of glass industry and glassware business in India.
b) To form a common link amongst Glass Manufacturers' in India and thus develop a spirit of mutual help and co-operation with one another.
c) To promote the study and research in Glass Technology.
d) To consider all matters relating to the manufacture and marketing of glass articles in India and the question of export and import thereof.
e) To devise ways and means for securing necessary supply of raw materials required for the manufacture of glass articles at comparatively lower prices and thus to decrease the cost of production and increase the national wealth.
f) To collect necessary information and data and propagate it for the benefit of Glass Industry and trade in India.
g) To make representations whenever necessary to the Union Govt. or any unit of the Union of India for the removal of difficulties that might hamper the trade of glass articles or for grant of special facilities for the Glass Industry.
h) To draw Government or public attention to the difficulties in the way of Glass Industry and to solve other problems confronting it and to solicit their help and support through concerted action.
i) To organise a united front on behalf of all glass manufacturers and thus strive to gain all those advantages which may not be possible through individual effort.

All those engaged in the manufacture of glass and glass articles are enrolled as 'Ordinary' members of the AIGMF and those associated with the Glass Industry are enrolled as 'Affiliate' members of the Federation.

Almost all glass manufacturers including many in the small Scale Sector are 'Ordinary' members of the Federation. Articles of Association of the AIGMF were amended in September 1992 to enroll foreign companies as Affiliate Members of the Federation.

Manohar Lal
Secretary AIGMF



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SEPR INDIA
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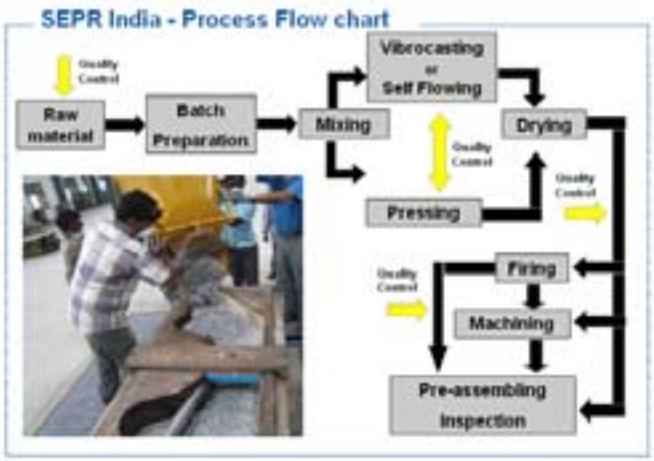
SEPR INDIA - Palakkad

SEFPRO is proud to announce its new state-of-the art manufacturing facility for Sintered Refractories in SEPR India Palakkad in their existing site where presently they make Fused Cast products. This plant is located in Palakkad, 60 km away from Coimbatore International airport.

SEPR India is using state-of-the art equipment with western technology. Its workshop for pre-assembly offers unique opportunity to preassemble Sintered and Fused Cast refractories both produced from SEPR India.

Both mechanical press and vibrocasting processes are available on site to offer a complete portfolio for Sintered products.



The product range includes Sillimanite, Mullite, High Alumina, Sintered AZS and Zircon, all specifically designed for the Glass Industry.

Sintered products made at SEPR India can be used for various glass furnace applications in the container, tableware, fiber glass, flat glass, and specialty glass field. Main applications include rider arches, transition blocks, regenerator wall, paving first back up layers, paving for melter area, foreheart glass contact and superstructure, Furnace crown, peep hole, burner block etc...

Technology transfer has been completed from Savoie Sintered plant in France to SEPR India with the support of our strong R&D capability. All products are made to the same high quality standards as in Savoie Refractaires sites in France whose performance has been recognized worldwide.

Sintered Products Manufactured by SEPR INDIA

	Mechanical Pressing	Vibro Casting	Key Component
Sillimanite	MS 6	ARKAL 60 V	61% Al_2O_3
Mullite		ARKAL 65 V	67% Al_2O_3
	MS 4		72% Al_2O_3
	MS 75 *		75% Al_2O_3
	BP MULLITE *	BP MULLITE V *	75,5% Al_2O_3
High Alumina	AL 100	BPAL	93% Al_2O_3
		HPAL	94% Al_2O_3
Bonded AZS		ZA 33	10,5% ZrO_2
	PROMOLD *	PROMOLD *	28,5% ZrO_2
	ERMOLD 300 *	ERMOLD *	31% ZrO_2
Zircon		CZCT	63% ZrO_2
	ZPR		65% ZrO_2
	CZ 66	CZ 66	66% ZrO_2

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We would like to thank you, on behalf of Saint-Gobain SEFPRO, for your continuous trust and support. The Saint-Gobain SEFPRO team looks forward to welcoming you in Palakkad!

Thierry Azencot, Marketing and Sales Director, Savoie Réfractaires, Saint-Gobain SEFPRO.

For more information please contact: thierry.azencot@saint-gobain.com

Glass News INDIA

AGI GLASPAC INSTALLS FIRST GIA INSTALLATION IN INDIA

Gedevelop supplied the Gob Image Analyser with a Gob Weight Controller unit. The system was aimed at their Line 25 double gob operation, at the time of producing jars, at the Hyderabad plant. As they were planning to also go NNPB, the system was equipped with Individual Needle Control function to give the operators full control over the forming process.

This was AGI's first system utilizing automatic gob weight control and the operators showed a big acceptance of the system.

The documentation on installation was concise and easy to follow as was the training documentation. A good level of understanding from the AGI staff simplified the training sessions. Gedevelop's engineer on-site Mr. Jesper Modig went through all benefits and features together with AGI staff at all levels who were all well prepared. All this resulted in the installation going smoothly with minimum downtime.

Representatives of Gedevelop and Mascot

The system has been running without problem since the installation.

"As the GIA concept is designed for all the bottle forming processes we now have the possibility to easily switch between jobs on the same machine and still maintain high level of quality." says Mr. S.P. Chanda, Sr. Vice President Technical at AGI.

B.V. Mr. Rambabu, Asst. Vice President Production also would like to point out that repeatability is a keyword in this kind of production. "The importance to find optimal needle/shear setup to ensure proper gob loading and the possibilities of following the process with reference gobs in the GIA helps us in the task of having a consistent gob forming process" and also added that a significant reduction of job change time could be observed.

TURKISH GLASS MAJOR ACQUIRES 45% STAKE IN HNGFLOAT GLASS LIMITED

Turkish Glass maker Trakya Cam Snayii AS bought a 45 per cent stake in HNG Float Glass Limited (HNGFL) through a joint Venture (JV) agreement.

According to the JV, Hindustan National Glass and Industries Ltd. (HNGIL), the share-holding company in HNGFL and its promoter, the Somany family, will now dilute their stake in HNGFL.

HNGIL is one of India's leading glass manufacturers, with a total production capacity of 4,300 tonnes per day. It promoted HNGFL in 2006. Trakya Cam Sanayii AS, which was founded by Sisecam in 1978, is the leading

company in the flat glass market in Turkey and a pioneer in the region. The company reached $751 million net sales with 2,768 employees in FY 2011.

Trakya Cam Sanayii AS had taken a strategic step in 2009 with the decision to jointly develop its flat glass activities with Saint-Gobain, one of the biggest companies in the industry.

HNGFL is engaged in the business of manufacturing float glass and related value added float glass products.

The company's plant is located in Halol, Gujarat with the current capacity of the furnace being 600 tonnes per day.

PLANET CERAMICA PRIVATE LIMITED COMMISSIONS NEW GREEN FIELD GLASS PROJECT

Planet Ceramica Private Limited has commissioned new green field glass project in January 2013 with a responsibility of complete turnkey project management from conceptualization stage along with complete planning, budgeting, engineering, selection of plant and machinery, vendor selection, plant integration, erection & commissioning under single point responsibility.

The project has been set up with fully state of the art equipments of global standards to manufacture 5.1 expansion neutral borosilicate glass for primary pharmaceutical packaging for our client M/s. Cogent Glass Ltd, Hyderabad, India.

This is the first plant in the world which manufactures 5.1 expansion neutral borosilicate glass moulded vials and also manufacturing moulded vials & tube drawing from the same furnace.

It was a great challenge for the company, as no body in the world has attempted this before and many people associated with this segment globally have never believed that this project would be successful till we commissioned the plant and proved.

SIEMENS LAUNCHES SIMATIC S7-1500 CONTROLLER FAMILY ALONG WITH UPDATED VERSION OF ITS TOTALLY INTEGRATED AUTOMATION PORTAL (TIA PORTAL)

With the launch of SIMATIC S7-1500, Siemens Industry Sector's Industry Automation division announced the introduction of a whole new family

of next generation controllers for medium to high-end machine and plant automation. The new generation of controllers is characterized by high performance and efficiency and offers numerous benefits such as integrated motion control, plant security, and safety applications that are easy to implement. Greater efficiency is represented in particular by the innovative design that enables simple commissioning & safe operation, by the configurable diagnostic functions that provide the plant status and by the integration into the TIA Portal for simple engineering and low project costs.

With regard to overall performance, the technology, security, safety and system performance have been considerably improved. In order to increase efficiency, further developments have been made specifically in the areas of design and handling, system diagnosis and engineering with the TIA Portal.

Commenting on the new product S7-1500, Mr. Bhaskar Mandal, Executive Vice-President, Industry Sector, South Asia, Siemens Ltd, said "Being in the Indian market for decades, Siemens has a thorough understanding of the industry needs and has continuously designed products and solutions that help our clients maximize productivity and increase efficiency. The new SIMATIC S7-1500 controller sets new standards for maximized productivity. This benefits small-series machines as well as complex installations that place high demands on speed and deterministic communication. The SIMATIC S7-1500 is seamlessly integrated in the Totally Integrated Automation Portal (TIA Portal) for maximum engineering efficiency."

Engineering framework for automation and drive technology extended

Siemens Industry Sector's Industry Automation division also announced the enhancement of its "Totally Integrated Automation Portal" (TIA Portal) engineering framework with numerous new functions. Version 12 enables all Siemens drives of the Sinamics G converter series to be parameterized via the TIA Portal, and additional diagnostic functions have also been integrated. Among other things, the safety functionalities have been extended for SIMATIC S7-1500 and the Profinet communication performance has been expanded.

The programming languages have been trimmed for even greater efficiency and new security functions provide improved protection of know-how, and better security against copying and access. Within the framework of the new version of the TIA Portal there are also updates for engineering tools for the configuration, programming, commissioning and servicing of the Siemens automation devices and drive systems. These include, for example, the following engineering systems: SIMATIC Step 7 V12 for SIMATIC controllers, SIMATIC WinCC V12 for HMI systems (SIMATIC HMI) and Sinamics Startdrive V12 for the Sinamics G converter family.

Mr. Mandal adds, "Integration of automation platforms in a manufacturing environment is vital to avoid automation islands. While our current version of Totally Integrated Automation portal performs automation and drive tasks quickly and intuitively, the new version provides seamless drive integration, integrated system diagnostics and safety functionality along with a powerful Profinet communication."

The Siemens TIA Portal is designed for high efficiency and user-friendliness, and it is suitable for both first-time users and experienced users. It offers a standardized operating concept for controllers, human machine interface (HMI) and drives, for shared data storage and automatic data consistency, for example during configuration, communication and diagnosis. It also offers powerful libraries covering all automation objects.

In its latest Version 12, Siemens has extended the TIA Portal to include numerous functions for drive integration, system diagnosis, safety, Profinet communication, security and programming language.

(Glass News Source: World Wide Web)

Updated Contact Details

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Papers to be presented in 10th International Glass Technology Conference of the AIGMF, themed 'Managing Sustainable Growth'

(March 20-21, 2013)

BATCH3: The integrated concept for batch handling at the furnace provides economic and ecological benefits

Richard Sims / Fred Aker
Nikolaus Sorg GMBH & Co. KG

The industry is under huge pressure to reduce energy consumption but further improvements are difficult to find. The energy distribution of a typical end-fired container furnace shows little room for further reductions. However, the waste gases leaving the regenerators contain 20 - 25 % of the total applied energy, The recovery of some of this waste heat can lead to an important reduction in energy consumption. (figure 1)

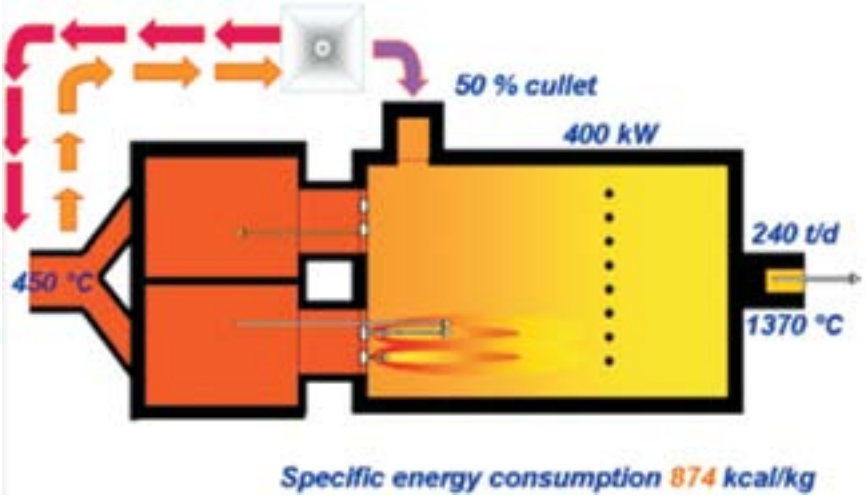

Figure 1 : the reference furnace

The most efficient energy recovery systems are those that return the energy directly to the glass melting process, and the use of the waste gases to preheat raw materials would be a good example of this.

We can look at a specific furnace for an example of the potential offered by batch preheating. The furnace is an end-fired regenerative unit with a melting capacity of 240 t/24 h, used to produce green glass, with 50 % cullet and 400 kW electrical boost. The temperature of the waste gases leaving the regenerators is 470 °C, which means that the gases have an energy content of approximately 3000 kW, equivalent to approximately 25 % of the total applied energy. (figure 2)

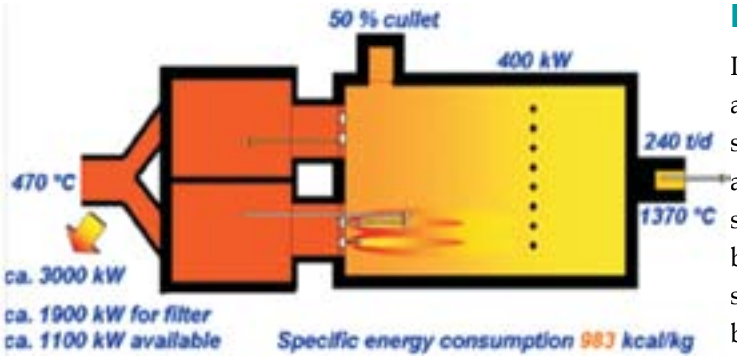

Figure 2 : the reference furnace with a batch preheater

Operation of the electrostatic filter downstream requires a certain minimum temperature, so not all the waste gas energy is available for recovery. Nevertheless, more than one third, equivalent to about 1100 kW, could be returned to the process.

Calculations based on operating data collected during an extensive development and testing programme show that the use of a batch preheater on this furnace would lower the specific energy consumption from 983 to 874 kcal/kg glass, a reduction of more than 10 %. (figure 3)

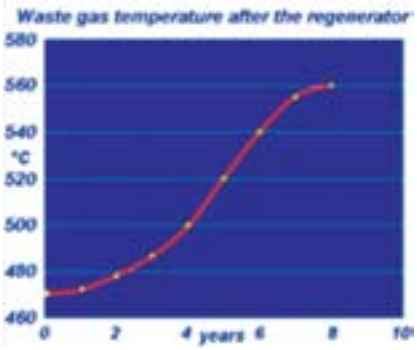

Figure 3. Effects of regenerator aging

Claims of energy savings of 11 – 20 % can be found in the published literature. The relatively wide range of such figures can be explained, at least partially, by the fact that the potential for energy saving by waste heat recovery outside the furnace depends initially on the efficiency of the furnace itself. Higher thermal efficiency of the furnace diminishes the potential for external systems such as batch preheaters.

Another interesting aspect of furnace performance is the drop in efficiency of the regenerators during the furnace life. Measurements taken over the lifetime of an actual furnace show a gradual increase in the waste gas temperature, equivalent to a 10 % increase in specific energy consumption. This effect can potentially be compensated by the use of a batch preheater.

BATCH PREHEATING

In view of the well-documented potential advantages of batch preheating it may be surprising to discover that very few systems are actually in commercial use. The reason for this is simple – there is a major technical problem with batch preheating. Preheated batch readily forms solid clumps that can easily cause mechanical blockage of the preheater. (figure 4)

Figure 4 : typical batch clumping

The problem can be reduced if a cullet ratio of at least 50% is used. But this is impractical for many manufacturers. To ensure stable operation it may also be necessary to reduce the water content of sand and cullet, which is both difficult and costly.

The problem of clumping is caused by the ability of soda ash to absorb water, which is then released during the preheating. Soda ash can exist as a monohydrate (1 molecule of water), heptahydrate (7 molecules) or decahydrate (10 molecules of water). The decahydratecan form easily at ambient temperatures if sufficient water is available, but then degrades to hepta and then to monohydrate as the temperature rises above 35 °C. This leads to the release of vast quantities of water.

The process is described by :

$$Na_2CO_3.10H_2O = Na_2CO_3.H_2O + 9H_2O$$

A temperature of 35 °C is reached near the entry to the batch preheater. In existing designs the water cannot escape from the preheater and so it remains in contact with the batch materials. It begins to react with sand and limestone to form cement-like compounds that are both extremely stable and very hard. This leads to clumping in the low temperature area of the unit, causing blockages.

THE SORG BATCH PREHEATER

The new SORG batch preheating concept combines innovative features to allow a large part of the water

released by the soda ash to leave the preheater, so there is much less water available to cause clumping of the batch materials.

The batch in the collecting chamber at the top of the preheater has an open surface. Fresh material is charged and distributed onto this surface automatically. The waste gases are passed through closed heating pipes in the batch, and these pipes can be vibrated as and when required to destroy any residual clumps.

As the batch temperature rises above 35 °C water is released by the soda ash and most of this can leave the system through the open batch surface in the collecting chamber. Any remaining clumping is destroyed by the vibration of the heating pipes. Water vapour and dust are removed continuously from the collecting chamber by a suction fan.

A 250 ton per day unit has been in operation since October 2011.(figure 5) This preheater was added on the fly during the furnace campaign. With the exception of a planned inspection, all of the batch materials for this container furnace have been preheated and fed through the preheater resulting in increased tonnage, reduced electrical boosting and 12% overall energy savings.

Figure 5 : Production Preheater 250t/d

DUSTING

The advantages of batch preheating are well documented, and the new SORG preheating system provides a practical solution to the problems normally associated with the process. However, the use of batch preheating can lead to another significant problem – that of dusting in and around the furnace.

External dusting can cause damage to nearby equipment or result in attack of crown refractories.

Internal dusting is potentially a far greater problem. Increased batch carry-over into the regenerators can lead to attack and blockage. There are reports of the necessity to clean the regenerator packing regularly from below when batch preheating is used – a dangerous and expensive procedure.

In order to solve the dusting problem SORG has developed an integrated concept for batch handling at the furnace - BATCH3. This is specifically designed to alleviate the dusting problems caused by batch preheating.

BATCH3

The BATCH3 concept consists of 3 elements :

- the batch preheater
- a new batch charger
- a new doghouse concept

The batch preheater can recover energy from the waste gases, and is capable of continuous operation without blocking. The other components of the concept ensure that the use of the batch preheater does not cause additional problems.

THE EME-NEND BATCH CHARGER

The new **EME-NEND charger (**figure 6**)** features a combination of multiple screw feeders and a pusher.

Figure 6 : The EME-NEND batch charger

The screws are controlled by individual frequency converters that provide independently variable charging speeds. The pusher drive is independent of the charging function.

The design offers important advantages compared with a conventional pusher charger :

- multiple screws produce smaller batch piles (figure 7)

Figure 7 : The improved charging pattern

- independent control of the screws gives a better charging pattern without having to move the charger
- the independent and effective pusher action gives a positive impetus to the batch piles
- the use of screw feeders reduces local dusting
- the doghouse is completely sealed

The sealed doghouse eliminates external dusting. More importantly, it also prevents uncontrolled entry of air through the doghouse.

The new charger significantly improves the charging pattern in the furnace with more, smaller batch piles.

The **EME-NEND charger** represents a major advance in charging technology, as well as being an important part of the SORG **BATCH3** integrated concept for batch handling at the furnace.

THE IRD DOGHOUSE (figure 8)

Early glazing of the batch surface is an effective method of preventing dusting in the doghouse and reducing batch carry-over. The SORG IRD doghouse incorporates two major changes to conventional doghouse design to ensure that surface glazing of the batch piles is completed before the piles leave the doghouse :

- the doghouse is larger to increase residence time

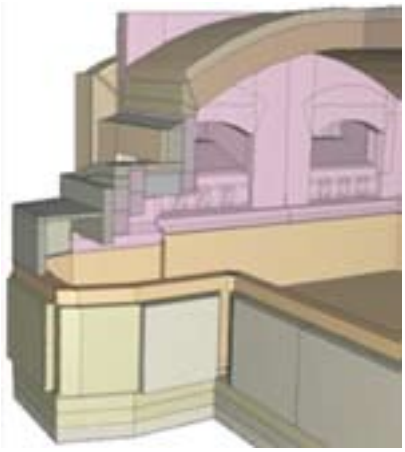

Figure 8 : The IRD doghouse

- the doghouse crown is raised to allow more radiation into the doghouse from the hotter areas of the melter.

The combination of more time and higher temperatures is sufficient to ensure that glazing of the surface takes place before the batch piles leave the doghouse.

Mathematical modelling shows that glass temperatures below the surface remain high enough even without additional heating. Very low gas velocities are found in the super-structure of the new doghouse. This means there is no dust pick-up from the rear of the doghouse where the batch piles have not yet had time to glaze over. The testing also indicates that use of the new doghouse design will result in a decrease in the extent of the batch coverage in the furnace.

THE BATCH3 CONCEPT – WHERE ARE WE TODAY?

The **EME-NEND batch charger** was the first part of the **BATCH3 concept** to be introduced. The first installation on an operational furnace was commissioned in March 2010. Operational experience has confirmed the expected improvement in the charging pattern, whilst the ability to seal the doghouse has eliminated external dusting.

On one furnace a conventional pusher was replaced by an **EME-NEND charger**. Comparative measurements made before and after the change show a 10 % reduction in the NO_x emission from a base level of less than 800 mg/Nm³. The values found with the new charger are lower and more stable than the preceding values (see figure 9).

Over 30 machines have already been sold, and

interestingly, the glass manufacturer that hosted the initial installation has now installed **EME-NEND**

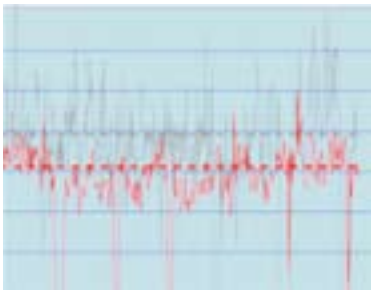

Figure 9 : direct continuous NO_x measurements, grey - conventional pusher charger, red - EME-NEND charger

machines on all 4 of their regenerative furnaces. On three of them the conversion was carried out during normal operation – surely a remarkable testimony to the capabilities of this machine.

At the end of 2010 the first **IRD doghouse** was commissioned on a 250 t/24 h furnace producing green containers. Standard green, olive and dead leaf have already been produced. The installation has confirmed the modelling predictions in terms of temperatures and residence times. The atmosphere in the doghouse is not affected by that in the melter.

Thermgraphic mapping shows the much higher internal temperature of the **IRD doghouse** (figure 10, right) compared with a conventional doghouse (figure 10, left).

Most importantly, the surface of the batch piles leaving the new doghouse are clearly glazed over (figure 11), and so the primary purpose of the new design is being achieved.

There is no doubt that the **IRD doghouse** reduces batch carry-over from the doghouse area and so makes the use of a batch preheater possible without the normal dusting problems.

Some question has been raised about the

Figure 11 : glazed-over batch piles leaving the IRD doghouse

influence of the new doghouse design on the energy consumption of the furnace as the **IRD doghouse** has a significantly greater surface area than conventional doghouse designs.

The conventional doghouse has considerable radiation losses from open areas, even though the areas themselves may be quite small. It also loses energy as a result of the inflow of cold air or the outflow of hot waste gases (depending on the furnace pressure in the melter). Summating all losses the conventional design actually has higher total losses than a comparable **IRD doghouse**.

Another benefit of the IRD doghouse has been a significant reduction in regenerator plugging due to batch carryover.

The **batch preheater** was the initial target of the development programme that has resulted in the **BATCH3 concept**. The first installation was so successful that we have a repeat order from our initial customer. The second SORG® batch preheater will be going into operation in spring 2013.

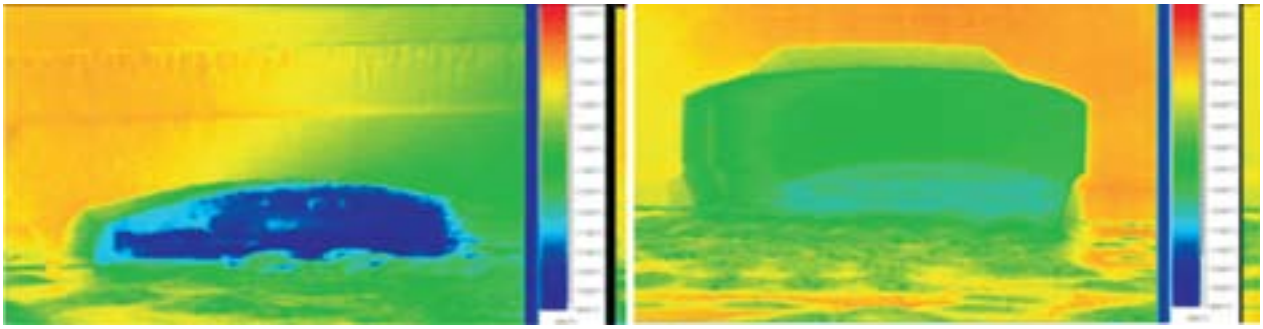

Figure 10 :Thermographic maps, conventional doghouse (left) and IRD doghouse (right)

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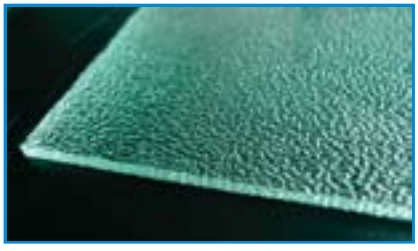

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Practical application results of new FLAMMATEC™ FLEX gas burner in float and container glass

Petr Vojtech
FlammaTec Ltd.

Abstract

There is a new situation in the world reflecting the economy, an increase in the price of oil, as well as a strong environmental concern that is causing a growing interest in use of natural gas in glass melting furnaces. It is a well known fact that control of the flame shape, its radiation and NOx production requires an advanced level of the furnace port design. Burner design, the burner operation, practice and the conversion from oil combustion is very important as well. A new advanced burner system, FlammaTec™ Flex, with highly adjustable flame controls has now been proven as a successful next step in the natural gas – air combustion systems. This presentation's aim is to introduce this combustion system and show some practical results from common operation in glass melting tanks as well.

SHORT INTRODUCTION

FlammaTec was found in year 2006 as a daughter company of Glass Service Czech Republic and STG Germany. The reason for founding of this company was the growing request new combustion systems, which are able to achieve lower energy consumption and lower NOx level in glass melting processes with using of natural gas as primary fuel.

First burners were installed in 2007, after developing period with using of mathematical simulation and previous practical knowledge, experience and theoretical background of combustion process in industrial furnaces.

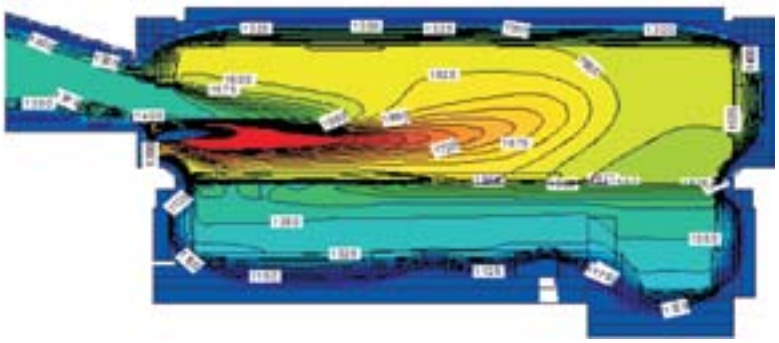
Main difference between FlammaTec concept and other existing system is in usage of two totally independent gas streams into one burner body – one stream is used for inner gas nozzle, second one for burner outer tip.

HISTORY OF DUAL GAS INJECTOR BURNERS

Dual gas injector burners are not a new technology and have been known since at least the 1960's. This concept had two (2) concentric pipes with two (2) separate gas streams.

Such dual gas injector burner was used in SkloUnion glass manufacturer since 1970. The construction was simple without any optimization. The burner required two (2) gas inlets with different pressure.

Newer generation of twin gas stream burners was



introduced during 1990's. These burners had only one (1) gas inlet with the two (2) gas streams separated inside the burner.

The common feature of all of these burners is that the gas enters the burner by only one (1) pipe with the second gas stream separated inside the burner.

FlammaTec utilizes a complete two (2) gas stream concept with new advanced features such as:

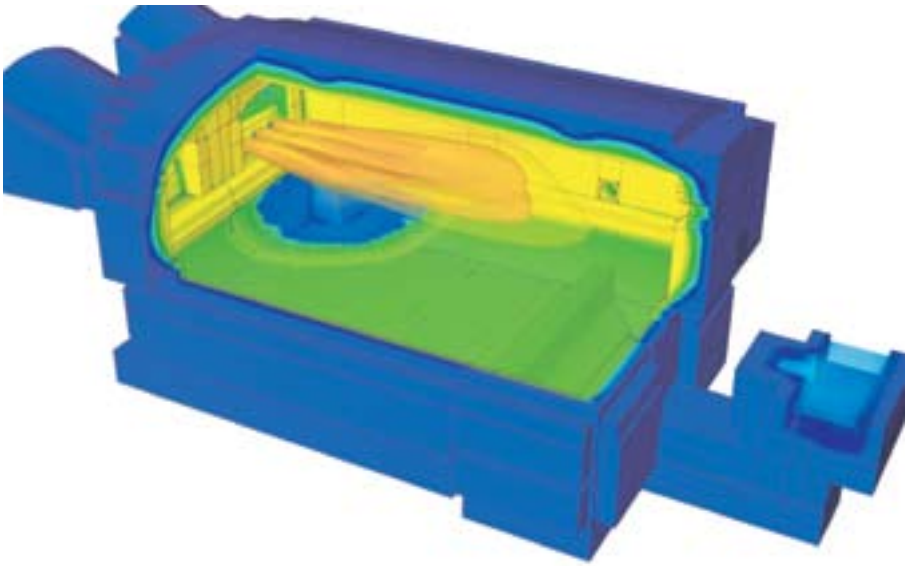
- Two (2) fully separate gas flows and control and measurement
- Adjustable burner nozzle
- Optimized burner tip using advanced computer simulation

Precise flame control and optimization of the turbulence within the flame resulted in highly radiative flame producing low levels of NOx.

Practical results, achieved after hot conversion from old conventional burner to FlammaTec burners are in following table:

CONCLUSION

- flame is easy to tune from short turbulent shape up to a long low turbulent shape and highly luminous flame
- highly luminous stable flame is achieved
- batch melting was enhanced after a change to FLAMMATEC burner creating shorter batch piles
- bottom temperatures were visibly increased, allowing glass quality improvements and a fuel reduction
- The practical results fully confirmed the expected benefits and almost one hundred furnaces are fired with FlammaTec burners worldwide.



	PREVIOUS BURNERS	FT BURNERS	IMPROVEMENT %
End fired furnace - tableware			
Total energy consumption Nm3/h	648	612.3	5.51
Specific energy consumption MJ/T	5209	4922	5.51
NOx level	not measured	not measured	
End fired furnace -container			
Energy consumption Nm3/h by natural gas	1005	963	4.18
Specific energy consumption MJ/T	3.66	3.54	3.28
NOx level	920	650	29.35
End fired furnace - tableware			
Total energy consumption Nm3/h	543	514	5.34
Specific energy consumption MJ/T	5135	4861	5.34
NOx level	2375	1625	31.58

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Optimisation by automation

Paul Schreuders
XPAR Vision

A strategic partnership between XPAR Vision and Bottero aims to control and optimise the forming process by automation. Using their respective systems as a basis, automated control loops with different functionalities are formed. Marketed under the name BoX, these automated control loops are discussed by Paul Schreuders and Gianclaudio Borsarelli.

BoX is represented as a black box; the automated control loops are intelligent software that is complex in itself but easy to use. Because many automated control loops can be considered, the BoX is set up as a modular system and thus, is designed for the future. Each module optimises and automates a specific sub-process of the glass forming process. With the modular approach, a customer can make a choice for only those modules that have relevance to specific glass forming processes.

The philosophy behind the BoX is that automatic control is much faster, repeatable and accurate than manual control. Besides, an operator hardly has the time or the knowhow to adjust the settings of the IS machine (up to 48 cavities) to optimise the glass forming process. The BoX calculates optimal settings every minute and performs optimised corrective actions against every disturbance due to changes in the forming process, for example ambient temperature, glass temperature, IS machine wear etc. In many cases, manual control is simply impossible and/or certainly not as effective.

In the first phase, two different BoX modules have been developed and tested and both are now ready to present to the market at glasstec 2012 exhibition in Düsseldorf this October.

MODULE 1: WARE SPACING

Ware spacing is the distance between bottles on the conveyer belt. The more even this distance, the better the transport on the conveyer belt. Better, stable transport means less fallen and stuck ware on the belt, less coating hood jams and reduced levels of fallen ware in the annealing lehr. Properly organised transportation is also a precondition for speed increases.

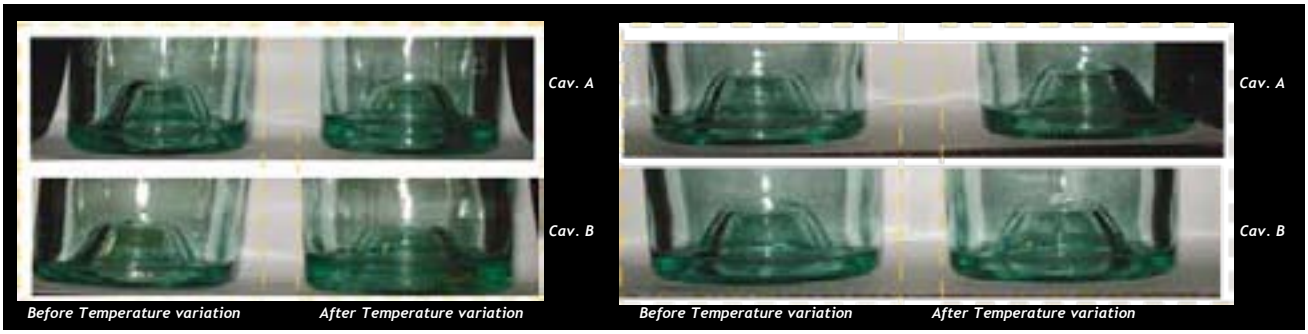
Even more importantly, with properly organised transport, the shop floor remains free from glass and is therefore safer. Furthermore, the operator's workload reduces significantly, allowing him to focus on other forming process parameters.

The BoX automatically controls and optimises ware spacing. The result is stable ware spacing between all sections/cavities. After a job change, the ware spacing module takes control and ware spacing is optimised automatically. No time is wasted transferring faulty bottles into the lehr. Simply press the start button and the BoX takes control.

As proved by several customer trials, the accuracy of this automated control loop goes beyond what the best operator/specialist is capable of achieving. Figure 1 presents the mean squared error of the ware spacing in time. It is obvious that manual control leads to a much higher mean squared error than automatic control.

In this example, the bottles were positioned on the conveyor with a distance variation between the bottles of less than 0.3°! This distance variation is automatically kept low, because the automatic feedback corrects the ware spacing continuously and takes the correct corrective actions every minute against changes in temperature, speed fluctuations etc. >

Figure 1: Ware spacing overview.



Effects on glass.

MODULE 2: VERTICAL GLASS DISTRIBUTION

Vertical glass distribution is the distribution of glass from top to bottom. It tends to drift over time, for example due to fluctuating ambient temperatures (day and night rhythms) and fast changes in the cooling capacity of IS machines due to weather changes. In addition, unwanted changes in the forehearth are common causes of change in vertical glass distribution.

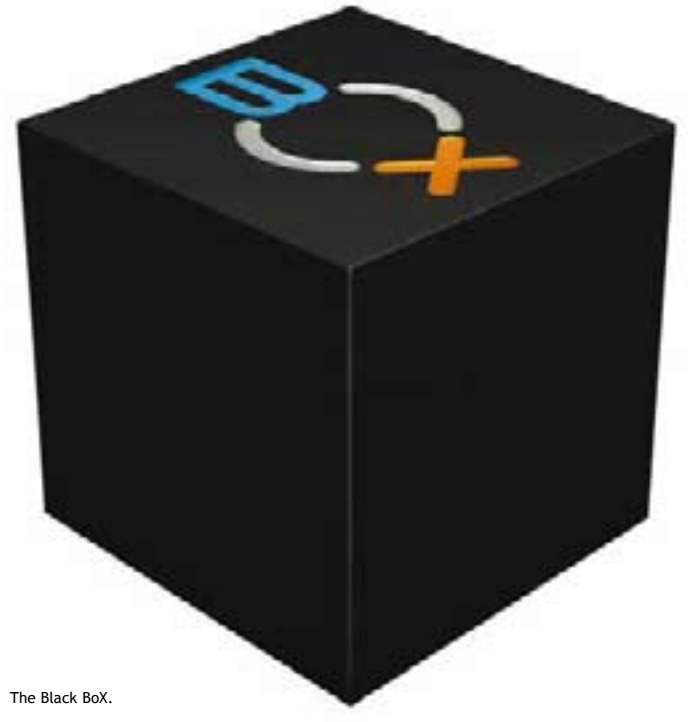
Less variation in vertical glass distribution means less quality problems related to glass distribution, as there are thick/thin bases, thin spots, thin necks etc. Also, the IS machine will run more smoothly, as the number of outliers reduces due to stable glass distribution.

The aim of this control loop is to achieve a stable and repeatable vertical glass distribution across all cavities and to make vertical glass distribution independent from ambient temperature fluctuations (day/night) and from feeder (glass) temperature fluctuations, whereby human interaction is excluded.

Unlike the ware spacing module, controlling vertical glass distribution goes beyond current operator and specialist capability. This control loop brings controlling functionality to the glass forming process, which brings the forming process as a whole to a higher level of control. As such, this control loop is the key towards the future of operating an IS machine.

Figure 2 shows the effects of the vertical distribution module on glass. Shown at left is the situation without BoX control, where it can be seen that a variation in gob temperature leads to a thick base. In the right-hand image, the gob temperature also changed but due to BoX control, there is no difference in glass distribution at the base.

With these automated control loop systems, forming process variation and thus forming process performance can be improved dramatically. As a result, the number of so-called outliers will reduce and thus, fewer critical defects will be produced. A leap in improvement is within reach with regard to pack-to-melt, weight/volume ratio, speed of production, customer complaints and resorting. A better future is gaining shape!



The Black BoX.

THE FUTURE

The question arises what this future will look like. Without doubt, BoX automation has started and the next innovative step in the glass container industry has been taken. From what has been learned so far, the attainment of equal bottles from all different cavities seems to be within reach! This means that the control level of the forming process goes up and the variation in the forming process is minimised. Consequently, lighter and stronger bottles, produced at higher speed, are within reach. Moreover, dependence on machine operators and/or specialists is reduced, thereby refocusing their work priorities.

In the knowledge that the market requires greater flexibility, higher quality and lower costs, the BoX is a necessity; fulfilling customer demands is only feasible when the glass forming process can be automated and continuously optimised against external disturbances. ■

ABOUT THE AUTHORS:
Paul Schreuders is Chief Executive Officer at XPAR Vision and Gianclaudio Borsarelli is Hollow Glass Business Unit Leader at Bottero

FURTHER INFORMATION:
XPAR Vision BV
email: schreuders@xparvision.com
web: www.xparvision.com

Bottero SpA
email: claudio.borsarelli@bottero.com
web: www.bottero.com

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  - Selection of raw material
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Development of radiation burner for glass conditioning improvement

U.Imhof
HORN Glass Industries AG

Heat transfer through radiation is the most significant heat transfer mechanism at high temperature processes like glass production. In addition molten glass as a semitransparent media allows the radiation energy to be the most effective heat transfer mechanism in the glass bulk. Based on these facts HORN has developed the "H R – Burner" (High Radiation Burner) to be installed in fore hearth and distributor channels. Through combination of theoretical thermodynamic and material science and practical tests in a pilot fore hearth, the special design of burner and suitable material has been specified by HORN. Besides the development of the new burner, the fore hearth superstructure shape has been modified accordingly in order to succeed highest efficiency of firing system as well as fast and safe burner installation during construction. The radiation burner, utilizing high quality refractory material, emits radiant heat precisely to the molten glass without flame impingement. Fast and controlled heating in forehearth/distributor as well as improvement of glass thermal conditioning are the result of this new firing concept. Through the focused radiation to desired surface areas, effective independent control of left/right forehearth temperature even in a channel with asymmetric geometry is possible. The higher heating efficiency of this burner leads to significantly energy saving. Multi-functional features allow the burner a wide range of application in container glass, tube glass and fiber glass production. The new burner has been installed and proved in two real forehearthes.The mentioned improvements have been verified through evaluation of experimental data from running fore heads.

Tangible and intangible benefits of good ware handling

Elliott Seymour
Sheppe International Ltd

The title will be tangible and intangible benefits of good ware handling and look at how strong the link is with good bottle manufacturing and high quality pack percentage. If you get the ware handling right, you will get the manufacturing improvement in quality and quantity. The stakeholders in the business will all see the overall factory improvement. The best performing factories all have excellent ware handling. Good ware handling is often overlooked but its importance is like a chain link. If the chain link breaks or is weak, the customer and factory does not get the results desired.

Plant wide automation & energy optimization for glass industry

Dawidowski, Hans-Dieter and Sanjay B K
SIEMENS

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Answers for industry.

HOT Batch- the future of batch preparation

Dr. Philipp Zippe
ZIPPE

For more than 90 years, company Zippe Industrieanlagen has been dedicated to the field of batch preparation. The target in principal is still the same, to bring batch in the right and homogeneous composition and in the right quantity to the furnace, and that in a very reliable automatic manner. Major enhancements are possible, since we can also utilize the waste gas from the furnace and by such increase the batch temperature to a very high level.

Still about 30% of the total melting energy in container glass is usually heat losses through the stack. This high temperature (>400°C) of the flue gas is utilized inside the preheater and by such cooled down. A high gap between inlet flue gas temperature and the needed temperatures for the respective waste gas filtering equipment is beneficial for the economics of the preheater, as there is more potential energy available. Preheaters installed show energy savings between 10 and 14%. Besides energy and emissions savings, also an increase of total production capacity is possible.

Typical container glass installations vary between 250 and 400 tpd, with a cullet level of 40 to 80%. All preheaters so far are running in container glass, mostly using waste gas from regenerative type of furnaces. After the preheater the batch is totally dry and hot, so careful consideration needs to be taken on the batch handling. Insulated and very robust equipment has been applied and proven for such. Installations so far are in countries with relatively high energy costs. A waste gas filtering system is needed for the application, which mostly already existent in any case. Batch preheating is yet by far not the standard technology for all cases however it shows remarkable energy savings and constitutes a reliable and economical enhancement of batch preparation for many selected applications.

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Integrated pollution prevention and control in glassmaking

Bianca Maria Scalet discusses the European Industrial Emissions Directive 2010/75/EU and its main conditions for an integrated pollution prevention and control system for the glass manufacturing industry.

The Integrated Pollution Prevention and Control approach was introduced with the Council Directive 96/61/EC of September 1996, generally known as the 'IPPC Directive', which was in place for over 10 years. The IPPC Directive was codified in 2008 (Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control).

The IED is the recast of the IPPC Directive and six other directives related to industrial emissions into a single legislative instrument, with the main scope of ensuring the prevention and control of pollution, while simplifying the existing legislation and cutting unnecessary administrative costs.

The European Industrial Emissions Directive (IED) aims at preventing at source, reducing and as far as possible eliminating pollution arising from industrial activities, ensuring a high level of protection for the environment as a whole.

It requires industrial installations to be operated according to an integrated permit issued by competent authorities, which should contain emission limit values based on the implementation of Best Available Techniques (BAT). The implementation of BAT, while assuring compliance monitoring, should guarantee the protection of human health and the environment and contribute to providing a level playing field in the European Union by aligning environmental performance requirements for industrial installations.

Permits for industrial installations covered by the IED should contain emission limit values (or equivalent parameters and technical measures ensuring an equivalent level of environmental protection) for polluting substances listed in Annex II of the IED, as well as for other polluting substances that are likely to be emitted from the installation in significant quantities. The emission limit values should be set to ensure that, under normal operating conditions, the emissions of the installation do not exceed the emission levels associated with the best available techniques (BAT-AELs).

For this purpose, the IED requires the drawing up of reference documents for best available techniques (BREFs), based on an exchange of information with stakeholders and the adoption of the key elements (BAT conclusions) through committee procedure (Article 75 Committee composed by representatives of the Member States). BAT conclusions should be the reference for setting permit conditions.

IED APPLICATION

The manufacture of glass, including glass fibre and mineral fibres, with a melting capacity exceeding 20 tonnes/day is covered by the IED (Annex I – Categories of activities), as it was already covered by the former IPPC Directive.

The original Best Available Techniques (BAT) reference document for the Manufacture of Glass (GLS BREF) was drawn up between January 1998 and 2000; the document was officially adopted by the European Commission in December 2001. Its review process started in 2006 under the IPPC Directive and was finalised under the recently adopted Industrial Emissions Directive 2010/75/EU (IED).

The BAT conclusions for the manufacture of glass were submitted to the vote of the Article 75 Committee in November 2011, together with the BAT conclusions for the production of iron and steel. The document is now legally binding; it has been the first to be adopted under the IED and was published in the Official Journal of the European Union on 8 March 2012 (Commission Implementing Decision 2012/134/EU of 28 February 2012) in all official EU languages.

GLS BREF

The review of BREFs is a continuing process, which aims to update the information included in the documents with the latest measures and techniques to emerge, technologies or processes that are being successfully introduced into the specific industrial sector.

The review of the existing GLS BREF (originally adopted in 2001) was carried in the period 2007-2009 on the basis of the exchange of information between the members of the Technical Working Group (TWG).

The GLS BREF covers eight different sectors: Container glass, flat glass, continuous filament glass fibre, domestic glass, special glass, mineral wool, high temperature insulation wools and frits. Although, the high temperature insulation wools manufacturing sector does not fall under the IED, due to the small capacity of its furnaces (typically between 5 and 10 tonnes/day), the sector fully supports the objectives of the BREF and therefore, it is included in the GLS BREF.

The main updates and changes made to the document concerned the following parts:

- A general update of the document was necessary in order to include the latest EU Members (from EU-15 to EU-27 Member States).
- The latest topics were introduced, such as diffuse/fugitive emissions, noise and environmental management systems.
- Downstream activities were covered in a more systematic way, for each sector.
- The latest data on emission and consumption levels (Chapter 3) and specific data concerning techniques to consider in the determination of BAT (Chapter 4), in particular the performance levels from example installations, were added to the document.
- Chapter 6, concerning emerging techniques for the glass sector, was totally modified in order to report the >

most recent developments and applications of new techniques.
- A dedicated annex concerning costs and cross-media effects associated with the implementation of the different available techniques was added.
- BAT conclusions were significantly modified and adapted to the provisions of the IED, in order to draw up a standalone document.

BAT CONCLUSIONS

Since the final TWG meeting with related conclusions was held in December 2009 under the IPPC Directive and well before the publication of the IED, a transformation of the BAT conclusions into an IED-compliant document has been necessary; this was realised without altering the technical content agreed upon at the final TWG meeting.

In order to fulfil the definition of 'BAT conclusions' given in Article 3 (12) of the IED, a number of changes were made to the document, in particular, a short description of techniques and information to assess their applicability was included.

The added text was based mainly on the BAT chapter (Chapter 4) and to a lesser extent on other parts of the revised GLS BREF. The structure is an appropriate balance between details and user friendliness (size of the document), where information is reported to the extent necessary.

Any text that could give an interpretation of the IED provisions was removed from the BAT conclusions, as well as from other parts of the GLS BREF.

A short technical description of the different techniques identified as BAT is now given in the BAT conclusions. This addition may provide important elements for explaining the associated emission levels (BAT-AELs) and may also clarify some limitations to the applicability of the specific technique. This could be the case for:

- Dimensions of the necessary structure and consequent space limitations.
- Requirements for a specific temperature of the flue gases to be treated.
- Physical and/or chemical characteristics of the released materials (to air, water or soil), consequent to the use of the technique.

Information to assess the applicability of a technique is of great importance in order to determine the possibility to comply with a certain emission level that may depend on the type of technique applied. A technique which is successful in an application may have very different implications if used in a different sector or even at a different installation in the same sector.

Restrictions to the applicability of a technique may be associated with:

- Plant age; a different applicability to new or existing installations.
- Plant size; the technique may be applicable to small plants and not to large plants or vice-versa.
- Type of product with different characteristics and/or quality requirements.
- Factors involved in retrofitting the existing plant, eg space availability, existing structure and associated equipment.
- Technical restrictions, eg flue gas composition, available temperature window.
- Limited availability of specific raw materials and fuels, including the energy policy of the Member State where the installation is located.

It should be noted that the techniques reported in the BAT conclusions are neither prescriptive nor exhaustive. Other techniques that ensure at least an equivalent level of environmental protection may be used to comply with the emission limit values based on the BAT-AELs.

For the manufacture of glass, a total of 76 BAT conclusions are given, with 15 general conclusions applicable to the whole industrial sector and 61 sectoral BAT conclusions, all associated to specific BAT-AELs.

Among the BAT conclusions generally applicable to the whole glass industry, only three are associated to a specific BAT-AEL:

- Conclusions concerning carbon monoxide emissions from the melting furnace, with a BAT-AEL equivalent to 100mg/Nm^3, addressing in particular the application of primary techniques for the reduction of NO_x emissions.
- The conclusions on ammonia emissions when SCR or SNCR techniques are applied, with a BAT-AEL equivalent to <5 – 30mg/Nm^3.
- The BAT-AELs for waste water discharges to surface waters.

Other general conclusions cover the following aspects:

- The implementation of an environmental management system.
- A careful selection of substances and raw materials in order to control emissions at source.
- The prevention and minimisation of diffuse/fugitive emissions from material handling and storage.
- The minimisation of energy consumption by constant monitoring of the operational parameters and a programmed maintenance of the furnace and associated equipment.
- The monitoring of emissions and/or other relevant process parameters in order to ensure compliance (at least twice a year).
- Minimisation of boron emissions when raw materials containing boron are used in the batch formulation.
- The minimisation of solid waste that needs to be disposed of and cannot be recycled into the glass manufacturing process or employed in other external uses.
- The reduction of noise emissions.

In setting BAT-AELs for the eight sectors of the glass industry and for the different emission sources identified as significant, particular attention has been given to the most suitable expression of BAT-AELs and therefore, emission data. The manufacture of glass presents various situations, requiring a specific reference oxygen:

- 8% oxygen for continuous furnaces.
- 13% oxygen for discontinuous furnaces.
- 15% oxygen for frit melting furnaces.

The use of electric melting and oxy-fuel combustion have been specifically addressed, indicating in a dedicated table (Table 1.1 in the BAT conclusions published on 8 March 2012) the most suitable reference conditions for the melting activities carried out at a given installation.

For the melting activities, BAT-AELs are generally given both in concentration (mg/Nm^3) and specific mass emissions (kg/tonne melted glass). This approach allows taking into account the specifics of oxy-fuel combustion or oxygen-enriched air/fuel firing.

Some examples of BAT conclusions and associated BAT-AELs are summarised below.

DUST EMISSIONS

In general, the use of a secondary technique (filtration system or, in some specific cases, wet scrubbing) is indicated as the BAT for all sectors. Some distinctions were made for the continuous filament glass fibre, where a primary technique consisting of a different formulation of the melting batch is mentioned and for domestic glass production, where considerations concerning the economic viability of secondary techniques for furnace capacities <80 tonnes/day are mentioned.

For dust emissions, BAT-AELs of <10 – 20mg/Nm^3 are generally given, with the exception of some glass types applying batch formulations that may contain significant amounts of constituents meeting the criteria as dangerous substances, in accordance with the EC Regulation 1272/2008. In these cases, BAT-AELs were set at <1 – 10mg/Nm^3.

NO_X EMISSIONS

The use of primary techniques for the reduction of NO_x emissions from the melting furnace is considered BAT for all sectors of the glass industry.

Technique	Applicability
Combustion modifications	
Reduction of air/fuel ratio	Applicable to air/fuel conventional furnaces. Full benefits are achieved at normal or complete furnace rebuild, when combined with optimum furnace design and geometry.
Low NOX burners	The technique is generally applicable. The achieved environmental benefits are generally lower for applications to cross-fired, gas-fired furnaces due to technical constraints and a lower degree of flexibility of the furnace. Full benefits are achieved at normal or complete furnace rebuild, when combined with optimum furnace design and geometry.
Electric melting	Not applicable for large volume glass production (>300 tonnes/day). Not applicable for production requiring large pull variations. The implementation requires a complete furnace rebuild.
Oxy-fuel melting	The maximum environmental benefits are achieved for applications at the time of a complete furnace rebuild.
Selective non-catalytic reduction (SNCR)	The technique is applicable to recuperative furnaces. Very limited applicability to conventional regenerative furnaces, where the correct temperature window is difficult to access or does not allow good mixing of the flue gases with the reagent. It may be applicable to new regenerative furnaces equipped with split regenerators. However, the temperature window is difficult to maintain due to the reversal of flame between the chambers that causes a cyclical temperature change.

Table 1: Abstract text from the adopted BAT conclusions for the reduction of NO_X emissions.

Parameter	BAT	BAT-AEL	
		mg/Nm^3	kg/tonne melted glass[1]
NO_x expressed as NO_2	Combustion modifications, special furnace designs[2, 3]	500 – 800	0.75 – 1.2
	Electric melting	<100	<0.3
	Oxy-fuel melting[4]	Not applicable	<0.5 0.8
	Secondary techniques	<500	<0.75

1. The conversion factor for general cases 1.5 × 10-3 has been applied, with the exception of electric melting (3 × 10-3).
2. The lower value refers to the use of special furnace designs, where applicable.
3. These values should be reconsidered in the occasion of a normal or complete rebuild of the melting furnace.
4. The achievable levels depend on the quality of the natural gas and oxygen available (nitrogen content).

BAT-AELs for the use of nitrates and/or special oxidising combustion conditions, in the case of short campaigns or for melting capacities <100 tonnes/day.

NO_x expressed as NO_2	BAT	BAT-AEL	
		mg/Nm^3	kg/tonne melted glass[1]
	Primary techniques	<1000	<3

1. The conversion factor reported in table 2 for specific cases (3 × 10-3) has been applied.

Table 2: BAT-AELs for NO_X emissions from the melting furnace in the container glass sector.

In summary, the identified BAT based on primary technique are the following:

- Combustion modifications.
- Special furnace designs.
- Electric melting.
- Oxy-fuel melting.
- Fenix process (limited to the flat glass sector).

The definition of 'combustion modifications' includes a number of techniques, some of which extensively applied within the glass sectors (eg reduction of air/fuel ratio, low-NO_x burners) and characterised by different degrees of applicability, as reported in the adopted BAT conclusions.

The use of secondary techniques such as Selective Catalytic Reduction (SCR), Selective Non-Catalytic Reduction (SNCR) and chemical reduction by fuel (3R process applied only to flat glass furnaces) is considered BAT for the main sectors, in particular for the production of container, flat and special glasses.

In all cases, for each technique identified as BAT for the specific glass sector, information on its applicability is given, indicating technical restrictions and limitations to the implementation of the specific technique. As an example, a list of techniques potentially applicable to the glass industry for the reduction of NO_x emissions, together with the information necessary for assessing their applicability, is presented in table 1. The text has been extracted from the adopted BAT conclusions, as published in the OJ of the European Union on 8 March 2012.

The use of nitrates in the batch formulation for the production of special types of glass is addressed in the BAT conclusions, with special consideration to those situations when nitrates are used for short campaigns or for melting furnaces with a capacity <100 tonnes/day.

As an example, the BAT-AELs concluded for the container and flat glass sectors are reported in tables 2 and 3 respectively.

Parameter	BAT	BAT-AEL[1]	
		mg/Nm^3	kg/tonne melted glass[2]
NO_x expressed as NO_2	Combustion modifications, Fenix process[3]	700 800	1.75 – 2.0
	Oxy-fuel melting[4]	Not applicable	<1.25 2.0
	Secondary techniques[5]	400 700	1.0 – 1.75

1. Higher emission levels are expected when nitrates are used occasionally for the production of special glasses.
2. The conversion factor 2.5 x 10-3 has been applied.
3. The lower levels of the range are associated with the application of the Fenix process.
4. The achievable levels depend on the quality of the natural gas and oxygen available (nitrogen content).
5. The higher levels of the range are associated with existing plants until a normal or complete rebuild of the furnace. The lower levels are associated with newer/retrofitted plants.

BAT-AELs for the use of nitrates for the production of special glasses and in a limited number of short campaigns.

NO_x expressed as NO_2	BAT	BAT-AEL	
		mg/Nm^3	kg/tonne melted glass[1]
	Primary techniques	<1200	<3

1. The conversion factor 2.5 × 10-3 has been applied.

Table 3: BAT-AELs for NO_X emissions from the melting furnace in the flat glass sector.

SO_X EMISSIONS

The use of a secondary technique consisting of dry or semi-dry scrubbing, in combination with a filtration system is considered generally applicable for most glass sectors. Primary techniques, such as the minimisation of the sulphur content in the batch formulation and the use of low sulphur content fuels are also considered BAT, even though some constraints on their applicability are reported.

For the two main sectors, container and flat glass, BAT-AELs for SO_x emissions were set between 200 and 500mg/Nm^3 for gas-fired furnaces and 500 – 1300mg/Nm^3 for oil-fired furnaces. The lower levels are associated with conditions where the reduction of SO_x is a high priority over a lower production of solid waste, corresponding to the sulphate-rich filter dust.

The values adopted as BAT-AELs for SO_x emissions from the melting furnaces in the container glass sector may be difficult to achieve in combination with a high rate of recycling of external cullet and the recycling of filter dust. This concern has been expressed in a footnote to the table with the BAT-AELs.

CONCLUSIONS

The revised GLS BREF is the result of an extensive exchange of information and a good compromise between different positions expressed by industry and Members States. In general, BAT-AELs have been based on current emission data, accompanied by a certain degree of expert judgement, where available information was considered incomplete or weak.

The different characteristics and requirements of the eight glass sectors included under the scope of the GLS BREF have been taken into account when deriving BAT conclusions and setting BAT-AELs. However, some BAT conclusions and BAT-AELs may present a challenge for the glass industry. In particular, for some sectors the levels for NO_x and SO_x emissions may be onerous to achieve and maintain over time. ■

ABOUT THE AUTHOR:
Bianca Maria Scalet works at the European Commission DG Joint Research Centre (JRC) Institute for Prospective Technological Studies (IPTS) Unit Sustainable Production and Consumption

FURTHER INFORMATION:
European IPPC Bureau, Edificio EXPO – C/ Inca Garcilaso, Seville, Spain
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Special Glasses for Electro-Chemical Applications:

Part-I: Electro-Chemical Sensors

Prof. (Dr.) A. K. Bandyopadhyay
Technology Consultant & Ex-Principal,
Govt. College of Engg. & Ceramic Technology,
West Bengal University of Technology, Kolkata.
asisbanerjee1000@gmail.com

Abstract:

Technology is driven by the development of basic science, whose principles are eventually used in the design of various technologies, and glass technology is no exception in this respect. While appreciating the evolution of glass technology over many hundred years, comparatively speaking, development in the field of newer types of glasses and moreover on the newer types of applications is relatively recent. Some details on special types of glasses are presented for "electrochemical applications" for sensors in order to appreciate how the development takes place by the need of the society.

INTRODUCTION

Glasses have been used for various purposes for thousands of years. However, until recently, silicate glasses were the major type of material that was commonly used by the households, different industries, building and other construction purposes, decorative applications, etc. The advent of float glasses has also evoked a number of new applications **[1]**. During the past decades, so many new types of glasses have been discovered for satisfying different technical and other needs of human society. The method of fabrication of such type of so-called technical glasses with a wider composition range outside the realm of silicates comes into existence. The refinements of the process technology are continuously evolving for satisfying the needs of the hour, and thereby cutting cost and easy availability. In that sense, there is a similarity with those evolution processes of commercial silicate glasses. A comparison is beyond the scope of this present article.

These special or technical glasses are available in the form of both bulk and thin-films. From the business point of view, it makes sense for value addition and it gives a very good measure of "tonnage to investment" ratio. This might be one of the main reasons for their rapid development and also the expansion of the field of work, and thereby extending the range of their usage, e.g. in electro-chemical, electronic, magnetic and optical applications. Some of these applications could be considered predominant in the hi-tech domain.

Glassy materials have several advantages over their crystalline counterparts as far as applications are concerned. Generally

speaking, glassy materials are relatively much easier to fabricate: large areas **[2]**, homogenous thin-films **[3]**, complicated shapes **[4]** could be prepared. For example, Si:H for solar cell or thin-film transistors, while bulk glasses could readily be prepared from the melt of different volumes by relatively slower quenching procedure or by sol-gel route. Moreover, quite importantly, the material of fabrication could remain workable near the glass transition temperature. This means that the viscosity remains relatively low for the glass to be workable over the range of temperature so that it could be fashioned into various shapes and sizes, or drawn into fibres, as desired. It should be further noted that particularly bulk glasses are often structurally homogeneous and isotropic on macroscopic length scale (i.e. uniform property in any direction). As a result, the concerned physical properties are also isotropic and homogeneous unlike crystalline materials for which the intrinsic behaviour of even single crystals may be anisotropic (i.e. different values of a given property in different directions), and also the presence of 'grain boundaries' in polycrystalline samples could dominate the overall behaviour.

Therefore, the large-scale optical transparency is readily achievable, e.g. in silicate glasses for optical components including optical windows and fibre-optic cables for optical communication systems. The absence of structural defects, such as grain boundaries or dislocations as an area of concern in crystalline materials, also has a tremendous impact on the 'mechanical behaviour' and on the use of glassy materials in mechanical engineering applications. Due to this mechanical advantage, the glasses could often reach the 'ideal' value of mechanical strength and consequently the fibres of silica glass or ribbons of metallic glasses could be used as fibre-reinforcement elements in composite materials. It has to be noted that some of these composites could be very expensive in the aviation industry.

Moreover, glassy materials have another important advantage over their crystalline counterparts in getting a homogeneous structure even in the multi-component systems in a wide range of compositions. The physical properties are sometimes "additive" in nature, and they can be varied continuously by changing the percentage of one or more components within a particular base-glass composition. In this way, in the ornamental or decorative silicate glass matrix, the intensity of the colour can be controlled by varying the concentration of transition metal ions, i.e. colouring agents.

In this paper, one of the important technological applications of glassy materials is explored. In particular, here electro-chemical applications are considered in terms of electro-chemical sensors in Part-I. In the Part-II for the same application, solid-state batteries based on glassy materials will be described, i.e. it is focussed on two most popular applications in the field.

ELECTRO-CHEMICAL APPLICATIONS

2.1 Preamble:

The diffusion of different alkali ions, such as Na^+, K^+ or Li^+ and alkali metal ions, e.g. Ag^+ inside the glass matrix is important to understand different chemical behaviours of glasses. This diffusion is a thermally-activated process and hence to stop diffusion of such ions at higher temperature of exposure of a given glass could be somewhat difficult. Likewise, the same is true for the chemical corrosion of a glass at elevated temperature. This behaviour can be also due to a chemical gradient and an electric field gradient.

The ability of such ions to diffuse readily in oxide or chalcogenide (i.e. sulphur, selenium, and tellurium) based glasses in the present of a concentration gradient or an electric field opens up a range of options in the field of electro-chemical applications. For example, in energy storage (batteries), displays or chemical sensors, glassy materials can be good candidates by offering certain advantages in such applications over their crystalline or liquid counterparts. Glassy electrolytes that could be often made in the form of thin-film have more isotropic diffusion compared to many well-known crystalline electrolytes.

For commercial glass production, the difficult matter of electrochemical behaviour of glass melts and solid glasses that lays the foundations for a sound understanding of physico-chemical redox and ion transfer processes is of fundamental importance. Also, the interpretation of experimental results as well as the control of production processes, including refining, interface reactions

and thermodynamic equilibria of glass melts with refractories and the surrounding atmosphere, could be better understood with the knowledge of this behaviour.

2.2 The Definitions:

Electrochemistry is a branch of chemistry that studies chemical reactions which take place in a solution at the interface of an electron conductor (the electrode: a metal or semiconductor) and an ionic conductor (the electrolyte), and which involve electron transfer between the electrode and the electrolyte or species in solution.

If a chemical reaction is driven by an external applied voltage, as in electrolysis, or if a voltage is created by a chemical reaction as in a battery, it is an electrochemical reaction. In contrast, chemical reactions where electrons are transferred between the molecules are called oxidation/reduction (redox) reactions. In general, electrochemistry deals with situations where oxidation and reduction reactions are separated in space or time, connected by an external electric circuit. Oxidation and reduction always occur in a paired fashion such that one species is oxidized when another is reduced. This paired electron transfer is called a "redox" reaction.

An electrochemical cell is a device that produces an electric current from energy released by a spontaneous redox reaction. This kind of cell includes the Galvanic cell or Voltaic cell, named after Luigi Galvani and Alessandro Volta. Both scientists conducted several experiments on chemical reactions and electric current during the late 18^{th} century. Electrochemical cells have two conductive electrodes (the anode and the cathode). The anode is defined as the electrode where oxidation occurs and the cathode is the electrode where the reduction takes place. Electrodes can be made from any sufficiently conductive materials, such as metals, semiconductors, graphite, and even conducting polymers. In between these electrodes is the electrolyte, which contains ions that can freely move.

To provide a complete electric circuit, there must also be an ionic conduction path between the anode and cathode electrolytes in addition to the electron conduction path. The simplest ionic conduction path is to provide a liquid junction. To avoid mixing between the two electrolytes, the liquid junction can be provided through a porous plug that allows ion flow while reducing electrolyte mixing. To further minimize mixing of the electrolytes, a salt bridge could be used which consists of an electrolyte saturated gel in an inverted U-tube. As the negatively charged electrons flow in one direction around this circuit, the positively charged metal ions flow in the opposite direction in the electrolyte. A voltmeter is capable of measuring the change of electric potential between the anode and the cathode. Electrochemical cell voltage is also referred to as electromotive force or simply e.m.f.

2.3 Electro-Chemical Sensors:

At the interfaces between the cathode or anode and an electrolyte (i.e. a glass), there are certain electro-chemical processes taking place. This can be used to measure the concentration or activity of the electrochemically active ionic species in the electrolyte. This is done by simply monitoring the e.m.f. of the cell thus formed. Hence, if glassy materials have to be used as ion-selective electro-chemical sensors, they should satisfy the requirements for their use in the energy-storage or battery applications.

The so-called 'glass electrode' that is commonly employed to monitor proton activity or pH level of a given chemical solution is the breeding ground for the widespread use of glassy materials as an electro-chemical sensor **[5,6]**. In this type of sensor, a cell is constructed from the glass membrane in the form of a sealed tube containing an internal 'buffer solution' and reference electrode, i.e. the glass electrode, together with another reference electrode and both are in contact with the solution being measured. For the glass electrode, the glass that is used for the active membrane could be a simple alkali-silicate glass, if hydrogen ion concentration or pH has to be measured. Otherwise, various alkali-alumino-silicates or boro-silicate glasses could be employed, if the "alkali-ion selectivity" (pM, where M = alkali metal ion) is desired. Normally, one could use any glass as long as the type of alkali ion that is used as a "network modifier" in the glass electrode should be different from that which is desired to monitor the solution.

The mechanism underlying the operation of the glass electrode can be appreciated as follows **[6]**:

Let us consider a simple alkali-silicate glass. The surface of the glass electrode contains – Si – O – M′ groups, where M′ is the modifier ion in the glass, and it is in contact with an aqueous solution containing M^+ ions. The single "dash" on the left hand side of Si atom actually consists of three bond directions. Here, as said above, M′ and M^+ are different alkali metal ions. These groups will totally dissociate, as there are no M′ ions in the solution. In this condition, there will be a complete equilibrium that can be attained by the resulting surface 'siloxy' groups (-- Si – O^-) with the protons in the solution forming "silanol" groups as:

$$SiOH + H_2O \Leftrightarrow SiO^- + H_3O^+$$

For this reaction, the e.m.f. of the cell reaction can be written as **[6]**:

$$E = - (RT/F) \ln K_d + (RT/F)\ln [(a_{H3O} \, . \, a_{SiO-})/a_{SiOH}]$$

Where R is the gas constant, F is the Faraday's constant, K_d is the dissociation equilibrium constant for the silanol group reaction, and a_X is the activity of the respective species involved in the reaction process. Therefore, the above equation shows that the e.m.f. of the glass electrode should be linearly proportional to pH. This behaviour can be experimentally observed over a pH range of 10-11 units. The metal ion (pM) response of the glass electrode can be regarded as arising from an association equilibrium between siloxy group at the surface and metal ions in the solution as:

-- Si – O – M^+ (solution) $\Leftrightarrow$ -- Si –O^- . . . . M^+.

In this case, an expression similar to that of the above e.m.f. equation can be derived, whereby K_d is replaced by the 'association constant' (K_a) for the above equilibrium reaction. Here, a_{H30+} is replaced by a_{M+} and hence the e.m.f. is linearly proportional to pM.

As oxide glasses are used to normally fabricate ion-selective membranes, it was demonstrated that chalcogenide glasses (e.g. As_2Se_3) doped with an appropriate metal can be used as the basis for electro-chemical sensors for Cu^{2+} or Pb^{2+} ions, and Hg^{2+} or Cd^{2+} ions, respectively **[7]**. These sensors appear to be attractive, as the glasses are predominantly electronically conducting, rather than ionically-conducting. Hence, the problem with the reversibility at the interface between the membranes and the back contact are relatively minimized. Barium-boro-vanadates are glassy semiconductors that could also be used for this purpose **[8]**.

2.4 Newer Developments:

A majority of newer developments have taken place around nano materials or glasses containing different nano varieties. Electrochemical devices have the potential to pose powerful solutions in addressing rising energy demands and counteracting environmental problems. However, currently, these devices suffer from meager performance due to poor efficiency and durability of the catalysts. These suboptimal characteristics have hampered widespread commercialization. It was reported that $Pt_{57.5}Cu_{14.7}Ni_{5.3}P_{22.5}$ bulk metallic glass (Pt-BMG) nanowires had novel architecture and outstanding durability that could circumvent the performance problems of electro-chemical devices **[9]**. Pt-BMG nanowires were fabricated using a facile and scalable nano-imprinting approach to create de-alloyed high surface area nanowire catalysts with high conductivity and activity for methanol and ethanol oxidation. After 1000 cycles, these nanowires maintained 96% of their performance, i.e. 2.4 times as much as conventional Pt/C catalysts. Their properties make them ideal candidates for widespread commercial use such as for energy conversion/storage and sensors **[9]**.

A new approach was used to investigate a well-known chemical process, the propagation of electro-chemical signals through a thin glass membrane. This process, which has been extensively studied over the last century, is the basis of the response of a potentio-metric glass pH sensor, as no ampero-metric glass sensors have yet been reported because of its high ohmic resistance. Voltammetry at nano-electrodes has revealed that water molecules could diffuse through nanometer-thick layers of dry glass and undergo oxidation/ reduction at the buried platinum surface. After soaking for a few hours in an aqueous solution, voltammetric waves of other redox couples, such as $Ru(NH_3)_6$ could also be obtained at the glass-covered platinum nano-electrodes. This behaviour suggests that the nanometer-thick insulating glass sheath surrounding the platinum core could be largely converted to hydrated gel, and electro-chemical processes occurred at the platinum/ hydrogel interface. Potential applications range

from use in solid-state pH probes in the nanometer scale and determination of the water content in organic solvents to glass-modified voltammetric sensors and electro-catalysts.

CONCLUSIONS

In the Part-I of this article, the electro-chemical behaviour has been shown to be important for technical applications as sensors as well as in understanding the behaviour of both liquid and solid commercial glasses in terms of production processes. After a general introduction and basic definition of the process, the behaviour of glass sensors has been shown with required theoretical explanations. Some newer developments have been covered very briefly. Considering the widespread use of such sensors, it is argued that such materials should be produced in bulk volume with continuous research and development efforts, as the return on investment is quite high.

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Key Features of Indian **Union Budget (2013-14)**

GROWTH

India faces challenge of getting back to its potential growth rate of 8%

India must unhesitatingly embrace growth as highest goal

INVESTMENT, INFRASTRUCTURE AND INDUSTRY

- Communication with investors to be improved to remove any apprehension or distrust, including fears about undue regulatory burden
- Need of new and innovative instruments to mobilise funds for investment in infrastructure sector. Measures such as:
  - ➲ Infrastructure Debt Funds (IDF) to be encourged
  - ➲ IIFCL to offer credit enhancement
  - ➲ Infrastructure tax-free bond of ₹ 50,000 crore in 2013-14
  - ➲ Build roads in north eastern states and connect them to Myanmar with assistance from WB & ADB

Road Construction

- A regulatory authority for road sector
- 3000 kms of road projects in Gujarat, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh to be awarded in the first six months of 2013-14

Cabinet Committee on Investment

- The Cabinet Committee on Investment (CCI) has been set up. Decisions have been taken in respect of a number of gas, power and coal projects

New Investment

- Companies investing ₹ 100 crore or more in plant and machinery during the period 1.4.2013 to 31.3.2015 will be entitled to deduct an investment allowance of 15 per cent of the investment
- Incentives to semiconductor wafer fab manufacturing facilities, including zero customs duty for plant and machinery

Industrial Corridors

- Plans for seven new cities have been finalised and work on two new smart industrial cities at Dholera, Gujarat and ShendraBidkin, Maharashtra will start during 2013-14
- Delhi Mumbai Industrial Corridor (DMIC) to be provided additional funds during 2013-14 within the share of the Government of India in the overall outlay, if required
- Chennai Bengaluru Industrial Corridor to be developed
- Preparatory work has started for Bengaluru Mumbai Industrial Corridor

Ports

- Two new major ports will be established in Sagar, West Bengal and in Andhra Pradesh to add 100 million tonnes of capacity
- A new outer harbour to be developed in the VOC port at Thoothukkudi, Tamil Nadu through PPP at an estimated cost of ₹ 7,500 crore

National Waterways

- Preparatory work underway to build a grid connecting waterways, roads and ports

Coal

- In the medium to long term need to reduce our dependence on imported coal
- One way forward is to devise a PPP policy framework with Coal India Limited as one of the partners

Micro, Small and Medium Enterprises

- Benefits or preferences enjoyed by MSME to continue upto three years after they grow out of this category
- Refinancing capacity of SIDBI raised to ₹ 10,000 crore
- Another sum of ₹ 100 crore provided to India Microfinance Equity Fund
- A corpus of ₹ 500 crore to SIDBI to set up a Credit Guarantee Fund for factoring
- A sum of ₹ 2,200 crore during the 12th Plan period to set up 15 additional Tool Rooms and Technology Development Centres with World Bank assistance

Foreign Trade

- Support to measures to be taken to boost exports of goods and services

FINANCIAL SECTOR

- A standing Council of Experts to be constituted in the Ministry of Finance to analyse the international competitiveness of the Indian financial sector

OTHER PROPOSALS

Skill Development

- Target of skilling 50 million people in the 12th Plan period, including 9 million in 2013-14

DIRECT TAXES

- Surcharge of 10 percent on persons (other than companies) whose taxable income exceed ₹ 1 crore to augment revenues
- Increase in surcharge from 5 to 10 percent on domestic companies whose taxable income exceeds ₹ 10 crore
- In case of foreign companies who pay a higher rate of corporate tax, surcharge to increase from 2 to 5 percent, if the taxabale income exceeds ₹ 10 crore
- In all other cases such as dividend distribution tax or tax on distributed income, current surcharge increased from 5 to 10 percent
- Additional surcharges to be in force for only one year
- Education cess to continue at 3 percent
- Contributions made to schemes of Central and State Governments similar to Central Government Health Scheme, eligible for section 80D of the Income tax Act
- Donations made to National Children Fund eligible for 100 percent deduction
- Investment allowance at the rate of 15 percent to manufacturing companies that invest more than ₹ 100 crore in plant and machinery during the period 1.4.2013 to 31.3.2015
- 'Eligible date' for projects in the power sector to avail benefit under Section 80- IA extended from 31.3.2013 to 31.3.2014
- Concessional rate of tax of 15 percent on dividend received by an Indian company from its foreign subsidiary proposed to continue for one more year

Indirect Taxes

- No change in the normal rates of 12 percent for excise duty and service tax
- No change in the peak rate of basic customs duty of 10% for non-agricultural products

Goods and Services Tax

- A sum of ₹ 9,000 crore towards the first instalment of the balance of CST compensation provided in the budget
- Work on draft GST Constitutional amendment bill and GST law expected to betaken forward

(Source: World Wide Web)


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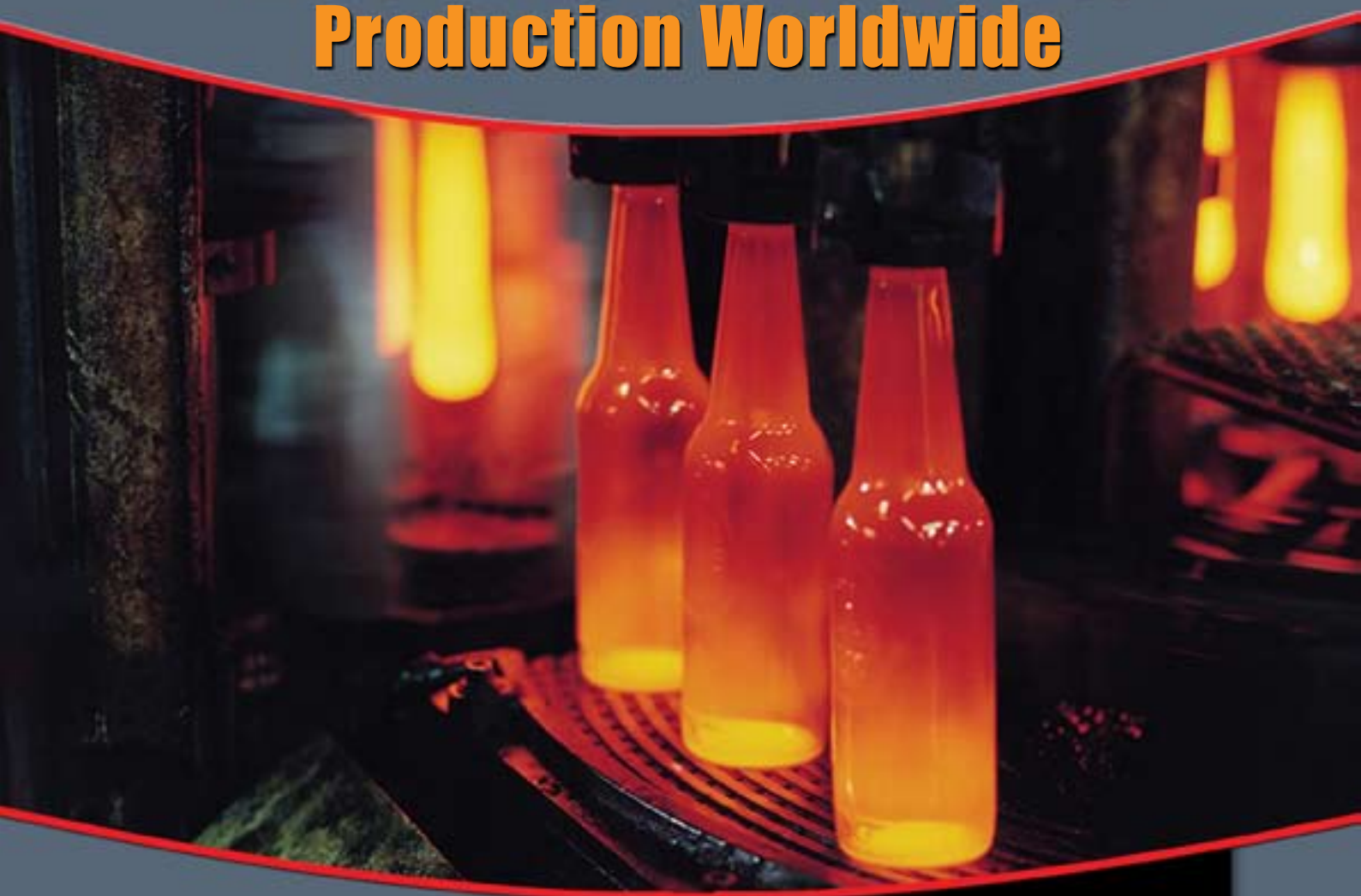

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Mascot Engineering Company

Company Profile

Mascot Engineering Company, a key representative of hi-tech companies in glass industry, was founded in 1969 by its Chairman, Mr. Mohan Lalvani, a versatile visionary and an entrepreneur, for marketing oil fired equipments, blowers, pumps, heaters, burners and filters and other fluid power products.

Mohan Lalvani was born in undivided India on 23rd May 1942 in Karachi. After his school and college education in Bombay he graduated in mechanical engineering from ECOLE DES METIERS VERSAILES in France. Mascot is an affiliate member of the AIGMF since 1989 and takes active part in its activities. Since 2007, Mohan has been editor of **Kanch**, the quarterly journal of the AIGMF. His wife Usha also took interest in activities of the Federation and was a master of ceremonies on a few occasions.

The Glass Service Division of MASCOT came into being in 1975 acquiring agency of VGT Dyko, Germany (presently part of P-D Refractories Group), the largest manufacturer of silica and bonded refractory materials. With a view to serve the glass industry comprehensively, MASCOT started seeking agencies from manufacturers of machinery equipments resulting in agreements with SORG and its subsidiary EME to represent their interests in India.

After liberalization of economy in 1991, there was a greater quest in entrepreneurs of glass industry to import latest machinery to upgrade their manufacturing technology. MASCOT being the representative of reputed concerns put in its best to meet needs of the industry and continue to do so.

To ensure quality service to its clients, MASCOT has been selective in choosing principals for supply of equipments and ancillary products.

Mr. C K Somany (HNG), Mr. Balkishan Gupta (Advance Group of Glass Industries) & Mr. Mohan Lalvani at AIGMF Meeting at Firozabad

MAJOR COMPANIES REPRESENTED BY MASCOT ARE:

Bonded Refractories	PD GROUP
Furnaces and Forehearths	SORG
Batch & Cullet Treatment Plant	EME
Annealing Lehrs	PENNEKAMP
Hot End Inspection Systems	GEDEVELOP
Vial, Syringe & Flask Forming Machines	AMBEG
Tableware, Tubes & Lighting	olivotto
Fused Cast Refractories	
IS Machines & Spares	GPS
Decorating Machines	ROSARIO

Mr. Mohan Lalvani honouring Mr. Alexander Sorg during his visit to Mascot's Mumbai office

As stated earlier, the first principal to be represented in India was the German refractory manufacturer Dyko, which was later taken over by Vesuvius and subsequently acquired by German based **P-D Refractories**. P-D's acquisitions also include Dr C Otto, Premier and Wetro. Informal association began with the Companies in mid-1970, but it was in 1980 that MASCOT formalized the relationship and became their sole representative in India.

Primarily but not exclusively the principals represented by MASCOT were involved in the Container Glass Sector. German company FASTNER and Hungary's MOTIM, multinational organizations, producers of specialty ceramics and refractories are also represented by the company.

MASCOT expanded its sphere of working in glass industry by entering into agreement with GLASSROBOTS, MACOTEC, SYNERGX, ADELIO LATTUADA, JLI, manufacturers of machinery and equipments for processing of Flat Glass.

Team Mascot at glasstec 2012 in Dusseldorf

MASCOT'S agency list also includes IS machinery builder GPS Glasproduktions-Service, Annealing Lehr specialist Ernst PENNEKAMP and OLIVOTTO, supplier of tube drawing lines and table ware. Also represented are Netherlands based ROSARIO Productie specializing in decorating machinery and IMACA which produces coating equipment, GEDEVELOP of Sweden producers of hot end analysis measurement and control equipments.

The company has achieved noteworthy success in promoting AMBEG's machinery for manufacturing vials and syringes.

For Solar Glass Equipments, MASCOT represents RUREX the foremost in rolling machines for pattern glass.

SORG SERVICES INDIA PVT LTD

Recognizing a need to offer on the spot and

Mr. Manohar Lal (centre), Secretary AIGMF with Mr. Mohan Lalvani (right) & Mr. Mohit Lalvani (left)

Mascot Team with AIGMF Secretary

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MOHAN LALVANI, CHAIRMAN

MASCOT ENGINEERING COMPANY

prompt services to Indian and Asian glass plants manufactured by SORG a leading supplier of melting furnaces and conditioning systems. The company has recently set up SORG SERVICES INDIA PVT LTD.

OTHER GROUP COMPANIES

In the 90s when the Indian economy was on a fast track growth and the business was expanding, Mohan's son Mohit Lalvani, a commerce graduate, joined the company and started diversifying its activities.

Following companies in personal and health care segments were added to the group:

MASCOT UNIVERSAL PVT. LTD

Personal Care Division

is in the beauty and personal care industry and CHANNEL PARTNERS for DOW CORNING, CRODA, DOW CHEMICALS, BIOSPECTRUM, BUHLER & HONEYWELL.

Health Care Division

is known for its expertise in Dermatological Formulations Development, providing innovative & sustainable "Turnkey Solutions" to its customers.

MASCOT SPINCONTROL INDIA PVT LTD.

is a joint venture between Mascot Universal & Spincontrol France. The company specializes in the in-vivo & in- vitro evaluation of various cosmetic products (Skin care, Makeup, Hair care) for safety and efficacy.

Keeping in view advancements being made in different fields of glass, globally MASCOT continues to strive and offer its dedicated services to customers so that they get full value for their investments in glass industry.

Note : This profile is based on Company information as provided by Mascot Engineering Company to the AIGMF

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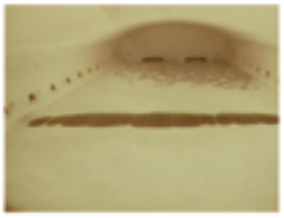


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Glass Technology Services

(Helping you make your mark in glass)

Flat-glass manufacturers are gearing up for major changes this year in the way they get their products to market in the construction industry across the European Union, while manufacturers of domestic glassware and packaging continue to face increasing quality and brand image demands.

For independent research, test and design specialist Glass Technology Services (GTS), it has meant a period of considerable investment and technological development, as it moves to become an accredited performance test laboratory for CE product conformity testing and to help meet the industry's ever increasing legislative, product quality and brand identity challenges.

"We work with highly innovative glass manufacturers and suppliers across the world," said GTS Commercial Director Dr. Malcolm Glendenning. "They face new challenges every day, in terms of quality standards and regulations, but also from brand owners and new product developers, who want to push the boundaries in specialized and technical glass as well as in flat glass and containers."

Over the past two years, GTS has invested in staff, equipment, infrastructure and training and grown its team of specialists by more than 25%, recruiting material sciences, physics, chemistry and mechanical engineering graduates as well as apprentices, to work alongside its leading technical experts, who have some 380 years' combined experience in the glass industry.

CONSTRUCTION PRODUCTS

GTS is in the process of becoming a Notified Testing Laboratory in order to enable manufacturers to use its test results to contribute towards the CE Marking of their construction products and comply with the new Construction Products Regulation 2011 (CPR), which governs entry of all flat glass products to the EU market.

Replacing the Construction Products Directive (CPD), it comes into effect on July 1st 2013 and effectively limits the ability of manufacturers of building products from CE marking their own products. Therefore, they must use an independent testing laboratory such as GTS to undertake product conformity testing in order for the manufacturer to CE mark their products.

BESPOKE SOLUTIONS

"This is just one of the many challenges facing glass manufacturers worldwide," said Dr. Glendenning. "We're continually evolving our services to meet those challenges and provide a wide range of bespoke solutions covering all aspects of glass including new product development, melting, fitness for purpose, failure assessment and environmental monitoring.

"Working in partnership with our clients we've been able to design, manufacture and bring to market some highly innovative glass products across the glass packaging, glazing, fibre insulation, continuous fibre and technical glass sectors. At the same time, we're supporting their quality and performance credentials, through chemical analysis, durability testing, mechanical performance analysis, product conformity testing,

foreign fragment identification and process troubleshooting."

EXPORT STANDARDS

Increasingly commissioned to undertake long-term consultancy contracts as well as one-off projects, GTS works with global manufacturers and retailers across India as well as in the Middle East, America, China, Australia and South Africa, to ensure their products meet all the required and pending standards for export across the world.

The team regularly undertakes audits of glass production and filling lines on behalf of glass manufacturer customers, such as international pharmaceutical companies and spirit and beer brand owners, to ensure that the product is manufactured to their requirements. Its specialists are also increasingly being commissioned as Expert Witnesses, in both criminal and civil cases, giving independent advice and findings on all aspects of glass quality and performance.

"Seeing our test facilities in operation, is a great reminder of just how extensively used and valuable a commodity glass is," said Dr. Glendenning. "At any one time we could be testing glass for new office buildings, shop windows, car windscreens, furniture, lighting and containers for food and drink or pharmaceutical products and from a wide variety of international manufacturers and suppliers.

MANUFACTURING SOLUTIONS

"Rather than simply presenting the analysis or data, whether we're assessing product quality and fitness for purpose, analyzing fracture and failure, or examining colour and light transmission, for example, we help to provide solutions to manufacturing issues and make recommendations on how to improve the product's performance as well as to meet legislative requirements and industry, national and international standards."

Independent product testing has become increasingly vital to demonstrate due diligence and compliance, even where the materials were not directly covered under standards or best practice guides, Dr. Glendenning added.

"Toughened glazing has to meet extensive safety

breakage standards, automotive glass must meet the very specific requirements of the R43 guide and annealed beverage bottles should comply with TEC7 or TEC 9, to name just a few," said Dr. Glendenning.

"But General Product Safety Regulations which apply across the European Union have as much legal weight and associated responsibilities and liabilities. Independent test laboratory reports are becoming an essential part of the due diligence process across every glass product area."

INNOVATION AND NPD

GTS specialists also have extensive experience in new product development. In collaboration with leading universities and businesses, the team is developing new technology and coatings for glass products, bio materials, photonics and optical devices.

Some of the development programmes are supported under the EU's Seventh Framework Programme (FP7) and the UK Government's Technology Strategy Board (TSB) – both of which aim to boost research and innovation across Europe and the UK. The TSB's most recent grants awarded to GTS for research and analysis work are part of a £20 million UK government investment programme.

One of the grants supports the development of a working prototype production facility to pave the way for industrial manufacture of phosphate fibre tows. These specialist fibres can be used for a multitude of biomedical applications, including the treatment of serious bone trauma. Other partners in the project include The University of Nottingham, Controls Interface Ltd, Invensys-Eurotherm and P-D Interglas Technologies.

Another TSB grant supports GTS's provision of photonics and material science expertise to a development project on eye-safe sensors. Led by Thales Optronics Ltd UK, the Light-MiLES (Miniature Laser-illuminated Eye-safe Sensors) project will develop and demonstrate an innovative, compact, low cost and eye-safe laser-illuminated imaging sensor, capable of long-range operation. Other partners in the specialist consortium include Gooch and Housego Ltd and the University of Leeds.

The technology has far reaching applications, especially where human exposure is unavoidable – and could include applications such as optical communications, medical diagnostic use, remote sensing (LIDAR), range finding and targeting across defence, medical, construction, domestic and commercial markets.

Dr. Nick Kirk, Technical Director of Glass Technology Services Ltd, said: "Developing new technologies is crucial to advancing our understanding and capabilities in material science. These grants will enable us to develop prototype production facilities and new glass compositions and apply them in new and innovative ways."

INDEPENDENT SPECIALISTS

GTS training services, through webinars and online consultancy are in increasing demand across the glass industry, particularly for global suppliers, who want individuals and teams in many different locations to tap into the latest knowledge, best practice and industry developments.

An independent specialist, GTS works across the glass supply chain for manufacturers and manipulators, fillers, brand owners and retailers, architects, building contractors and consulting engineers. Its international client base is drawn from a wide range of markets including architectural and automotive, food and drink, pharmaceutical and technical, defence, photonics and biomedical.

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Reacting to changing market demands

Theresa Green offers a UK perspective on recent global trends in the glass container, flat glass, glass fibre and technical glass sectors.

Not compromising on taste, quality or convenience, the features of glass packaging continue to lead the way in many key markets, such as the spirits, wines and beer segments, while winning more and more space in the food sector. This is due not only to new trends for local, organic and natural food but also by a return of consumers to glass as their preferred packaging material. The craft beer segment increased by 8.0% in 2011 and this is one area gaining increasing momentum. Glass is infinitely recyclable and totally inert (unequalled in preserving the original taste and nutritional qualities of products). Furthermore, it is a healthy and sustainable product that helps to minimise the effect of packaging on the environment.

As the glass packaging market globally undergoes regional shifts and technological changes, the industry has responded with innovation and flexibility, particularly in the UK. With regard to domestic production, glass container manufacture remains stable. In Europe, the industry is growing, where volumes grew by 4.2% in 2011 (ref: www.feve.org).

In the UK in 2011, although volumes fell slightly by around 0.8% to 2,310,667 tonnes, this figure is still nearly 200,000 tonnes up on 2009 levels. When taking into account other factors such as lightweighting, the figures are even more impressive. If production volumes remain the same year-on-year, then lighter glass bottles mean that more of them are produced and all UK glass container manufactures have made great progress in successfully reducing the weight of glass containers.

One UK manufacturer, for example, has recently introduced a 500ml lightweight beer bottle that weighs just 285g. This compares with an original weight of 403g. Benefits of lightweighting include reduced production costs and the ability to offer clients a more cost-effective product, without compromising on quality. By reducing the use of raw materials and energy consumption, lightweight bottles can also help to meet waste reduction and emissions targets. Several market research companies are predicting growth of around 2% per year for glass packaging through to 2015.

ENERGY AND RAW MATERIALS

Energy prices and the price of raw materials remain causes for concern throughout all glass manufacturing sectors. Although there is little the manufacturer can do to control the situation, the UK industry has remained very competitive in an uncertain economic climate and kept any price rises to a minimum.

British Glass runs the UK Climate Change Levy for the entire glass sector. All UK businesses, including the flat and fibre glass sectors, pay the Climate Change Levy but are eligible for 80% relief if they meet government-agreed, tight, energy reduction targets. This is something the glass industry has consistently done, despite continued tightening of targets over the past 10 years.

With regard to raw materials, prices have stabilised recently due to alternative supplies becoming available in the market. India's Tata Chemicals, for example, has recently opened a US$100 million soda ash plant in Kenya that enhances the capacity of its Kenyan subsidiary and places this East African nation on the global map for the production of this multi-utility commodity. According to a company press statement, Tata Chemicals Magadi is now gearing up to boost its production capacity of soda ash to one million tonnes over the next three years, while celebrating the opening of the unit in November.

"The facility will propel Kenya to produce 2% of the world's natural soda ash", Tata Chemicals Director, Prasad Menon said at the inauguration. "From a technical perspective, the new plant will produce a superior product at 99% purity which is a key ingredient in the manufacture of flat, float and sheet glass and related container glasses."

The Shard, the latest example of architectural glass innovation in London.

According to Mr Menon, the importance of this facility is particularly vindicated by the fact that global demand for soda ash is expected to reach 58 million tonnes/year by 2015, against the current demand of 49 million tonnes. "With Tata Chemicals Magadi's production capacity expected to hit the one million tonnes mark before 2015, it is crystal clear that Kenya will be contributing close to 2% of global production capacity - a major feat for Kenya." >

GLASS FOCUS CONFERENCE 2013

Glass Focus 2013 will be held on 23 May 2013 at the Radisson Blu Hotel, Manchester Airport, UK. Themed 'Forward thinking and innovative dimensions for glass and the glass supply chain', the conference will feature sessions from Rt Hon Michael Fallon MP (Minister of State for Business and Enterprise), James Fothergill (Head of Education and Skills at CBI) and Dave Dalton (CEO of British Glass).

This conference brings together senior representatives across the glass supply chain, including raw material suppliers, manufacturers, processors, recyclers, designers, architects, food and drinks brand owners and retailers.

"We hope you will come and share some of the excitement about the creative and innovative opportunities, both active and deveoping, across the glass supply chain" said Dave Dalton, Chief Executive Officer at British Glass.

FURTHER INFORMATION:
Jackie Donoghue, British Glass, Sheffield, UK
tel: +44 114 290 1850
email: glassconference@britglass.co.uk
web: www.britglass.org.uk/Glass-Focus-2013

FLAT GLASS

The latest statement from Glass for Europe (www.glassforeurope.com) comments that, at EU level, there is growing awareness of the necessity to make new and existing buildings as energy-efficient as possible. This translates into two important EU policy instruments; the adoption in 2010 of the Energy Performance of Buildings Directive (EPBD) and the current debate on the proposal for an Energy Efficiency Directive (EED).

The economic crisis has been crippling the construction sector throughout Europe and is seriously affecting the flat glass and glazing industries. Conditions in the UK are depressed, to say the least. The way out of this difficult situation is known; accelerating the rate of energy-efficient renovations of buildings will push the market uptake of added-value glazing solutions.

Glass manufacturers are continually investing in new technologies, bringing enhanced glass performance and comfort to buildings and homes, such as low emissivity glass, a type of insulating glass that increases the energy efficiency of windows by reducing the transfer of heat or cold through glass. Switchable glass or smart windows have been developed and discussed for decades. They have bright futures in applications such as vehicle, architecture, privacy and energy efficient glazing etc. The next generation of switchable glass based on micro-blinds might help the incursion of smart windows to the market, or at least to some niche markets. Micro-blinds are composed of invisible and electrostatically-activated curling electrodes of 100 micrometer size. They can be deposited on flat glass by magnetron sputtering like regular low-E coatings and are then patterned by laser. They possess several advantages such as switching speed, UV durability, customised appearance and transmission and do not employ costly ITO, relative to the current smart windows technologies: Electrochromic, suspended particles and liquid crystals.

Value £000s

UK sales		Intra EU exports	Intra EU imports	Extra EU exports	Extra EU imports
2011*	768,473	45,223	119,054	15,810	22,819
2010	706,958	35,677	106,433	13,771	23,212
2009	713,993	57,429	88,516	9,396	19,779

UK glass container sales, imports and exports, 2009-2011 (ref: www.ons.gov.uk - ONS Prodcom Reports 2009/10/11). *2011 Provisional data published June 29, 2012. **Suppressed.

Value £000s

UK sales		Intra EU exports	Intra EU imports	Extra EU exports	Extra EU imports
2011*	352,842	67,908	58,832	51,244	18,567
2010	307,958	49,086	50,268	33,813	23,836
2009	268,817	46,035	44,382	22,848	21,487

UK flat glass sales, imports and exports, 2009-2011.

Value £000s

UK sales		Intra EU exports	Intra EU imports	Extra EU exports	Extra EU imports
2011	S**	200,317	407,146	41,569	173,908
2010	732,672	187,446	395,501	39,966	165,822
2009	781,438	174,428	297,376	39,409	134,269

Shaping and processing of UK flat glass sales, imports and exports, 2009-2011 (ref: www.ons.gov.uk - ONS Prodcom Reports 2009/10/11). *2011 Provisional data published 29 June 2012. **Suppressed.

Value £000s

UK sales		Intra EU exports	Intra EU imports	Extra EU exports	Extra EU imports
2011*	166,535	S**	127,318	S**	104,431
2010	185,307	S**	110,881	S**	105,971
2009	144,122	S**	125,422	S**	84,540

UK technical glass sales, imports and exports, 2009-2011 (ref: www.ons.gov.uk - ONS Prodcom Reports 2009/10/11). *2011 Provisional data published 29 June 2012. ** = Suppressed.

Value £000s

UK sales		Intra EU exports	Intra EU imports	Extra EU exports	Extra EU imports
2011*	447,522	174,557	124,891	49,915	75,374
2010	496,246	149,000	120,454	45,729	62,104
2009	S**	141,682	96,396	39,563	45,423

UK glass fibre sales, imports and exports, 2009-2011 (ref: www.ons.gov.uk - ONS Prodcom Reports 2009/10/11). *2011 Provisional data published June 29, 2012. ** = Suppressed.

TECHNICAL/SPECIAL GLASS

The technical, special and scientific glass sectors comprise many diverse glass products including tubing, toiletries and cosmetics, syringes etc. It is not possible to give a breakdown of the individual sections covered in this category, although there are positive indications of improvements across many lines. Scientific and technical developments, coupled with a surge in demand in emerging markets for industrial and consumer goods are helping the industry to make steady progress.

The prefilled syringes sector has witnessed healthy growth in recent years and demand is expected to rise. This is due to the increased number of injectable biological drugs in the pipeline and healthcare professionals and patients demanding safer, more convenient drugs, devices and delivery systems. According to a recent iRAP report (www.pharma-iq.com), 'PH-1 Nano-Enabled Packaging for the Pharmaceutical Industry A Global Technology, Industry and Market Analysis', global demand for prefillable inhalers and prefilled syringes will generate the fastest growth opportunities among all pharmaceutical packaging products, based on performance advantages in drug delivery and the introduction of new bio-engineered medicines. Markets for perfumes, cosmetics and toiletries are dependent on consumer expenditure and most recent data shows that sales were around 3% down on 2010 levels. However, this market is also dependent on seasonal trends and with Christmas on the horizon, the market is expected to improve somewhat.

GLASS FIBRE

According to a recent 451 page report from Companies and Markets, by 2017, the world glass fibre market is expected to reach 8.5 million tonnes, with increasing demand coming from niche applications. Post-recession, the emerging economies of the Asia-Pacific are representing strong growth opportunities, particularly from a construction perspective. Asia-Pacific, Europe and the USA are the dominant geographic markets, with China holding over 50% of global glass fibre production capacity due to lower pricing.

The UK craft beer sector increased by 8.0% in 2011 and is an area gaining increasing momentum.

This study splits the product segments of the maturing glass fibre market into glass wool and textile glass fibre. Glass wool is used widely in the construction industry, though there is increasing demand for the fibre within the advanced technology industries such as aircraft, automotive and electronics sectors. Textile glass fibres find applications in numerous sectors and there is strong potential from within the telecommunications and electrical markets. The markets are further segmented by end use, eg for glass wool; housing construction, commercial/industrial/infrastructural, industrial/commercial equipment and others. The market is highly competitive and consolidated in nature, with just six companies controlling nearly three-quarters of production. Key players highlighted in the report include Guardian Fiberglass Inc, Knauf, Owens Corning Inc and Uralita Group. For further information, contact www.companiesandmarkets.com ■

ABOUT THE AUTHOR:
Theresa Green is Information Officer at British Glass

FURTHER INFORMATION:
British Glass Manufacturers' Confederation, Sheffield, UK
tel: +44 114 290 1850
web: www.britglass.org.uk

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Driving progress

Flaws and Fracture of Container Glasses

A. K. Bandyopadhyay
Technology Consultant & Ex-Principal,
Govt. College of Engg. & Ceramic Technology,
W. B. University of Technology, Kolkata.
asisbanerjee1000@gmail.com

Abstract:

The mechanical properties of glasses are very important considerations for glass quality. By using Griffith formulation of theoretical strength of glassy materials, a modification of the equation for theoretical strength could be achieved by changing the limit of integration within the zone where fracture occurs in brittle glasses, based on a sinusoidal approximation. Here, the question of measuring fracture in glasses is discussed on commercial container glasses with some data and the relevant equations, which are used to quantify flaws and fracture in glasses.

Keywords: Griffith equation, Theoretical strength, Hook's law, Fused silica.

INTRODUCTION

Glasses are brittle materials and hence they easily break. For practical applications of container glasses for the packaging industry, however, the mechanical strength is very important. It is also important for their marketability. It appears from a vast amount literature data that there is a considerable amount of work done on fracture, the effect of micro-flaws on fracture, the effect of fracture strength on the overall mechanical behaviour of glasses, etc. The sheer number of papers on this subject justifies its importance. Thus, the study of fracture on glasses assumes special significance for the mechanical properties **[1-4]**.

In a previous article on "Theoretical Strength of Glasses" in *Kanch* **[5]**, the problem of theoretical strength in glassy materials was discussed in the context of Griffith formalism by taking fluctuation in spatial elongation near the maximum value of applied stress. In this manner, the theoretical strength could be predicted by a multiplication factor, when micro-flaws are present in glasses. The mechanical properties in terms of fracture of such glasses are also of great importance, since these glasses are mostly used in the building industry and façade decoration purposes, wherein fracture in any form can cause damage to the installation that will result in a loss to the investment made. Although the present article deals with the problem of fracture in brittle materials, such as commercial glasses, the importance has to be also given to the float glasses, as these glasses have aesthetic appeal with the highest quality requirements so far the glass industry is concerned **[6]**.

There has been a tremendous amount of work done in the field of fracture mechanics in brittle materials and glasses, particularly on their theoretical strength for a long time **[1,2]**. This is mainly done on Griffith equation based on the formation of an elliptical crack and its main plank is the utilization of material

parameters or constants, which are measurable, in designing suitable materials for various important applications **[1].** An insight should be obtained on the nature of theoretical strength based on a sinusoidal approximation in the stress vs. spatial elongation curve. In the context of this approximation, our focus was on the "fluctuation" of the spatial elongation value at or near fracture so that a modified equation could be developed to better predict the theoretical strength of glasses.

Although the subject of much research over the past decades, the fracture of brittle glassy materials remains in many ways not understood. Of particular interest is the mechanism by which energy in the system is dissipated. Experimental measurements of the flow of energy into the tip of a running crack have indicated that the fracture energy (i.e., the energy needed to create a unit extension of a crack) is a strong function of the crack's velocity and that the majority of the energy stored in the system prior to the onset of fracture ends up as heat. An example of the fracture of soda-lime-silica glass has been taken into consideration. Residual stress profiles were introduced in sodium alumino-silicate glass disks using an ion-exchange process, i.e. after chemical strengthening. They were fractured in two loading conditions: indentation and biaxial flexure. The fractal dimension of the macroscopic crack branching pattern called the crack branching coefficient (CBC), as well as the number of fragments (NOF) were used to quantify the crack patterns. The fracture surfaces were analyzed to determine the stresses responsible for the crack branching patterns. The total strain energy in the body was calculated. The CBC was a good measure of the NOF. They are directly related to the tensile strain energy due to the residual stress profile for fractures due to indentation loading. However, in general for materials with residual stresses, CBC (or NOF) is not related to the strength or the stress at fracture, or even to the total stored tensile strain energy. A study was done to determine the geometric characteristics associated with the critical crack caused by cyclic loading in baria-sillicate glass **[3]**. Such studies have also been undertaken in many other systems of glasses including many commercial glasses.

The objective of such a study on fracture is to understand how flaws in a material affect fracture and appreciate the basic features of a brittle fracture surface. One should be able to calculate the average flaw size present in a sample or its fracture stress and then understand why the fracture stress of a brittle material varies from sample to sample.

DESCRIPTIONS OF THE EXPERIMENT

Most materials, when subjected to a tensile stress, break without any apparent plastic flow, and these are known as brittle materials. Even though there is no plastic flow, they still break at a stress well below the theoretical value calculated from the strength of the atomic bonds. One should look at an experiment in which glass rods break under an applied load. Examination of the fracture surface allows us to determine how they failed, i.e. the failure analysis. The analysis of the fracture stresses enables some conclusions to be drawn about the link between this failure stress and the surface treatment of the rods.

In this experiment, a cylindrical soda-lime silica glass rod with diameter (d) is fixed as a cantilever. A constant load (W) is applied to the free end and the free length (L) of the cantilever rod with is gradually increased until the rod fractures. For each specimen the free length at which the rod fractures is measured. The highest tensile stress in the rod is at a point closest to the fixed end. The maximum tensile stress under these loading conditions is calculated using the expression:

$$\sigma_{max} = 32\mathbf{WL}/\pi d^3$$

To examine the effect of surface treatment, we compared the results from testing as-received rod with those obtained where (a) Surface of the rod was abraded using silicon carbide abrasive paper with a grit size of about 60 microns and (b) Flame polishing was done by heating the lengths of rod in a blue Bunsen flame by moving the flame up and down the length of the rod. This is a method to heal the flaws.

The examination of the fracture surfaces showed that the fracture originated from a flaw on the top surface of the glass rod. Three distinct regions could be seen on the fracture surface:

a) A smooth region surrounding the fracture origin called the mirror zone
b) A small band of rougher surface surrounding the mirror region, which is known as the mist zone

(c) An area beyond this is known as the hackle zone, which is composed of large irregularly oriented facets fracture surfaces

The fracture process involves a tensile crack initiating from a flaw on the top surface, which travels quickly through the rod until it reaches the mid-point (neutral axis). Here the crack continues to propagate, although the stresses in the rod become compressive. This assumes that the stresses are unaffected by the propagating crack, which is a reasonable assumption as the crack is growing much more rapidly than the rod can deflect.

RESULTS AND DISCUSSION

The results of the above experiment are given below:

Sample	Mean Fracture Stress (MPa) [Std. Deviation]
As-received	118 [22]
Abraded	70 [11]
Flame Polished	132 [16]

The above results show that the flame polished samples break at a higher mean fracture stress (by as much as 12%) than that of the as-received samples, while abrading the surface lowers the fracture stress by a significant value, i.e. by 41% compared to that of the as-received sample. It is interesting to note that the standard deviation for all the experiments is quite large, but as a percentage of mean fracture stress, it is 19%, 16% and 12% for the three samples respectively. The scanning electron micrograpghs (SEM) on the surfaces of the glass rods showed that abrading has introduced some larger flaws in the surface of the glass, thereby reducing the strength by about 41% from 118 MPa to 70 MPa. The surface of the flame polished rod shows much lesser number of flaws than were present in the as-received glass, thereby increasing the strength by 12% from 118 MPa to 132 MPA.

The importance of flaw sizes was discussed in Ref. **[5]**. On many occasions, a visual check under a powerful microscope on the "flaw sizes" will reveal the difference in strength of two pieces of glasses, if they are to be compared on their different mechanical behaviour. From the relationship derived by Griffith, it is now possible to calculate the "flaw sizes" present in the glass rods. The average flaw size is related to the mean fracture stress by:

$$C \propto \frac{1}{\sigma_f^{\,2}}$$

So, we can write the following relation as:

$$\sigma_f = \frac{K_c}{\sqrt{\pi C}}$$

Where, σ_f is the fracture stress, $\mathbf{K}_C$ is the fracture toughness and C is the flaw size. To estimate the fracture toughness, $\mathbf{K}_C$, we need to know the flaw size present on one of the rods. If we assume that the flaw size of the abraded sample is the same as the grit on the abrasive paper, i.e. 60 microns, then for a flaw size of 60 microns and a fracture stress of 70 MPa, (after dropping π) the fracture toughness $\mathbf{K}_C$ is found as:

$\mathbf{K}_C = 70\text{x}10^6$ Pa x $(60\text{x}10^{-6})^{½}$ $m^{½}$ = 0.54 MPa.$m^{½}$

The flaw sizes for the as-received sample, abraded and flame polished rods can now be calculated from their respective mean fracture stresses. In comparison with the as-received sample, the abraded samples have a larger average flaw size, whereas the flame polishing reduces the average flaw size. The important conclusion is that the introduction of larger flaws into the surface of a brittle glassy material will lower the stress at which it fractures. This means that the samples with larger flaw sizes will always break easier and faster.

As also indicated in Ref. **[5]**, the glasses contain microflaws at the smaller length scales. The initiation of the cracks start at this point through nucleation of smaller cracks, which then propagate as the applied stress increases on the glass rod. After the critical limit, these cracks ultimately give rise to the fracture of the glasses. It means that the fracture is a two-step process. So, the history of the glass subjected under certain stress is very important to know the fracture behaviour and hence to predict the mechanical behaviour of glasses. This must be supplemented by the observation of flaw sizes, their number and also the orientation. A classic example is that a piece of glass with uniform distribution of smaller size flaws might not crack so easily compared to another glass having less uniform distribution with the same number or even lesser

number of flaws.

Therefore, the flaw sizes within the glass matrix and/or on the surface will clearly determine the suitability of a particular glass composition in a given environment. For example, for windows or large glass doors in a dusty environment (say, near a Thermal Power Plant with abrasive "fly ash" flying around), the resistance of the float glass or normal window glass has to be mechanically much stronger, or rather they have to contain lesser number of flaws with smaller size. Under each value of flaw size for the above three samples, the 'mean fracture stress' in MPa is given in third bracket in the table that is shown below:

Sample	Flaw Size (micron) [Mean Fracture Stress (MPa)]
As-received	21 [118]
Abraded	58 [70]
Flame Polished	**17** [132]

As far as the statistical treatment is concerned, it is seen that the standard deviation calculated for each of the experiments is fairly large. It is the largest for the as-received rods and this reflects some statistical variation, possibly due to fluctuation of composition at smaller length scales, i.e. inherent inhomogeneity. The introduction of flaws of a certain dimension or the removal of the majority of the flaws from the surface (for example, by flame-polishing) causes a reduction in the standard deviation. Under given conditions, microflaws in different pieces of material will vary in size, number and orientation. From this observation, it becomes evident that there will be some statistical variation in the fracture stress of each sample. This could happen even if several samples are made from the same large piece of material.

CONCLUSIONS

From this investigation, it is now understood how flaws affect the stress at which a material will fracture. All materials contain defects, and in brittle materials such as glasses, these defects act as tiny pre-existing cracks, which could propagate through the material to cause fracture. The propagation of these cracks is dependent on an energy balance, which leads to a critical crack length. The stress at which a glass fractures depends on the size of the largest flaws present, i.e. the larger the flaw, the lower the fracture stress. For commercial soda-lime-silicate glass, the behaviour is dominated by the surface defects, and the condition of the surface of the glass controls its strength. If steps are taken to remove or avoid the presence of defects, then the glass can be very strong. However, without special precautions, the strength of the glass is rather low and can show substantial statistical variations.

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Interpane: The Curve, new all-glass office building–a glass funnel on an ocean liner

Jaap-Willem Kleijwegt

Amsterdam, like many European cities, is renovating and developing its once-industrial areas. The area of the harbour is no exception and, with the most recent addition: 'The Curve', is gaining more and more prestige.

The ipasol neutral 50/27 solar control glass panes, some of which are five metres long and weigh over a tonne, ensure solar control, thermal insulation and lots of daylight

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The old NDSM (Dutch Dock and Shipbuilding Company) docks in Amsterdam just got richer by one architectural highlight: the asymmetrical cone of 'The Curve', a highly transparent office building with six floors totalling 4,350 square metres in area, lies right by the harbour. Designer Ed Veenendaal and architect Oever Zaaijer have created a building that looks like the funnel of an ocean liner.

Metal construction specialist Octatube was responsible for implementing the challenging structural glazing façade: sloping triple panes up to five metres long, each with a unique shape and some weighing more than a tonne. Solar control glass ipasol neutral 50/27 with additional iplus E thermal insulation coating ensures a light-flooded interior, excellent protection from the summer heat and effective thermal insulation.

The site of the old docks is, today, a colourful creative centre – artists, designers and business start-ups have settled here. The old warehouses are filled with a labyrinth of containers sheltering offices and studios. The first new office buildings have risen on the large open spaces – MTV, Red Bull and now 'The Curve'. Due to the good location, the building is even visible from the centre of Amsterdam.

CHALLENGING GLAZED FAÇADE CONSTRUCTION

The asymmetrical elliptical floor plan of the ground floor of 'The Curve' is 54 metres long and 26 metres wide. Vertically, the building forms a slightly twisted ellipse, giving the walls up to a height of 26 metres the form of a tilted cone.

The main frame consists of reinforced concrete floors and diagonal concrete pillars as well as steel tubes that run along the glass front. The floor-to-ceiling glass panels, some of which weigh more than a tonne, are mounted on stainless steel fixtures, point-fitted and held with clamping plates.

The construction of the triple glazing is a complex affair: the inner and outer panes are laminated safety glass, the middle pane is monolithic. The coatings guarantee an optimal interior climate: highly functional ipasol neutral 50/27 from Interpane on the exterior ensures effective protection from the heat of the summer. A further iplus thermal insulation coating on the central pane (position 4), and argon between the panes, prevent excessive cooling in the winter. The result is colour-neutral transparency, relatively high daylight transmission, with a low solar factor. On cold days, the excellent Ug value of 0.6 W/(m²K) (according to EN 673) ensures effective thermal insulation. The energy needed for heating, cooling and lighting is minimized – lowering costs and protecting the environment. ■

THE COMPANY AND ITS HISTORY

Interpane is a medium-sized corporate group and one of the major European glass processors.
The company's product range includes float glass and low-iron float glass for photovoltaic and solar thermal applications, high-quality coated insulating glass, sound-proofing glass, solar-control glass, safety glass and all-glass doors and panels.
Today, the Interpane group comprises production facilities at 11 locations in Germany, Austria, and France. The headquarters is located in Lauenförde, Germany. In addition, Interpane produces float glass at Seingbouse in France.
Interpane Entwicklungs- und Beratungsgesellschaft in Lauenförde is the group's research and development centre and their services are also available to partners and customers when it comes to finding solutions for their applications.

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Plant-wide Automation

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To be able to optimize production processes, you need to know them very well. With plant-wide automation – based on Totally Integrated Automation (TIA)–, Glass Producers can more easily make the required data transparency a reality and benefit from higher efficiency over the entire life of the plant.

Glass producers have long attempted to integrate all the plants of a production line into a common information system in order to draw conclusions from these data about the current situation of the entire plant. Until now, there have been no easy solutions to accomplish this. For example, every supplier has its own operating philosophy, and the corresponding diversity of user interfaces even for tasks that are in part identical means that the costs for training, engineering, commissioning, and maintenance are higher. In addition to the same look and feel of all screens, uniform operation and monitoring of the process means that all information from the system components can be stored in a uniform database for further editing and processing for plant-wide process control, process optimization, energy management, or service, or as an interface to the manufacturing execution system (MES). For the construction of new plants, the factory planners need to define the specifications for plant-wide automation and communicate this information to the plant and machine builders as guidelines for the design of the machine automation. In addition to the specifications of the hardware and software for automation, interfaces must also be well defined so that everything will mesh seamlessly during the integration and commissioning of the plant.

SIMPLE INTEGRATION

Plant-wide automation pursues this approach and has been very well received in the glass industry. "Plant-wide automation provides optimal support for factory planners, machine builders, and operators of glass plants," says Wolfgang Räbiger, CTO of f | glass GmbH. "For the first time, our requirements for standardization and simple integration are being taken into account and implemented." The centralized engineering and the standardized reporting support efficient operation, according to Räbiger: "We know at a glance how much energy and raw materials we are consuming and where, and thanks to this information in critical production areas, we can adjust maintenance measures to the actual requirements."

With plant-wide automation, the integration of individual OEM automation solutions is technically simple, fast, and easy. In the process, these automation solutions remain the responsibility of the OEMs, while Siemens takes over their integration into an automation system for the entire plant. via remote access all OEMs can maintain, test, and change their applications separately, independently, and in a manner that protects their expertise. With standardized tools and individual coaching, Siemens provides advice and support to them in creating the optimal conditions for the integration of their system components.

ADVANTAGES IN ENGINEERING, OPERATION, AND MODERNIZATION

The heart of plant-wide automation is the Simatic PCS 7 process control system. All the plant's data and documents are organized in a centralized engineering database. The OEMs also use the centralized engineering of Totally Integrated Automation for diagnostics, software upgrades, configuration and calibration of field devices, and factory acceptance tests (FATs). For this, Siemens provides an interface and secure remote access. The plant operator has access to the entire plant from all operating stations, and individual access rights can be defined. The system logs what changes were made, who made them, and when they were made. An optional asset management system that provides maintenance information can be helpful.

The central data storage and uniform access keep all options open for subsequent optimizations of the process and energy management, for example.

OEMS BENEFIT THROUGH INCREASED SALES

The OEMs also benefit: "The concept supports us in the acquisition of orders," explains

Dr. Holger Zippe, CEO of Zippe Industrieanlagen GmbH, a global leader in the development of batch plants and plants for preparing glass and shards for the international glass industry. "Our plants are ultimately sold on the basis of the added value they bring to the operator." The initial increased expense for plant-wide automation solutions pays off. "Plant-wide automation offers many advantages," confirms Karl-Heinz.

Bertram, CEO of Bertram Elektrotechnik GmbH, "especially in the context of international markets. The concept enables operators to set up safe and standardized access, which we specifically use to access our applications for remote maintenance. The operator benefits from the increased security, and we benefit from the reliable, protected remote service access, which ensures the performance of our systems at a reasonable price."

Plant-wide automation is an investment in efficiency technology whose positive impacts quickly begin to pay off. A holistic approach is becoming more and more important in this context. This includes targeted investments in efficiency measures, first and foremost in better machines and optimized production processes. For many companies, in the Energy-intensive process industry in particular, the potential for energy savings would exceed the required investment costs four times over by 2050. The concept has already been successfully implemented in many countries within the scope of projects with internationally known OEMs.

For further details,

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Mind the gap!

An analysis highlighting the gaps in Life Cycle Assessments (LCA) was the subject of a recent debate in the European Parliament, as the following contribution from FEVE explains.

The European Container Glass Federation (FEVE) has recently launched the first co-organised permanent MEP policy dialogue on glass packaging within the European Parliament, hosted by MEPs Dr Filip Kaczmarek and Dr Vittorio Prodi.

This platform has been created to discuss openly and debate a range of EU policy issues affecting the glass industry with Europe's decision makers, NGOs and stakeholders. Among the hot issues, the inaugural dialogue centered on the popular and much debated Life Cycle Assessments (LCAs) and plugging the gaps that lie embedded within this commonly used tool to assess a product's environmental impact.

One message came across loud and clear during the first dialogue… policy makers need to work towards identifying and plugging the gaps for improved and more accurate results when creating LCAs. Until then, the only option available is to 'mind the gaps'.

The live streamed event from the European Parliament had Professor Dr Finkbeiner, Chair of Sustainable Engineering and Vice-Director of the Department of Environmental Technology at the Technical University Berlin, open the dialogue, presenting his findings on the gaps in LCA and advising that it is important to look into all aspects of environmental impacts when creating an assessment of a product.

Although stakeholders and policy makers frequently rely on LCAs, it is important to be aware of the methodological limitations and certain environmental impacts that can render assessment inaccuracies. For example, we have yet to see all environmental and health impacts such as marine litter, biodiversity, water consumption and toxicology taken into account.

Dr Vittorio Prodi MEP.

Dr Filip Kaczmarek MEP.

Professor Dr Finkbeiner, Chair of Sustainable Engineering and Vice-Director of the Department of Environmental Technology at the Technical University Berlin.

MEP policy dialogue on glass packaging at the European Parliament.

With water being the new carbon, it is a real problem that LCAs currently do not address water scarcity issues. One litre of water in Brussels is not the same as one litre of water in Sudan. This is an example of a gap that needs to be addressed and resolved through improved data availability and quality of data. Working towards breaking down the practical limitations regarding quality data and availability is without doubt a step in the right direction of more knowledgeable and accurate LCA results.

The first policy dialogue was a model example of the importance of progression through discussion. While LCAs are currently high on the agenda, even making the cover of *Time magazine*, workshop participants admitted that they were now sometimes misused. We believe that shedding light on the limitations brings us one step closer to narrowing the gaps created by factors that are not yet accounted for or that are repeatedly ignored.

Dr Finkbeiner stresses that we should not restrict our assessments to a simple model because it is more convenient; we must improve it to achieve more truthful results and ensure the sustainable use of LCA. ■

FEVE
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Glass News Worldwide

EU LAUNCHES ANTI-DUMPING PROBE AGAINST CHINESE SOLAR GLASS MAKERS

The European Commission has opened an anti-dumping probe against Chinese solar glass makers following a request by European manufacturers, in the latest row between China and its Western economic trading partners.

"The initiation is based on a complaint lodged by the association EU ProSun Glass, which claims solar glass from China is being dumped in the EU at prices below market value and causing material injury to the EU solar glass industry," the EC said in statement.

It said the probe could take up to 15 months to complete, "although under trade defense rules the EU could impose provisional anti-dumping duties within nine months if it considers these necessary," it added.

IRAN OPENS MIDDLE EAST'S BIGGEST FLOAT GLASS FACTORY

Iranian President Mahmoud Ahmadinejad inaugurated the Middle East's biggest float glass factory in the Central province of Yazd.

The factory, located in Yazd province's Ardakan city, is the world's third-largest float glass production complex and is capable of producing float glass with the thickness of 19 millimeters. Yazd Glass Production Complex has also the world's fourth biggest glass production furnace. Ardakan Glass Factory produces float glass, reflex mirror glass, double-glazed glass and safety glass. The factory has been built on a 75-hectare land.

The Ardakan Glass Factory has the capacity of producing 900 tons of different types of glasses per day. The factory is the biggest project implemented by the private sector in the Yazd province.

The construction of Ardakan glass factory lasted 35 months and has created jobs for between 1,600 to 2,000 people.

CORNING MUSEUM OF GLASS APPOINTS AUDREY WHITTY AS NEW CURATOR OF EUROPEAN GLASS

The Corning Museum of Glass in the western New York town of Corning has hired Audrey Whitty as its new curator of European glass, the Star-Gazette reports, though she will also curate the institution's Asian glass collection.

Whitty has been the curator of the Art and Industrial division at the National Museum of Ireland since 2011, during which time she has curated several exhibitions of glass art, including "The Light Fantastic: Irish Stained Glass Art," "Inspirational Awakening: Irish Contemporary Glass," and "Gloine: History of Irish Glass." She was also the first woman from Ireland to be appointed to UNESCO's International Academy

of Ceramics.

The Corning Museum of Glass recently embarked on a major expansion project that will see it add a new $64-million wing clad in glass to be inaugurated next year.

SWISS TECHNOLOGY DEVELOPER FLISOM AG RAISES FUNDING TO RAMP UP 15 MW FLEXIBLE CIGS PV PRODUCTION PLANT

Flisom (Duebendorf, Switzerland) a developer of manufacturing technologies for flexible thin film solar photovoltaic (PV) module based on copper-indium-gallium-diselenide (CIGS) has raised a substantially large investment to further develop its technology and build a production plant with an annual capacity of 15MW in Switzerland.

Besides securing financial backing, Flisom also signed an agreement with Empa, the Swiss Federal Laboratories for Materials Science and Technology, to provide research and development support on high-efficiency flexible CIGS solar cell technology, the company notes.

Flisom's third funding round was completed with participation from a Swiss investor along with Flisom's existing strategic investor, Tata, India's largest and most respected business house.

"This new investment marks investors' satisfaction with Flisom's progress towards the development of industrial manufacturing technology for roll-to-roll production of flexible solar modules. The 15MW plant will serve as a blueprint towards the establishment of larger-scale plants to manufacture flexible solar modules at low cost," says Flisom's interim CEO Marc Kaelin. "Flisom's technology shows strong potential in helping solar electricity become affordable."

Tata supports record setting efficiency CIGS technology

"At Tata, we are keen to support the company in achieving its vision. Such technologies have a potential to transform many lives for the better," adds K.R.S. Jamwal, Executive Director, Tata Industries.

"We admire the team and technology, based on a record setting efficiency of over 20% for CIGS from Empa, which we hope will be scaled up successfully. The funding will enable Flisom to purchase equipment and hire more experts to convert an innovative Swiss technology into an industrial reality."

Flisom's products, processes and systems could lower the price of solar power, thanks to low material usage, economic production technology, and reduced storage, transportation and installation costs, the company emphasizes. Markets addressable by Flisom's flexible solar module manufacturing technology include utility scale solar farms, building integrated photovoltaics (BIPV), building applied photovoltaics (BAPV), transportation, portable power and electronics.

The production technology is roll-to-roll manufacturing of flexible PV modules, involving deposition of CIGS thin films onto polymer foil.

Founded as a spin-off company from ETH Zurich (Swiss Federal Institute of Technology Zurich), Flisom has subsequently developed proprietary tools and processes for manufacturing solar modules. After moving to Empa's Duebendorf campus, Flisom has been collaborating with Empa's Laboratory for Thin Films and Photovoltaics led by Ayodhya Nath Tiwari through various projects.

20.4% conversion efficiency record

In January 2013, Empa announced that its CIGS flexible solar cells achieved 20.4% conversion efficiency – a world record for CIGS technology that equals the record efficiency of polycrystalline Si wafer solar cells.

"Scale-up for large-area solar modules and adapting these complex innovative processes for industrial manufacturability is quite a challenge and requires close collaboration between research labs and industrial partner," says Pierangelo Groening, head of the Department of Advanced Materials and Surfaces and member of the Board of Directors at Empa.

"Along with the success of Flisom's capital raise, we are very impressed by the high photovoltaic conversion efficiency attained by our scientific

partners at Empa," says Flisom interim CEO Kaelin. "We look forward to benefitting from the insights of Empa to further raise the efficiency of flexible solar modules produced using Flisom's industrial roll-to-roll vacuum deposition technology."

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ANALYSIS OF GLASS FRAGMENTS IN FOOD

Rapid test techniques are enabling food and drink manufacturers to achieve vital 24-hour turnaround on analysis of contaminants – glass and other fragments – found in their products.

In a recent test programme, independent experts Glass Technology Services Ltd (GTS) found that 70% of fragments, which had been found in products by consumers and submitted for analysis, had originated from items commonly found in the home, such as measuring jugs, mixing bowls and jars and of the remaining 30%, nearly all could not have been introduced in the food manufacturing process.

"Accuracy and speed are clearly vital with these kinds of analyses," said Andrew Broadhurst, GTS Development Technologist and former analyst with the Forensic Science Service. "Food manufacturers know the potentially devastating impact of customers finding foreign objects in their food and drink – when that object is thought to be a glass fragment, the ramifications are obvious.

"That's why we have been investing heavily in our fragment analysis service, both for glass and non-glass samples, enabling us to identify the most likely source of stray glass or other material and – most importantly – exclude potential sources. In the majority of cases submitted to us, contamination by the manufacturer is not the most logical explanation, even when glass packaging is used. Results can be issued electronically within 24 hours of receiving the sample and depending on the urgency within a few hours."

Composition alone was not enough to determine the source of an object as a wide variety of items could be made from the same kind of glass, Andrew added. The laboratory also looked at how the original article was manufactured and how it failed, in other words how the fragment was formed and what happened to it after the chip, crack or breakage. If potential sources of the fragment were available, the team could match or exclude in order to narrow down the options.

"In many cases we have been able to help manufacturers avoid product recalls as well as of course protect their vital brand reputation," said Andrew.

In the recent test programme, GTS used a random selection of 125 samples sent to them for fragment analysis. The findings showed:

- 32% were borosilicate based glass: typical for cookware and glassware made to withstand high temperatures and most likely to have been inadvertently introduced by the customer during cooking, from measuring jugs or casserole dishes
- 38% were clear soda-lime-silica based glass: a common glass composition used for a wide range of products, including jars, bottles or mixing bowls, commonly found in the home
- 30% were from other sources including lead crystal items, green soda-lime-silica container glass and flat glass, but the majority from non-

glass sources, including naturally occurring salt. In one case, they even found a piece of tooth that belonged to the complainant.

GTS laboratories employ a range of analytical techniques to determine fragment identity – using technology widely used in forensics, including:

- SEM-EDS (Scanning Electron Microscopy-Energy-Dispersive X-ray Spectroscopy)- measures the chemical composition of each sample, while allowing surface features to be examined at very high magnification
- GRIM (Glass Refractive Index Measurement) – combined with potential sources, provides strong evidence for product matching
- FTIR (Fourier Transform Infra-Red) Spectroscopy – provides valuable information about molecular structure, particularly useful for plastics/polymers

"Combining these techniques and our unique understanding of glass composition, forming and failure, we're able to assess a range of vital clues and provide clients with a comprehensive report on a sample's properties and likely source," said Andrew.

GTS is accredited to ISO 9001, ISO 14001 and ISO 17025 standards. The team provides analysis, consultancy, testing and research and development support to food and drink manufacturers across the UK and internationally.

(Glass News Source: World Wide Web)

Membership of AIGMF

MEMBERSHIP

Members of the Federation are classified into two categories; manufacturers of Primary Glass articles are enrolled as **Ordinary Members** of the Federation and suppliers to glass industry viz., suppliers of machinery, raw materials, Consultants and others connected with glass industry are enrolled as **Affiliate members.**

Foreign Companies supplying machinery etc., to glass industry are also enrolled as Affiliate members.

The membership forms can be downloaded from http://www.aigmf.com/membership.php Members of the Federation are enrolled on the recommendation of Zonal Associations viz.:

- Western India Glass Manufacturers' Association
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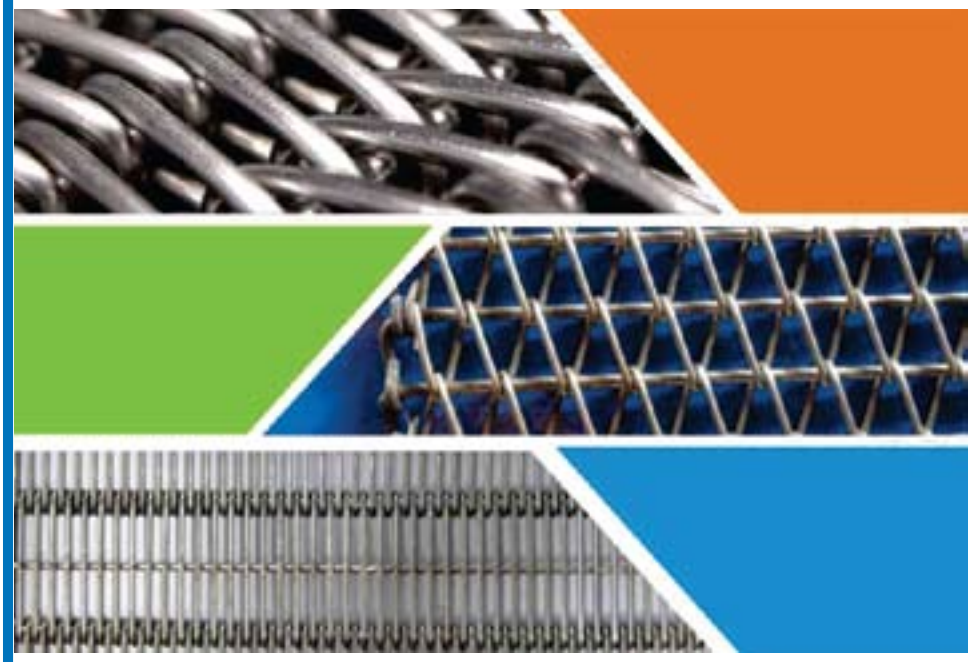

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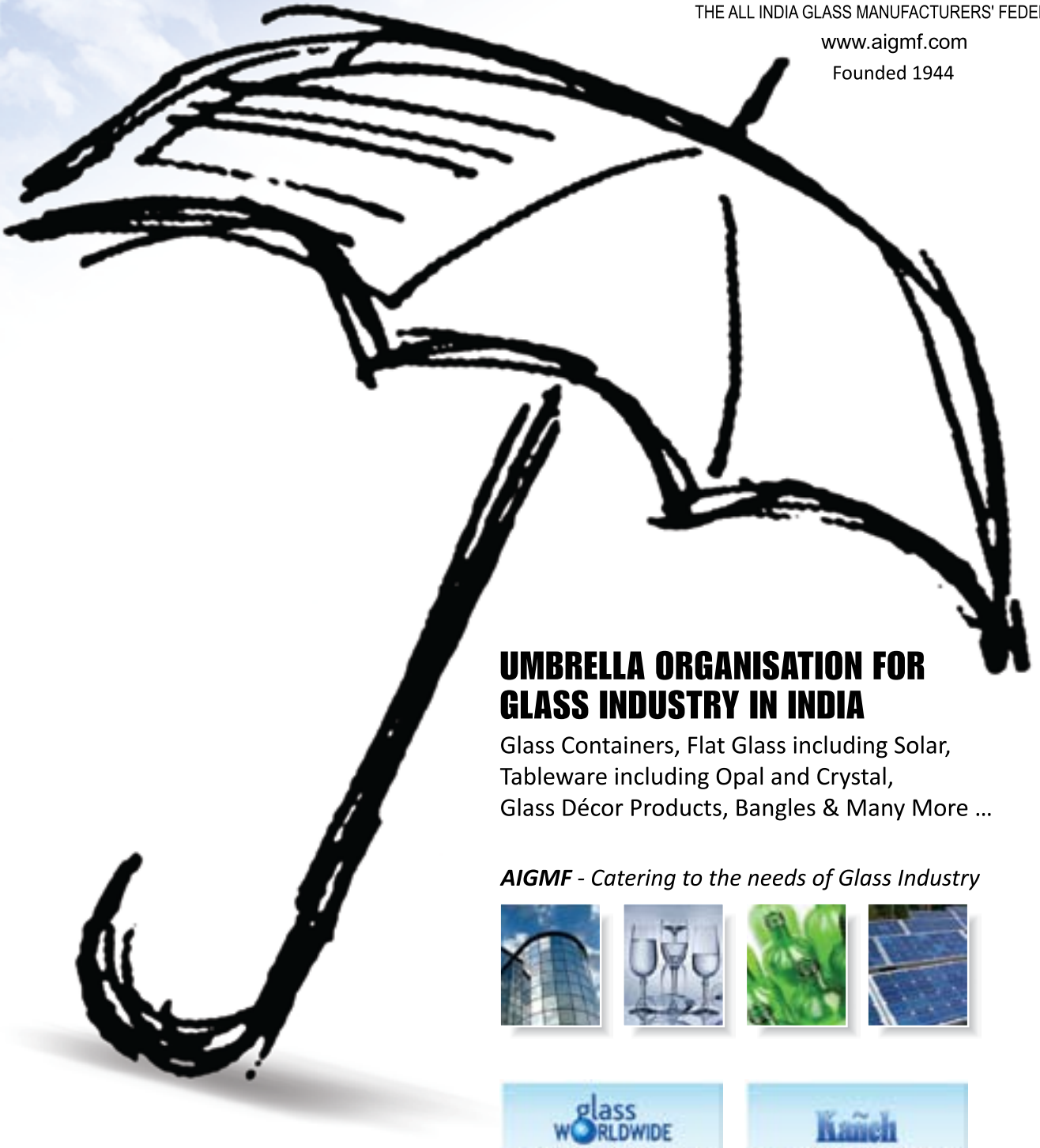

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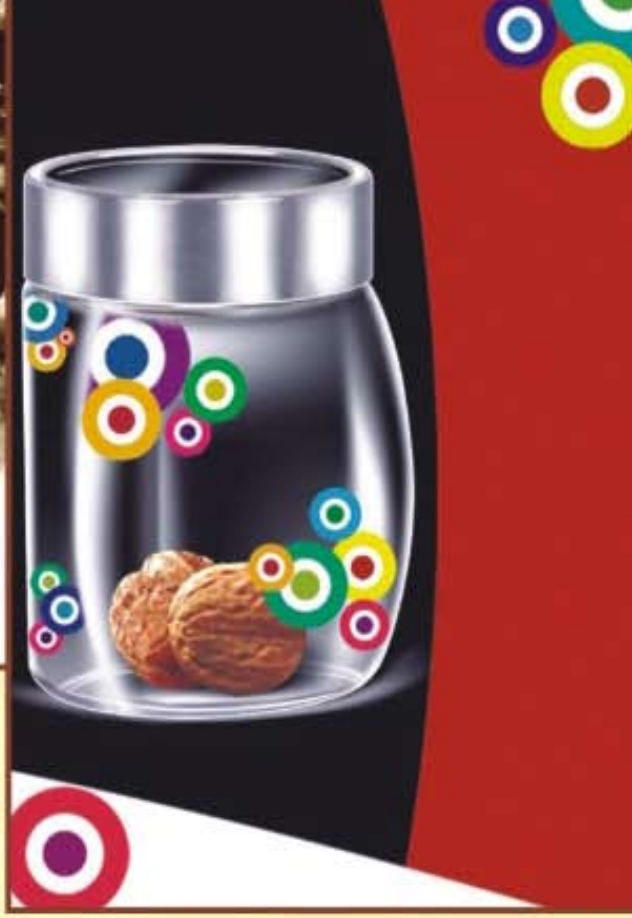

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