Vol. 9 | No. 4 | January - March 2022

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Quarterly Journal of Glass Industry, published and printed by Vinit Kapur on behalf of The All India Glass Manufacturers' Federation from 812, New Delhi House, 27 Barakhamba Road, New Delhi – 110001 and printed at New United Process, A-26, Ph-II, Naraina Indl. Area, New Delhi-110028

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Complimentary copy for Members / Government Departments / NGO's and those connected with Glass Industry

Others: Price (excluding bank charges):

Indian Companies : ₹ 125 per copy
Annual Subscription ₹ 450

Foreign Companies : US$ 25 per copy
Annual Subscription US$ 80

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Quarterly Journal of **THE ALL INDIA GLASS MANUFACTURERS' FEDERATION**

Vol. 9 | No. 4 | January-March 2022

Contents

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Hey!
(Health, Environment & You)

From President's Desk

Celebrations for the International Year of Glass (IYOG) kicked off on February 10 with a two-day Opening Ceremony in Geneva at the UN Palace of Nations. Bringing together glass communities from across the world, the programme featured 30 renowned speakers who shared the latest scientific and technical insights, and thoughts on how glass will be key to shaping the sustainable society of the future in line with the UN 2030 Agenda.

On Feb 23, an exhibition on artwork & photography by school children was unveiled at AIGMF Secretariat, which would remain on view for the whole of 2022 to showcase Indian contribution for the year of Glass in 2022.

Educational Institutions are invited to be a part of IYOG 2022 who in turn could adopt a week or day to celebrate the International Year of Glass by organizing activities for the Youth i.e. display of Touring Exhibitions, Debate or Essay writing on Glass as eco-friendly material, Quiz contests, Drawing Competitions, etc. AIGMF Secretariat could be contacted at info@aigmf.com who could provide a suitable speaker and other necessary support as appropriate.

Starting with January-March issue, we would be publishing 13 chapters in 4 parts till Oct-Dec 2022 issues from the book 'Welcome to the Glass Age' edited by Prof. Alicia Durán and Prof. John M. Parker of the IYOG 2022 Organizing Committee aimed at Celebrating the United Nations International Year of Glass 2022. The complete PDF version of the book is available at https://aigmf.com/glass-age.php

Mr. Dharmendra Mohan Gupta, Managing Director of Tigersons Glass India (P) Ltd., Firozabad left for heavenly abode on February 17. In 2019, Mr. Gupta received AIGMF's prestigious Balakrishna Gupta Award on behalf of Firozabad Glass Shell Industries as one of its Directors upon being recognized for their export contributions.

Mr. Manohar Lal, former Secretary of The All India Glass Manufacturers' Federation passed away on January 7 at the age of 91. Mr. Lal retired after 24 years of service to the Federation and was bid farewell on January 4, 2014 at the AIGMF Executive Committee meeting where senior Members of the Federation expressed appreciation for Mr. Lal's sincere and dedicated service. Many AIGMF dignitaries paid tribute to both Mr. Gupta and Mr. Lal ■

Bharat Somany

(Bharat Somany)
President AIGMF
and Vice - President, HNG & Inds. Ltd.

Exhibition on Artwork & Photography by School Children unveiled at AIGMF Secretariat

(FEB 23, 2022)

The Glass Promotion Committee met on Feb 23 for yet another meeting in the AIGMF office and to celebrate the International Year of Glass (IYOG 2022).

In the open gallery just outside AIGMF office area (812 and 813 New Delhi House, Connaught Place, New Delhi) a select artwork from the touring exhibitions namely 'Glass in our Lives / Glass Protects and Adopt a Glass Bottle' was unveiled together by Office Bearers of New Delhi House and the AIGMF.

Mr. Vikram Mittal, Treasurer of New Delhi House and Managing Director of Mittal Teas hailed this noble cause and said that *it is not only educational but a humble step under the CSR objectives to educate societies on the Glass being a sustainable packaging and building material, which is also in tune with Hon. Prime Minister's vision of Swachh Bharat Abhiyaan (clean India campaign).*

Select photos of the event can be downloaded from: https://aigmf.com/past-events.php

The exhibition would remain on view for the whole of 2022 which is yet another project to showcase Indian contribution for the Year of Glass in 2022.

Mementoes glass calendar bottles for 2022 (specially made by AGI glaspac as an Official Main Partner) as well as print calendars on 'Glass in our Lives' carrying logos of IYOG 2022 were freely distributed to all participants.

Educational Institutions are invited to be a part of IYOG 2022 who in turn could adopt a week or day to celebrate the International Year of Glass by organizing activities for the Youth i.e. display of Touring Exhibitions, Debate or Essay writing on Glass as eco-friendly material, Quiz contests, Drawing Competitions, etc. AIGMF Secretariat could be contacted at info@aigmf.com who could provide a suitable speaker and other necessary support as appropriate and to cover your initiatives in quarterly publications Kanch, Glass News and renowned bimonthly Glass Worldwide (our partner and preferred international magazine of AIGMF) for worldwide coverage ■

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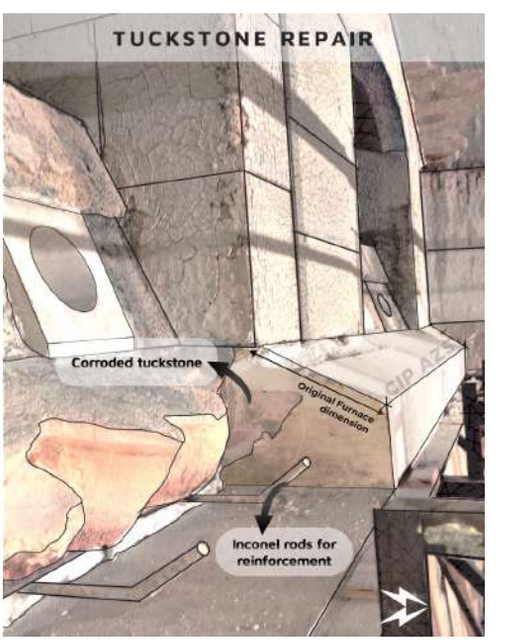

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GLASS News

'INTERNATIONAL YEAR OF GLASS' LAUNCHES WITH CELEBRATIONS IN GENEVA

Celebrations for the International Year of Glass kicked off on Feb 10 with a two-day Opening Ceremony in Geneva at the UN Palace of Nations. Bringing together glass communities from across the world, the programme featured 30 renowned speakers who shared the latest scientific and technical insights, and thoughts on how glass will be key to shaping the sustainable society of the future in line with the UN 2030 Agenda.

The ceremony in Geneva was the culmination of five years of efforts by the International Year of Glass Council to acknowledge the mark glass has

Photo Credits: Glass Worldwide & IYOG 2022 Council

made – and continues to make – on civilization. Glass has accompanied humankind for centuries, as one of the most important, versatile, and transformative materials in history. Used in everything from packaging food and drink in containers, to vaccine distribution, glass is a leading example of sustainable packaging – and its footprint also extends to construction, medicine and dentistry, communication technology, and beyond.

As efforts to build a truly sustainable future accelerate, glass is an ideal packaging for adopting sustainable production and consumption patterns including reuse and recycling. Mr. Vitaliano Torno, President of the European Container Glass Federation (FEVE) and O-I Glass' President of Business Operations & O-I Europe, commented: *"We have a unique opportunity to celebrate glass. Glass is endlessly recyclable, guarantees quality and safety no matter how many times it's recycled and it's virtually inert. It's the healthy choice, it is beautiful, it builds brands, and it is loved by people of all generations. That's what makes it the perfect choice for brands, retailers and consumers alike."*

To this end, a recent report on consumer trends published by FEVE researched over 150 expert reports to understand what drives consumer behaviour, and how brands and retailers can leverage these trends in the years to come. The results confirm that glass directly addresses consumers' priorities: more than ever, people care about environmental sustainability and circularity, hand in hand with prioritizing their own health and wellness. This extends to the products they purchase and the packaging those products come in. Fortunately, when it comes to packaging that delivers both on environmental credentials and helping brands tell their story authentically to today's consumers, glass is at the front of the pack.

Representing the International Year of Glass Council, Mr. John Parker commented: *"Whether you're a brand looking to make your product stand out, or a consumer keen to celebrate an iconic material, 2022 is the year to recognize glass for its many proven credentials and build on a long-standing cultural heritage for example by advancing its contribution to the UN's Sustainable Development Goals. Europe enjoys the world's highest glass recycling rates, and significant progress has been made in glass manufacturing in recent years to increase sustainable production and consumption. There is further potential to progress towards a climate-neutral Circular Economy, by moving to renewable energies and advancing the sustainable use of natural resources. This all starts with encouraging more people to choose and recycle glass, to appreciate its recycling and reuse as an inherent part of our future consumption patterns, and to do it right, so that more glass ends back in new production loops."*

In short, it's time to celebrate the past, present, and future of this iconic material, and reflect on how glass is driving progress towards the UN Agenda 2030 goals. That's why the container glass industry invites all brands, customers, and retailers to join in the celebrations, to promote, enjoy and recycle products in glass as the packaging of tomorrow, for the health of the public and the planet.

SAD DEMISE OF DHARMENDRA MOHAN GUPTA

Mr. Dharmendra Mohan Gupta, Managing Director of Tigersons Glass India (P) Ltd., Firozabad left for heavenly abode on Feb 17.

A Visionary, Pioneer and Philanthropist, Mr. Gupta started his Glass career in 1978. He led many Technological Advancements, which made the product not only valuable but also reduced the challenges faced by process engineers in glass manufacturing.

In 2019, Mr. Gupta received AIGMF's prestigious Balakrishna Gupta Award on behalf of Firozabad Glass Shell Industries as one of its Directors upon being recognized for their export contributions.

"Mr. Gupta was very humble and a dedicated glass industrialist. His absence will be felt in the Glass Industry", said AIGMF Secretary Mr. Vinit Kapur.

BOROSIL RENEWABLES TO EXPAND SOLAR GLASS MANUFACTURING CAPACITY TO 2,000 TONS PER DAY

Borosil Renewables Ltd., will expand its solar panel glass manufacturing capacity from 450 tons per day to 2,000 as it continues to see strong growth in demand. The company is adding a third solar line with a capacity of 550 metric tons which is expected to start production by September and will enhance the manufacturer's daily production capacity to 1,000 tons.

Thinner glass – 2 mm, 2.5 mm, and 2.8 mm – occupies almost 30% of Borosil's production capacity at

present and the company expects its 2 mm products to account for at least a similar slice of its expanded capacity, based on rising demand for bifacial solar panels.

The manufacturer has said it expects domestic demand to be driven by the big volumes of solar capacity which are being commissioned by government policies.

Presenting the company's report card for the third quarter of the fiscal year, Borosil Executive Chairman Mr. PK Kheruka said: *"The government has announced three major steps underlining its commitment to the establishment of a strong domestic solar manufacturing ecosystem. The first is the announcement of an additional allocation of INR 19,500 crore under the PLI (production-linked incentive) scheme (to incentivize manufacturing capacity for) solar cells and modules, raising the total allocation to a very impressive INR 24,000 crore. The second is the formal announcement of basic customs duty on solar panels at 40%, and on solar cells at 25%, effective from April 1, 2022. The third is the scheme of the approved list of models and manufacturers introduced some months ago, whereby effectively only Indian manufacturers of solar modules are able to supply to many types of government tenders, which have now been extended to open access and net metering projects as well. As a result, we are expecting that large incremental capacities, already announced, will now be implemented."*

"Even though 14 GW of solar module manufacturing capacity exists in India, actual production was about 5.5 GW during the financial year 2021. We see installed capacity rising to 50 GW of solar panels within the next three years. This will give a great boost to the domestic production of solar equipment in India, causing a major shift away from imports from China to sourcing from domestic manufacturers. Consequently, we expect increased demand for solar glass in India."

Mr. Kheruka added *Borosil is in advanced discussions with many domestic manufacturers seeking Indian-made solar glass*. The manufacturer is also anticipating attractive future growth in exports on the back of an expected rise in the production of solar modules in major markets such as Europe and the USA.

REMEMBERING MANOHAR LAL

Mr. Manohar Lal, former Secretary of The All India Glass Manufacturers' Federation passed away on January 7 at the age of 91.

Mr. Lal retired after 24 years of service to the Federation and was bid farewell on Jan 4, 2014 at the AIGMF Executive Committee meeting where senior Members of the Federation expressed appreciation for Mr. Lal's sincere and dedicated service.

'*Many AIGMF dignitaries paid tribute to Mr. Lal. He will be sadly missed by the Secretariat*', said Mr. Vinit Kapur, Secretary of the AIGMF.

GLASSPEX INDIA POSTPONED UNTIL SEPTEMBER 2023

Due uncertainty faced by the Pandemic, glasspex India, glasspro India and Fenestration pro India have been rescheduled for September 2023.

Mr. Thomas Schlitt, Managing Director, Messe Düsseldorf India, said: *"Our objective remains to support economic recovery by providing a leading platform for conducting business safely and effectively at our trade fairs. But the recent development in the pandemic situation makes it impossible to hold the glass events in India for March 2022. The decision to reschedule the fairs to September 2023 was taken after careful evaluation of the situation together with our partners and key stakeholders."*

With this decision, Messe Düsseldorf India is taking into account its obligations towards its partners of the glass industry in India and worldwide. The postponement to a later date will ensure that the event will continue to play its leading role in bringing the global industry stakeholders together once again.

"We are grateful to all our partners for their continued support in these unprecedented times. We stay committed and will take every possible measure in supporting and creating resilient businesses at India's leading industry event catering to the glass fraternity," he added.

AGI GLASPAC OPENS ₹400 CRORE MANUFACTURING UNIT IN TELANGANA

AGI glaspac, which is among the largest container glass bottle manufacturers, has commissioned its specialty glass manufacturing unit at Bhongir in Telangana at an investment of Rs 400 crore.

Set up amid growing demand in speciality glass segment, the 154 tonnes per day (TPD) facility has started producing clear glass products that are primarily used for

packaging cosmetics and perfumery, pharmaceuticals, premium spirits, food and beverages and also to make water bottles and candle jars.

The facility is expected to provide employment to 350 people and reduce dependence on imports and promote sustainability by encouraging various user-industries to choose glass over plastic in terms of packaging, said AGI, which is the packaging products division of HSIL Ltd. Besides India, the new unit will also serve foreign markets.

President and CEO Mr. Rajesh Khosla said: *"with the opening of this new facility, we are closer to our vision of building a centre of excellence in the container glass packaging in India, using globally-benchmarked manufacturing systems and practices. With an expected revenue of ₹275 crore, it will boost our commitment to produce sustainable world-class, innovative products."*

AGI said it also focused on serving niche customers with small batch requirements as the production lines are flexible and can be adapted based on their needs. It plans to forge warehouse at strategic locations near key markets so as to reduce the delivery lead time.

AIS DESIGN OLYMPIAD – 2022

The 3rd season of AIS Design Olympiad was concluded on 29th January 2022 with the National Level round being held on a virtual portal, where the top 10 finalists (top 2 teams from North, South, East, West & Central zones) presented their designs to the National Jury Panel.

To develop and share best practices for deploying energy-efficient, cost-effective, comfortable infrastructure and responsibly reducing energy loads while improving thermal comfort, this year's competition theme was 'Adaptable & Sustainable Architecture for tomorrow' and the topics students could choose from and work on were 'Design for Better Workspaces' (A better & safer work environment for employees) Or 'Rethinking Educational Institutions' (A healthier & safer educational institutes for the academic community).

The competition was judged by eminent architects from the fraternity– Ar. Sonali Bhagwati (President at DPA, New Delhi), Mr. Mahesh Arumugam (Director at Meinhardt Façade Consultancy, Chennai), Ar. Raghuram (Director at CRN, Chennai), Ar. Karl Wadia (Sr. Architect at Hafeez Contractor, Mumbai), Ar. Paul Moses (Director at RSP, Bangalore) and Ar. Vivek Bhole (Principal Architect at Neo Modern Architects, Mumbai). Ar. Vivek Bhole was also the curator of the entire event.

Mr. V. Suresh (Chairman of IGBC) graced the event as the Chief Guest and Mr. Jatin Shah (MD of Colliers India) was the Key Note Speaker.

The awardees were as follows:

Winners - Dr. Bhanuben Nanavati College of Architecture (Topic - Rethinking Educational institutions)

1st Runner up - IPS Academy, Indore (Topic - Design for Better Workplace)

2nd Runner up (There was a tie for the 2nd runner up position) - (1) Sir J. J. College of Architecture, Mumbai (Topic - Design for Better Workplace) & (2) Marg Institute of Design and Architecture, Tamil Nadu (Topic – Rethinking Educational institutions).

Speaking at the occasion Mr. Vikram Khanna, COO (Architectural Institutional Business) & CMO – Asahi India Glass Ltd. said, *'It has been an honor and privilege for us at AIS to organize the AIS Design Olympiad by having all eminent architects & industry experts on the Jury panel.' The contest was curated with the purpose of providing a platform for the architecture students to use their capability & creativity in the projects and interact with the leading architects in the industry. I sincerely thank all the honourable regional & national jury members, chief guests and keynote speaker for associating with us and imparting their wisdom to the budding architects throughout*

ADO 2022. I believe this event was a highly learning experience for all the participants, where they have been enriched with knowledge."

Ar. Vivek Bhole, Curator – ADO said, *"Being on this platform helps not only students but us to learn many new-gen things from the students. The contest helped to bridge the gap between two generations of architects. It was great associating with AIS Design Olympiad as a Curator and Jury member again in its 3rd edition. I thoroughly enjoyed this journey with the AIS team and budding architects*".

Mr. V. Suresh (Chairman of IGBC), who was Chief Guest at the ADO Finale said, *"It was a pleasure to share the panel with the renowned Jury members. I congratulate AIS for holding this Olympiad, where they challenged students to think beyond the ordinary, helping them in bringing out the best of their talents on a national level platform and in front of industry stalwarts. It is important to practice sustainability to ensure energy-efficient, cost-effective, comfortable infrastructure and responsibly reducing energy loads while improving thermal comfort."*

Mr. Jatin Shah (MD of Colliers India), who was Key Note Speaker at the ADO Finale, said *"I thank you for inviting me to be a part of the event and it's been a real pleasure to sit through some of the presentations. It has not just been a great learning but a thoroughly engaging session to say the least. It is an absolute pleasure to see the young minds stretching their limits and putting together some thoughts that are already future ready. Indeed, the future of the country is in the hands of really bright minds."*

KOTAK SPECIAL SITUATIONS FUND TO INVEST UP TO ₹450 CRORE IN GOLD PLUS GLASS INDUSTRY

Kotak Special Situations Fund (KSSF), managed by Kotak Investment Advisors Limited (KIAL), will make an investment of up to ₹450 crore in Gold Plus Glass Industry Limited (Gold Plus).

Gold Plus is one of the largest float glass manufacturers with two manufacturing lines in North India, and offers a full bouquet of product offerings of Clear Glass and Value-Added Glass.

Of the ₹600 crore to be raised by Gold Plus, KSSF will invest up to ₹450 crore, while Premji Invest, an existing investor in Gold Plus, will invest up to an additional ₹150 crore.

The funds raised by Gold Plus will be used to invest in the company's expansion plan of setting up of two new float glass manufacturing lines and one solar glass line in South India for a project of up to ₹2,500 crore.

Mr. Eshwar Karra, CEO-Kotak Special Situations Fund, said, *"Our investment in Gold Plus is in line with the Make-in-India programme of the Government and our philosophy of partnering with high-quality, growth-oriented businesses".*

He said that the Indian float glass industry is undergoing a structural shift with growing usage in architectural, automotive and industrial sectors, along with the Government's increasing support for domestic manufacturers.

"We believe Gold Plus, the only Indian player in the sector, is ideally poised to capture this growth trend in the coming years and we look forward to play an active role in the company's growth story", Mr. Karra said.

Mr. Subhash Tyagi, Chairman, Gold Plus, said, *"Gold Plus is poised for its next phase of growth by participating and contributing to the 'Make-in-India' vision of the Government of India. I am pleased to welcome KSSF on board, along with Premji Invest who have shown confidence in our company by investing in the second round of funding. Our journey over the past decade has been about being the one-stop solution for glass, investing in the future and capability enhancement. We will continue to create consistent value for our stakeholders and scale new levels of success."*

Mr. Rajesh Ramaiah, Partner, Premji Invest, said, *"We are excited to commit further capital to our existing partnership with Gold Plus for one of the largest expansions planned in the glass Industry. The expansion will help reduce the import dependency in line with Government's Atma Nirbhar initiative".*

CGCRI'S INAUGURAL IYOG 2022 EVENT

In the United Nations history, only a year (2022) is dedicated to a material, named "glass" which is a befitting tribute to this most fascinating

PROUD USERS OF IYOG 2022 CALENDAR GLASS BOTTLE – A GLIMPSE

Dr. Jacqueline d'Arros Hughes, Director General, ICRISAT

Dr. K Annapurna, Chief Scientist, Glass Division, CSIR-Central Glass & Ceramic Research Institute (CGCRI), Kolkata

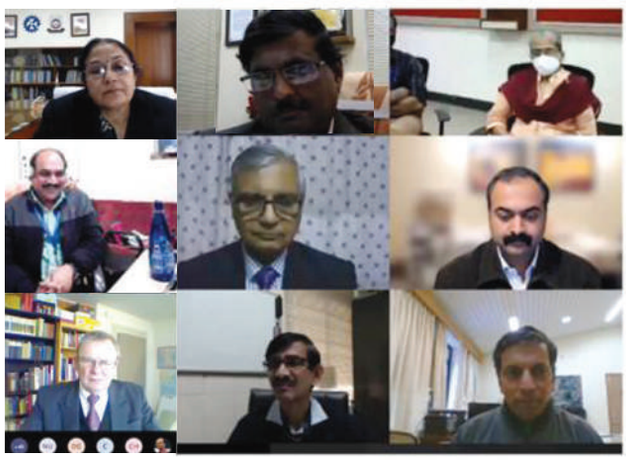
Ms. Sangeetha Shenvi, Vice President Sales, Schott Poonawalla Pvt. Ltd.

material. Glass is omnipresent in our daily life and a day without glass cannot be imagined, if we just think about displays of our mobile handsets, TV screens, car windshields, home windows and most importantly optical fibers made of glass which is the backbone of the modern civilization. There is no doubt we entered into the glass age which is going to sustain forever.

The International Commission on Glass (ICG), along with the Community of Glass Associations (CGA) and International Committee for Museums and Collections of Glass (ICOM-Glass) pursued the General Assembly of the United Nations for recognizing the importance of glass in our daily life and its pivotal roles in the advancement of mankind. The International Year of Glass 2022 (IYOG 2022) initiative received overwhelming support through about 2500 endorsements from over 90 countries finally resulting in the General Assembly of the United Nations declaring the year 2022 as an International Year of Glass. The year will celebrate the essential role that glass has and will continue to have in society. It will underline the technological, scientific and economic importance of this often unseen transparent and enabling material which underpins so many technologies and which can facilitate the development of sustainable societies to meet the challenges of globalization. It is also an important medium for art and its history is integral to that of humankind.

CSIR-CGCRI being the national council member of ICG was given a prime responsibility to mobilize various glass related organizations in India and to celebrate the IYOG 2022 with a motto to aware the common masses how glass continues to play an important role in their daily life and how it is going to influence the society in future. CSIR-CGCRI inaugurated the IYOG 2022 celebration events in India, in association with AIGMF, GSI and ICS, Kolkata Chapter on 28 January. IYOG 2022 selected India as the nodal agency for Regional Organization - 17 (RO-17) which comprises India, Iran and Pakistan. CSIR-CGCRI planned year long programs throughout 2022 that include monthly webinars on glass, an international conference on glass and a live demonstration of glass synthesis to name a few to celebrate the International year of glass with a motto to promote this versatile and sustainable material.

The IYOG 2022 inaugural event was started with the introductory remarks by Mr. Sitendu Mandal, Chief Scientist and Head, Specialty Glass Division and Chairman, IYOG 2022 Celebration



Committee, CSIR-CGCRI, Kolkata, India and Chairman, Indian Ceramic Society, Kolkata Chapter, India who also acted as Moderator of the program. He presented a brief overview of IYOG and elaborated on the efforts made by different people to convince the United Nations to declare the year 2022 as the International year of glass. Dr. (Mrs.) Suman Kumari Mishra, Director, CSIR-CGCRI, Kolkata, India delivered the welcome address. She mentioned how glass is important and how it is indispensable for mankind and lauded the efforts being made to popularize glass among common people.

The program was graced by Prof. Reinherdt Conradt, President, International Commission on Glass (ICG), who delivered the Inaugural speech as a Guest of Honor of the program. He also elaborated on how glass was important for the advancement of mankind from early civilizations to modern life. He congratulated CGCRI for inaugurating the IYOG 2022 in India, even before the formal opening ceremony by the UN slated to be held in UN's Palace of Nations in Geneva, Switzerland during 10-11 February 2022. He thanked CGCRI for playing a key role in the International Commission on Glass.

Dr. H. S. Tripathi, Senior Principal Scientist and Head, Refractory & Traditional Ceramics Division, CSIR-CGCRI, Kolkata, India and Scientist-in-charge, CGCRI Khurja Centre, UP, India and Secretary, Indian Ceramic Society, Kolkata Chapter, India introduced the Chief Guest Prof. Himadri Sekhar Maiti, Project Adviser, GCECT, Kolkata, India and Former Director, CSIR-CGCRI, Kolkata, India and Former INAE Distinguished Professor before the audience.

Mr. Bharat Somany, President, AIGMF, India and Vice President, Hindusthan National Glass & Industries Ltd., delivered a speech as a Guest of Honour of the program. He mentioned about the glorious history of glass usage in India and its proven sustainability. He said that AIGMF is committed to spreading the flavor of glass among the masses.

Prof. Himadri Sekhar Maiti, Project Adviser, GCECT, Kolkata, India and Former Director, CSIR-CGCRI, Kolkata, India and Former INAE Distinguished Professor glorified the event with his gracious presence as a Chief Guest of the Inaugural function and delivered the talk on "Glass in India: Research Development and Production". This was a very pertinent talk for the event that covered every aspect of glass in India. In his speech, he discussed origin of glass as well as the institutes engaged that are in glass research in India. He also pointed out how India has been contributing significantly to glass research globally as well as the development of technologies. He also did mention how glass production started in India with the Swadeshi movement led by

HNG ORGANISED 51st NATIONAL SAFETY WEEK

Hindustan National Glass and Industries Ltd., organised 51st National Safety week from March 4-10 at their unit in Bahadurgarh (Haryana).

The National Safety Day/Week is celebrated in India every year (organized by the National Safety Council) on 4th of March to enhance the safety awareness among people.

The Theme for this year was *'Nurture Young Minds, Develop Safety Culture*'.

Mr. Bal Gangadhar Tilak in the year 1899. The huge contributions made by the Firozabad glass cluster in India as a glass hub and modern float glass plants in India producing glass of about 8000 tons/day also got a mention in his talk.

The event was concluded by offering a formal vote of thanks by Dr. Atiar R. Molla, Principal Scientist, Specialty Glass Division, CSIR-CGCRI, Kolkata, India and Organizing Secretary, IYOG 2022 Celebration Committee, CSIR-CGCRI, Kolkata, India which was followed by playing of Indian National Anthem.

HE Mr. Dinesh Bhatia *(centre)*, Indian Ambassador Extraordinary and Plenipotentiary to the Republic of Argentina & Uruguay with Kapoor Glass team led by Director Mr. Dhruv Kapoor *(3rd from the left)*. Also in the picture is Commercial Attaché, Ms. Mohini Bhatia *(2nd from the right)*

KAPOOR GLASS AT ETIF 2022

Kapoor Glass India, participated at ETIF 2022 at Buenos Aires, Argentina from March 30-April 1.

ETIF is the leading exhibition and conference in Argentina for the Pharmaceutical, Biotechnological, Veterinarian and Cosmetics Science and Technology.

Argentina is considered as a gateway to many other smaller countries in the Region and hence widely attended. In line with the vision of PM Narendra Modi to support the growth of Industry and exports, His Excellency Mr. Dinesh Bhatia, Indian Ambassador to Argentina & Uruguay graced the occasion by inaugurating the Kapoor Glass stand. The level of proactive support and guidance imparted by the Ambassador and his Team was excellent and worth a round of big applause.

Kapoor Glass is one of India's leading glass ampoule, vial and cartridge producers and is optimistic of growing its presence in Latin America in the years to come.

IYOG 2022 MARCH MONTHLY LECTURE SERIES

CSIR-Central Glass and Ceramic Research Institute (CSIR-CGCRI), Kolkata is celebrating the "International Year of Glass (IYOG) 2022" through different events. The monthly webinar series 2022 is one such event being organized by CSIR-CGCRI in association with The All India Glass Manufacturers' Federation (AIGMF), Glazing Society of India (GSI) and Indian Ceramic Society (ICS), Kolkata Chapter.

The webinar for March 2022 was held on 28th March in a virtual mode with two interesting technical lectures.

The program was started with a welcome address and remarks on IYOG 2022 by Mr. Sitendu Mandal, Chief Scientist and Head, Specialty Glass Division (SGD) and Chairman, IYOG 2022 India Celebration committee, CSIR-CGCRI, Kolkata, India. Special Addresses were delivered by Mr. Sourabh Kankar, Secretary, Glazing Society of India and Mr. Antony John, Director Technical and System Engineering, Schüco India and Director R&D Schüco Asia followed by a technical session.

The Technical Lecture-1 was on "Energy Efficient Glass" delivered by Mr. Shailesh Ranjan, Head - Business Planning & Operations at Asahi India Glass Ltd. He presented how the glass is made energy efficient and how it in turn makes the buildings energy efficient with its usage which is the need of the present day. The Technical Lecture-2 was delivered by Mr. R. Venugopal, Head – Design and Sustainability, Saint Gobain India.

The title of his lecture was "New Age Glass" in which the speaker elaborated on the advanced innovations in Glass technology and presented the smart functionalities of Glass.

This was followed by a lively interactive session with the active participation of participants. The program ended with a formal vote of thanks by Dr. (Mrs.) Kalyandurg Annapurna, Chief Scientist & Coordinator of Monthly Webinar Series 2022, IYOG 2022 India Celebration Committee, CSIR-CGCRI, Kolkata, India.

MASCOT'S 3rd GENERATION RAAHIL LALVANI JOINS AS IT'S DIRECTOR

Mr. Raahil Lalvani, a graduate from the University of Westminster, United Kingdom was inducted into Mascot's business to serve its clients.

He is the 3rd generation of Lalvani family and is son of Mr. Mohit Lalvani who joined Mascot Engineering in 1992.

MASCOT Engineering Company has entered in its 52nd year, which was founded by Mr. Mohan Lalvani in 1968 who continues to be its Chairman and now counts on his son and grandson to expand Mascot's activities.

In 1975, a separate division was created to service the glass industry.

MASCOT is a one stop shop for Soda Lime Glass and specialty glass like Borosilicate, Opal, Fiber, Lead Crystal, Pyrex, Silicate Glass.

It provides turnkey solutions for Container Glass, Tubing, Flat Glass, Tableware, Fiberglass, Opal ware.

AIGMF since 1944

Welcomes It's New Members

Company	Products / Services
Pro-Quip Solutions Pvt. Ltd. Gat No. 6, Near Durga Mata Mandir Kasurdi Kheba, Tal : Bhor, Dist : Pune Maharashtra 412 205 CONTACT: Mr. S M Wagh / Mr. H.B.Yadav Tel: +91 9423578154 / +91 9922001350 Email: director@proquip.co.in hbyadav@proquip.co.in	Comprehensive Bulk Material Handling Equipment's & Process Automation viz: Glass Batch House on Turnkey basis, Weighing and Batching, Pneumatic Conveying Systems, Vibratory feeders, Bucket Elevator, Conveyors, Dust Collection System, Bin Vibrators / Fluidizers, Storage System, PLC Control Panel, Electrical Panels, Weigh feeders etc.
Kaisha Packaging Pvt. Ltd. Survey No.342/3 (16,17,18,19) Bharat Industrial Estate Village Bhimpore, Nani -Daman Dadra and Nagar Haveli and Daman and Diu-396210 CONTACT: Mr. Nikhil Chugh Head – Sales Tel: + 91 22 35200 800 Email: info@kaishapackaging.com nikhil.chugh@kaishapackaging.com	Aluminium seals and injection moulded articles, primarily meant for packaging of injectable vials & pharmaceutical applications. Company has successfully provided over 2 billion doses worth of flip-top aluminum seals used for packaging COVID vaccines.

CONTRIBUTORY FUNDS FOR IYOG 2022 ACTIVITIES

In addition to the normal IYOG 2022 Member contribution, a special contribution of Rs. 1,00,000 was given by Schott Glass (India) Pvt. Ltd., Gujarat.

SCHOTT

"We remain thankful to Executive Committee Member Mr. P K Shukla and MD Schott Glass for this noble support, which will help AIGMF to deliver more programs in the International Year of Glass 2022", said Secretary Mr. Vinit Kapur.

यूक्रेन-रूस के युद्ध में फिरोज़ाबाद की कांच इंडस्ट्री को भारी नुकसान

रूस द्वारा यूक्रेन पर हमला करने के बाद पेट्रोलियम प्रोडक्ट महंगे होने के कारण व्यापार को बहुत ज्यादा आर्थिक नुकसान होने की संभावना है। ऐसे में फिरोज़ाबाद की कांच इंडस्ट्री भी इससे अछूती नहीं है। दरअसल बहुत सारे कांच बनाने के केमिकल यूरोप देशों से आते हैं। जिसकी कीमतों में अचानक भारी उछाल हो गया है। वहीं जिन कांच की वस्तुओं के क्रय के आर्डर यूरोप से आए थे उनको होल्ड पर डाल दिया गया है।

एक अनुमान के मुताबिक करीब 3 सौ करोड़ रुपए से अधिक के ऑर्डर को होल्ड पर डाल दिया गया है। जबकि फिरोजाबाद के कांच की विभिन्न वस्तुओं का कुल निर्यात 1200 करोड़ का है। यदि युद्ध लम्बा चला तो सभी ऑर्डर कैंसिल होने की संभावना है।

फिरोज़ाबाद में निर्मित कांच के उत्पाद यूरोप देश के 70 से अधिक देशों को सप्लाई किए जाते थे। ऐसे में बहुत सारे ऑर्डर मार्च के अंत तक क्लियर करने थे। फिरोजाबाद के कांच के प्रमुख निर्यातक मुकेश बंसल टोनी कहते हैं कि इस समय यदि युद्ध जल्दी समाप्त नहीं हुआ तो फिरोज़ाबाद की कांच इकाइयों को और बड़ा झटका लगेगा।

साथ ही उन्होंने कहा कि चुनाव के बाद जैसे ही गैस डीजल और पेट्रोल की रेट में वृद्धि होगी कांच के उद्योग का प्रभावित होना लाज़मी है। जो केमिकल विदेशों से आ रहे थे उनके रेट में अचानक भारी उछाल आ गया है। कांच इडस्ट्री फिरोज़ाबाद से बेल्जियम, नीदरलैंड, कनाडा, अमेरिका, ऑस्ट्रेलिया, स्पेन, फ्रांस, अमेरिका, ब्रिटेन, हालैंड, रूस आदि देशों को भारी मात्रा में कांच की विभिन्न वस्तुओं का निर्यात किया जाता है। ऐसे में यह युद्ध होना किसी भी तरह से उचित नहीं है।

(News Source: AIGMF Research Team / World Wide Web)

Do you have news to share?

Send your news and press releases to info@aigmf.com

International Year of Glass (IYOG 2022) advertised at Iran Dragon Boat Premier League, organized by Iran Canoe Federation at Tehran Stadium Lake in March 2022.

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Creating a United Nations International Year of Glass

A SEED IS SOWN

Prof. John M. Parker

Prof. Alicia Durán

Prof. L. David Pye

In 2014 L. David Pye, Past President of The International Commission on Glass and The American Ceramic Society, learned that The United Nations General Assembly had declared 2015 an International Year of Light and Light-Based Technologies. As editor of *The International Journal of Applied Glass Science (IJAGS)* he realized that it was an opportune moment to showcase "Glass and Light" through a special edition. In 2016 a second special edition dealt with the emerging paradigm that we have entered *The Age of Glass*. David L. Morse and Jeffrey W. Evenson, senior administrators, Corning Inc., eloquently summarized this new thinking in their contribution "Welcome to the Glass Age" which was strongly reinforced by other contributions in this issue. Collectively and individually, they argued that we are at a special moment in time where the arrival of *The Age of Glass* can be declared —with certainty and pride— by glass scientists, engineers, educators, artists, and glass manufacturers across the globe.

From all of this, it is clear that glass has played a major role in advancing civilization and mankind throughout recorded history be it in the arts, architecture, transportation, medicine, communication, and especially important, other branches of science. Had it not been for glass, the microscopic biological world might never have been revealed, nor would we have discovered the universe beyond the earth, moon, and stars. How can we not marvel that several centuries ago glass allowed light to enter darkened buildings while keeping away the cold, rain, sleet and snow? How can we not marvel at the beauty and reverence of stained-glass artistry found in cathedrals across the world? Or the simple light bulb providing light for all we do when darkness falls? Or our increased ability to see by placing small pieces of curved glass before our eyes?

Figure 1. Because glass is transparent it is often used for viewing other objects without being seen itself, for example when using microscopes, telescopes, optical fibers and binoculars.

Source: Pixabay

While many other revolutionary innovations can be cited where glass was the critical component in their development, the view here is that the greatest contribution of glass to life as we know it today is its role in advancing communication in ways unimaginable a century ago. Has not the world been transformed by the optical glass fiber networks that span the globe? Or by ultra-thin glass plates for television sets and protective covers for mobile phones? Then there is the remarkable story of a small company in Rochester, New York, that realized the potential of a light sensitive metallic glass for making possible high-speed reproduction of documents. This company was eventually renamed Xerox Corporation. Similar stories can be found in the emerging field of glass and healthcare. Notwithstanding this remarkable history, the view here is that the best is yet to come as glass science continues to evolve and be better understood [1].

Paradoxically, despite this

history undergirding modern society, various texts written on nanotechnology rarely mention glass as *a quintessentially nanotech material*, while for glass scientists and engineers, the fabrication and application of glass begins and ends with their understanding physical and chemical phenomena at the nanoscale and below. Heralding the advent of *The Age of Glass* will help address this oversight and bring to the attention of the public at large the critical role glass has in our daily lives. Subsequent lectures by Manoj Choudhary, then ICG President, and David Pye given to international audiences explored the theme that glass science, engineering and art are entering new and profound chapters in their histories. Based on the above remarks, a sense of history, and appreciation of a seminal idea whose time has come it is a great honor to chronicle here and affirm the advent of *The Age of Glass*, and by extension a UN declared International Year of Glass.

Prompted by the very positive reactions to the above, David Pye discussed the concept of an International Year of Glass (IYOG) with Charles L. Craig, Senior Vice President, Science and Technology, Corning Inc. He was strongly supportive and encouraged its pursuit. Soon thereafter Profs. Choudhary and Pye introduced a motion in September 2018 at a meeting of the Council of the International Commission on Glass in Japan which read:

The International Commission on Glass, representing organizations and individuals throughout the world dedicated to the promotion of science, technology, artistry, and application of glass enthusiastically endorses the exploration of a future declaration of a Year of Glass by the United Nations.

Following its positive reception, Prof. Pye presented the concept to the American Ceramic Society and the Corning Museum of Glass (CMoG). Both embraced the idea, the latter leading Steven T. Gibbs, a senior administrator at CMoG, to play a pivotal role in advancing IYOG 2022 to the international art community. Buoyed by this groundswell of enthusiasm, ICG's current President, Alicia Durán, took up the baton to become Chair of an International Steering Committee for the proposed IYOG. The die was cast.

Figure 2. A white filigrana vessel created using techniques similar to those now used for optical fibers.
Source: © Fondazione Musei Civici di Venezia - Museo del vetro di Murano - Archivio Fotografico

CREATING THE RIGHT ENVIRONMENT

Throughout the past 60 years the General Assembly of the United Nations has honored contributions to society in many fields by declaring '*International Years*'.

A UN badged International Year requires a United Nations Resolution. The Spanish ambassador at the Mission of UN in New York, Agustín Santos Maraver, agreed to lead the process through the United Nations and explained the steps and documents needed. The application finally submitted included a main document justifying the role of glass following the Goals of Agenda 2030, an eco-social document reporting state of the art in glass industry and an Executive summary. They showed how the glass community is supporting UN developmental goals (2030 agenda): responsible production and sustainability; innovation and infrastructure; affordable and clean energy; climate action; unpolluted water and oceans; sanitation, health and well-being; education and gender equality. From these documents, the final Resolution was written promoting glass, its past and future potential.

The chair of the group that led to the International Year of Light, Prof. John Dudley, University of Franche-Comté, willingly shared his experiences with an initial IYOG team consisting of Professors Duran, Pye and Parker and explained more of the procedures involved. In March 2020, talks with senior administrators of UNESCO were held after learning of its approval of a 2022 International Year of Basic Sciences for Sustainable Development (IYBSSD) which included an International Year of Mineralogy. While 'competition' was the initial reaction, collaboration and mutual support with these groups

Figure 3. Flag of the United Nations adopted in December, 1946.

Source: Pixabay

were soon agreed to as the way forward. The IYBSSD, delayed by the COVID-19 pandemic, was finally approved at the General Assembly of UN on December 2nd, 2021.

Being aware of their value and potential contributions, the International Commission on Glass also approached several glass-based organizations as possible working partners. The International Committee of Museums, along with the Community of Glass Associations promoted by VITRUM and the Italian Government, accepted the challenge and joined ICG as sponsors of IYOG with many national Glass Societies to help.

A formal application for a United Nations International Year of Glass for 2022 to celebrate the technological, scientific, artistic and economic role of glass as an enabling material crucial to many technologies and cultures was shifting from a possibility to a probability.

A SEED GERMINATES

Meanwhile throughout these initial negotiations written documentation was in preparation. A major 20 page document was created from an initial draft by Prof. John C. Mauro, the Pennsylvania State University, and enhanced/ modified by many others drawing on information from numerous sources. Using an electronic format for easy circulation and with the help of David Moore, Managing Editor, The Society of Glass Technology, it was subsequently incorporated into an eight-page illustrated brochure. A document on the global economics of the glass industry was also generated from a variety of sources and national reports. As a supplement to these written texts, a thirty-minute video was created by Prof. Julian Jones, Imperial College, and Mathieu Hubert, Development Associate, Corning Inc. In addition to the main authors, many experts and colleagues collaborated in creating this splendid film and the documentation justifying our project; while too many to mention individually we would like to acknowledge their support; they were always ready to assist and overflowing with ideas.

THE PROJECT GROWS ROOTS

The next step was to generate international awareness and interest in the proposal for an International Year of Glass. Articles were written in Journals and Trade Magazines and a web site was developed. The documentation and videos created for the UN were also helpful as publicity.

Figure 4. A stained glass window reminding us of a Green World outside needing our care.

Source: The Metropolitan Museum of Art Sansbury-Mills and Friends of the American Wing Funds, 2010, 2010. 122a-d.

Figure 5. Sustainable development goals of Agenda 2030.

Source: United Nations

A LinkedIn site was started and Glass Societies throughout the world were contacted to circulate information.

To harness the enthusiasm generated, a contact form was made available on the International Year of Glass web site to gather the details of interested organizations and individuals. This created an invaluable database, and the associated statistical information became a significant part of the evidence submitted to the United Nations. Figure 6 is a chart showing the types of Institution offering support and Figure 7 indicates their geographical distribution.

Approaching the end of 2021 support has now been received from more than 2000 Universities and research centers, societies and associations, museums, artists, educators, manufacturers and companies in 89 countries spanning all five continents. Almost 1400 of these submissions offering enthusiastic support were received in time for inclusion within our final documentation submitted to the UN.

New partners are still welcome, particularly from the more under-represented areas such as Africa, and the Middle East. To join our circulation list email: manager@iyog2022.org and visit our web site www.iyog2022.org

COMING TO FRUITION

The UN submission was far from smooth because of frequent false starts caused by the effects of the COVID-19 pandemic and also by the sensitive nature of the politics behind such submissions. Dates anticipated for a formal submission came and went with no action because important international meetings were delayed or not everyone was yet agreed on the details of the submission. Eventually a draft Resolution outlining our ambitions was negotiated and accepted by the Missions of several UN countries during April 2021. It successfully passed a silent process of approval on 11th May —no one had objected. The formal resolution was agreed at the United Nations General Assembly on May 18th, 2021 during a meeting that took place on-line; several committee members sat glued to their seats during the proceedings and their response to the vote echoed around the world.

Heartfelt thanks go especially to

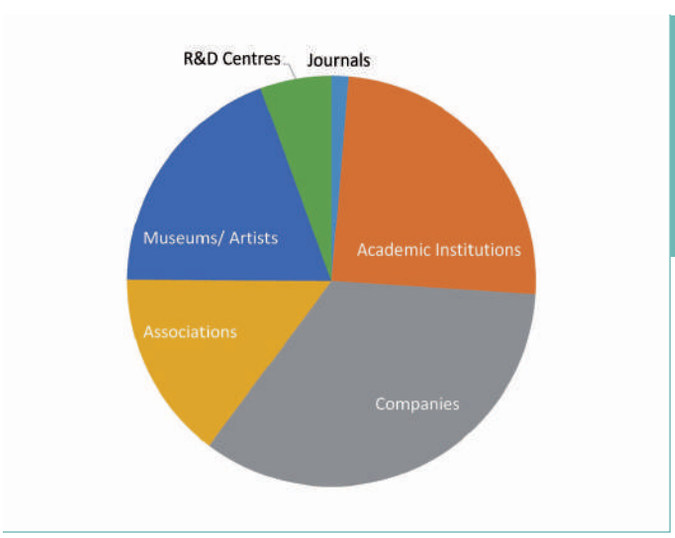

Figure 6. Showing the distribution of expressions of interest from various types of Institution.

Source: IYOG endorsers database

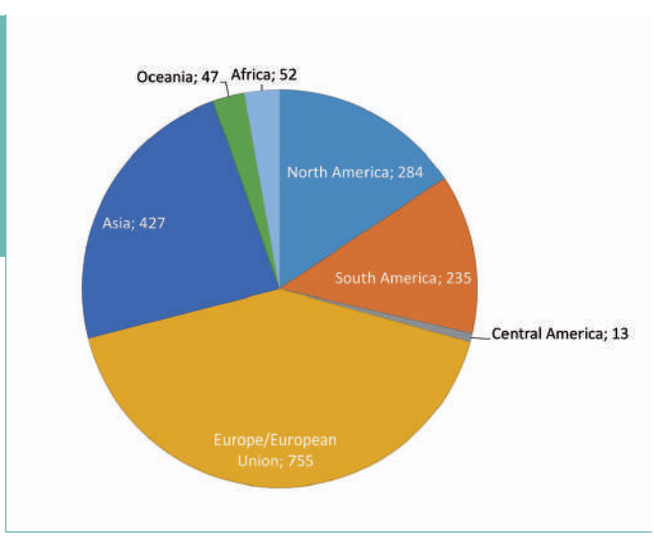

Figure 7. Showing the distribution of expressions of interest from different continents.

Source: IYOG endorsers database

is relying on grass roots input and a network of volunteers; delegation is indispensable.

Regional Organizations have been created based on location, language and the geographical distribution of endorsers across the planet. These total 18 groups and they are listed in Table 1. Each group will focus on coordination, advertising, sharing best practice and providing a supportive environment. Additionally, an Executive Committee, based on representatives from the Regional Organizations will promote the best ideas and multiply their impact. Financial arrangements for local activities are being dealt with at a local level but a Sponsorship Program has been created to support internationally activities, particularly the 'Opening Ceremony', a UN 'requirement'. Finally, an over arching small executive committee is able to

the Spanish Mission at the UN, particularly the Spanish Ambassador Agustín Santos Maraver and Ana Alonso Giganto, who led this process through the difficult twists and turns of diplomacy in stressful times. We are also grateful to the 19 countries that lent their support as Co-Sponsors by formally endorsing the UN resolution.

SUPPORTING GROWTH: RUNNING AN IYOG

From the start was a realization that such celebrations could not be organized solely by one committee; local communities had to be harnessed for local activities.

The task of diffusion and coordination of thousands of activities across the planet has started: congresses and seminars, industrial fairs and glass schools will co-exist with artistic exhibitions, books, social media, scientific, technical and general interest magazines. Event planning

Figure 8. United Nations Headquarters, New York.

Source: Pixabay

identify issues, react quickly and offer guidance as the need arises.

The internet, underpinned by glass fiber cables, and viewed through glass screens is supporting communication. One positive outcome of the Pandemic is the rapid growth in tools such as Zoom and Teams to allow widely separated groups to meet and communicate efficiently. We are also designing a framework to record, develop and share ideas across the glass world based on our web site www.iyog2022.org and a LinkedIn group *International Year of Glass 2022* exists.

Looking to the future, a successful sustainable development agenda will require partnerships between governments, the private sector and civil society built on principles and values, a shared vision and goals with people and the planet at the center; partnerships are needed at global, regional, national and local levels. An IYOG will initially underline the varied roles of glass but should also stimulate, mobilize and redirect such partnerships to unlock their resources and deliver sustainable development over the long term.

Figure 9. Nations from all 5 continents are working together to support activities across the globe.

Source: Pixabay

MAJOR EVENTS PLANNED

The original application was formulated around several significant historical anniversaries. These included the 670th anniversary of the earliest depiction of eyeglasses in a painted work of art (frescoes dated 1352 by Tommaso da Modena in Treviso, Italy); the 200th anniversary of the invention of the Fresnel Lens used in seashore lighthouses and attributed with preventing countless disasters; the 100th anniversary of the discovery of ancient Egyptian Glass in King Tutankhamun's Tomb in 1922; the Centennial Anniversary of the German Society of Technology (DGG); the 70th anniversary of the Pilkington patent in 1952 that heralded the float glass process and forever changed flat glass manufacturing; the 60th anniversary of the Studio Glass Movement; and the 45th anniversary of the Nobel Prize to Anderson and Mott for work on amorphous materials.

Events currently agreed are: an Opening Conference in Geneva from 9-11th of February; '*From Pharaohs to High Tech Glass*' in Egypt, April-May 2022 (celebrating 100th anniversary of the discovery of ancient Egyptian Glass in King Tutankhamun's Tomb); a *US Glass Day* in Washington DC, April 2022; an ICG International Congress in July in Berlin to celebrate the 100th anniversary of DGG; several *International Glass Art festivals and Museum events* in Europe and USA; finally a *Closing Congress in Japan*, on 8-9th December 2022. Additionally, there will be an Iberoamerican

Table 1. List of regional groups and the countries included in each

Group 1	Brazil
Group 2	Germany, Liechtenstein
Group 3	China
Group 4	Turkey, Greece, Cyprus, Malta, Jordan, Saudi Arabia, Lebanon, United Arab Emirates, Bahrain, Israel, Bulgaria
Group 5	Argentina, Bolivia, Chile, Peru, Uruguay
Group 6	Mexico, Costa Rica, Dominican Republic, Ecuador, Guatemala, Colombia, Venezuela, El Salvador, Panama
Group 7	USA, Canada
Group 8	Spain, Portugal, Andorra
Group 9	France, Belgium
Group 10	Japan, Korea
Group 11	Denmark, Finland, Norway, Sweden, Netherlands, Luxembourg, Latvia, Estonia, Lithuania
Group 12	UK, Ireland
Group 13	Russia, Poland, Armenia, Kazakhstan, Belarus, Uzbekistan, Moldavia, Ukraine
Group 14	Hungary, Slovenia, Serbia, Romania, Slovak Republic, Czech Republic, Switzerland, Austria, Croatia
Group 15	Algeria, Angola, Egypt, Eritrea, Morocco, Nigeria, South Africa, Swaziland, Tanzania, Ghana
Group 16	Australia, Malaysia, New Zealand, Singapore, Vietnam, Indonesia, Philippines, Thailand
Group 17	**India**, Iran, Pakistan
Group 18	Italy

Figure 10. An elaborately decorated glass beaker.
Source: Turner Museum of Glass (Simon Bruntnell)

International Congress on *Women in glass: Artists and Scientists*, Madrid. Also planned are the XI Fórum técnico para la conservación y tecnología de la vidriera histórica, Barcelona 2022 and the 16th International Conference on the Physics of Non-Crystalline Solids in Canterbury, UK.

Several Trades Fairs and exhibitions are planned, most showcasing the history of glasses and glass making: *VITRUM*, Milano, 5-8th October 2021, the *China International Glass Industrial Technical Exhibition* and Glass Week with *Hi-tech Industrial Congress* and other glass knowledge literacy events, Shanghai, 11-15th April 2022; *GLASSMAN*, in Monterrey (11-12th May) with satellite events; *MIR STEKLA*, at Moscow (6-9th June); and *Glasstech*, including Glass Week, Düsseldorf 20-23rd September 2022.

Dedicated issues of international journals will be published and exhibitions are planned in museums, public and private glass collections. Educational materials are being prepared for universal dissemination.

For example, the Spanish Research Council, CSIC, is committed to publishing this celebratory book and organizing exhibitions on: a) IYOG objectives and b) creating a Circular Economy based on recycling and glass containers. There will be a re-edition of *Glass Houses* and a *Glass and architecture exhibition* focused on sustainability. The preparation of a *Circular Economy exhibition* was designed with the participation of ANFEVI and ECOVIDRIO and the support of FEVE. English and Spanish versions of exhibition materials will be offered to all supporting countries with translation into local languages a possibility.

Another important task has been fund raising, particularly to finance the opening event in Geneva. At the time of writing, individuals and organizations can contribute directly through the IYOG web site but there are also numerous sponsorship opportunities for the formal Opening Ceremony in Geneva, designed to kick-start the whole journey.

SUMMARY

IYOG 2022 is a dream come true, one we scarcely dared to anticipate. We are moved by the possibilities, prepared for challenges ahead and limited only by our imaginations.

The application to the UN was based on the UN 2030 humanitarian and sustainability aspirations. This book goes on to examine each of the goals considered in the original application and looks in greater depth at what glassy products can contribute.

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List of Advertisers

Indian Glass Science: Current Status and Future Prospects

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Abstract

The United Nations has declared the year 2022 as an international year of glass (IYOG) to recognize the remarkable contributions of glass to society. Hence, it is an opportunity to evaluate the progress made by the glass community. Besides the IYOG celebration, a detailed survey on the present status of glass science in India is assessed here. The statistical analysis is done based on the number of publications on glass science in the journals published in the Scopus database. In this survey, glass is used as a keyword in the title of the publication in the Scopus search. Most glass activities are based on oxide glasses, but a few glasses belong to the metallic and chalcogenide systems. It has been observed that the number of publications concerning glass is increasing over the years. In this search, information is provided on the funding agencies that support glass research in India and the top Indian institutions where most of the activities concerning glass are going on. Brief details are also presented on different glass industries in India and their products. Finally, it is realized that there is a need for a serious effort to promote Indian glass science and glass technology to a large extent in view of future demands.

INTRODUCTION

The evolution of society endures with the discoveries of materials. Glass is a material that has continued to stay noteworthy in our lives and accomplish the demands of society since civilization (about 4000 years). Glass is considered an advanced material and has been constantly explored by the change in composition, synthesis processes, and applications [1]. Glass has evidenced a long journey of transformations from the glasses of ancient times to recent smart glasses used in displays, biomedical applications, and in buildings. We can find several glass applications in our kitchens, offices, in space research, drug delivery, etc. [2]. In recognition of the contributions of glass to humankind, the United Nations has declared the year 2022 as the international year of the glass [3]. Enthusiastic new research groups have focused on glass-related activities worldwide during the past few years. Several professional societies and institutions are engaged to promote glass science and technology globally.

In India, glass is popularly known as "kanch". India has started its efforts on glass activity long back. The first glass research institute was established in Kolkata in the year 1950, and today it is known as Central Glass and Ceramic Research Institute (CGCRI) [4]. This is the first institute under the Council for Scientific and Industrial Research (CSIR), the largest research network of institutions spread in different parts of India. In the sixties, the development of optical glasses for the strategic sector brought CGCRI into the international scenario. Even at present, CGCRI is providing different glasses for strategic applications. Its two extension centres at Naroda (Gujarat) and Khurja (Uttar Pradesh) are helping the local glass industries with advanced knowledge and technologies. India started its glass education in 1924 in the Ceramic Engineering Department at Banaras Hindu University (currently under the Indian Institute of Technology Varanasi) [5]. Interestingly, according to the Scopus database search (details mentioned in the methodology section), the first paper on glass published in India was in 1922 from an industry known as Ogale Glass Works Ltd. [6]. The first paper titled "Glass Industry in India" was published in the Journal of the American Ceramic

Society. In the early days of glass science in India, two important papers were published by Prof. R. S. Krishnan and Prof. C. V. Raman on optical glass in the year 1936 and 1940 respectively from the Indian Institute of Science, Bangalore [7,8]. It is evidenced that other academic and research institutions are also engaged in glass research, education, and technology development. It shows that India has recognized the importance of glass long back and has put significant efforts to endorse it.

Indian glass industries are manufacturing several glass products in different parts of India. A large number of these industries are engaged in producing glass articles for packaging and architecture. Most of them are multinational companies and are internationally reputed, and their products are supplied to domestic and international markets. Some small to medium-scale domestic glass industries are fulfilling the local needs. It is important to note that there is no significant investment in glass research from the Indian glass companies, unlike in other parts of the world, which limits the Indian-origin glass innovations that translate into products. This article presents a detailed analysis of glass research activities in India. Different institutions and funding agencies promoting glass in India have been discussed here. The current status of Indian glass industries and future directions of glass have been emphasized.

METHODOLOGY

In this survey, the Scopus search engine has been used for the search. In different publications, several synonyms are used for the glass, such as vitro, supercooled liquid, metastable, disordered materials, non-crystalline, amorphous, etc. However, the keyword "glass" was typed in the title to get the publication data on glass without any ambiguity in the search. The analysis was restricted between January 1, 2005, and November 30, 2021. During this period, more than 10700 glass publications were found in which at least one author has an Indian affiliation. The data was extracted from different publication sources such as articles, reviews, conference papers, book chapters, books, editorials, letters and notes. However, most of the publications are from the articles (about 80 %) and are followed by conference papers (about 20 %). Very few (about 1 %) publications from other sources are found in this search. This search involves different glasses such as oxides, non-oxides, and metallic systems. Nevertheless, a few publications (1-2 %) may use the keyword glass in their title for some meaning but do not relate to the glass research.

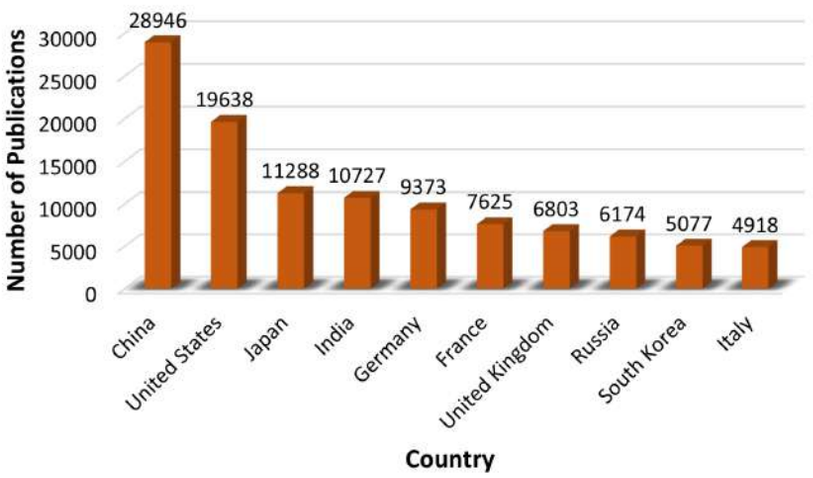


Figure 1: Number of publications in glass from different countries during 2005-2021.

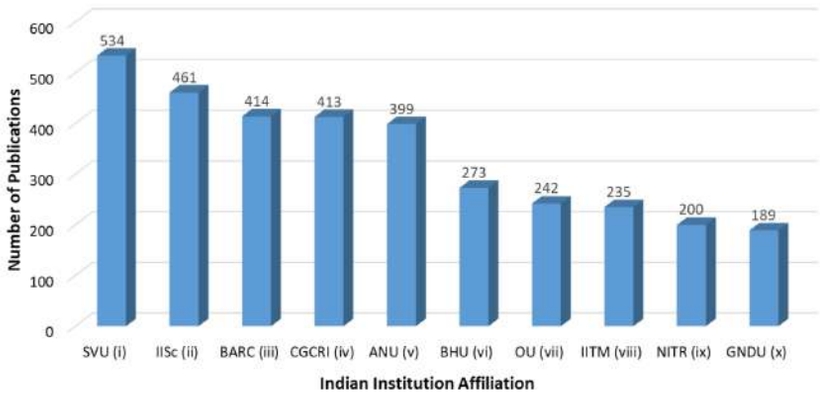
RESULTS

It is important to know the position of India worldwide in terms of glass publication. The number of publications concerning the top 10 countries is presented in Fig. 1. In this analysis, India occupied the 4th position. China, the United States, and Japan are placed as first, second, and third, respectively, ahead of India. However, regarding the number of publications, China and the United States are far ahead of India and published about three and two times more publications, respectively. Japan and Germany are publishing a comparable number of publications as India. Except for China, all the other countries are of small sizes comparable to India in terms of population. Hence, if per capita publications data are considered, India may be positioned far behind many other countries. On the other hand, it is interesting that most top countries presented in Fig. 1 are economically developed and rich in resources compared to India.

In the early decades of glass research (1920-1970), papers on the topic of glass were fewer than 10 per year. The publication trend increased after that; however, the number was still below 100 till 1990. Afterward, publications on glass showed a substantial increase in numbers, it may refer to the economic reform in the 90's in India. Figure 2 represents the number of publications in alternate years (2005-2021), with at least one author having an Indian affiliation. It is evidenced from Fig. 2 that the Indian publications related to glass increasing over the years showing a linear rise up to 2019 (i.e., 1093). However, in the following years 2020 and 2021, the numbers are decreased to 987 (not mentioned

in Fig. 2) and 827, respectively, which may be due to the COVID-19 pandemic, limiting the research work in the laboratories. However, the number of publications in 2021 is still higher than the previous years (i.e., year 2005 – 2018). From this trend, it is expected that the glass research and the number of publications in India will increase in the coming years.

It is fascinating to evaluate the publications from different institutions of India. Figure 3 displays the publications from the top 10 Indian institutions during 2005 - 2021. It is found that Sri Vanketeswara University is at the top of the list, which is remarkable since this University is funded by a state government, and one/two groups are active in the glass research with limited resources. Indian Institute of Science (IISc) is the top academic institution in India and had published the first glass papers in 1936 [7]. It is placed in the second position in the Indian institutions vs. glass publications list in Fig. 3. National laboratories such as Bhabha Atomic Research Center (BARC) and Central Glass and Ceramic Research Institute (CGCRI) have dedicated glass research departments with state of the art facilities. These two



(i) Sri Vanketeswar University (ii) Indian Institute of Science (iii) Bhabha Atomic Research Center (iv) Central Glass and Ceramic Research Institute (v) Acharya Nagarjuna University (vi) Banaras Hindu University (vii) Osmania University (viii) Indian Institute of Technology Madras (ix) National Institute of Technology Rourkela (x) Guru Nanak Deb University

Figure 3: Number of glass publications from different Indian institutions during 2005-2021.

institutions are placed third and fourth in the above list. However, most activities of BARC and CGCRI are to develop technologies to support strategic sector and industries rather than for publications. In this list, other universities like Acharya Nagarjuna University (ANU), Banaras Hindu University (BHU), Osmania University (OU), and Guru Nanak Deb University (GNDU) are in the fifth, sixth, seventh, and tenth positions in terms of the publication numbers. BHU had a separate Ceramic Engineering Department which merged with the newly established Indian Institute of Technology-Varanasi (IITV). So, some publications that are from IITV were not considered in this search.

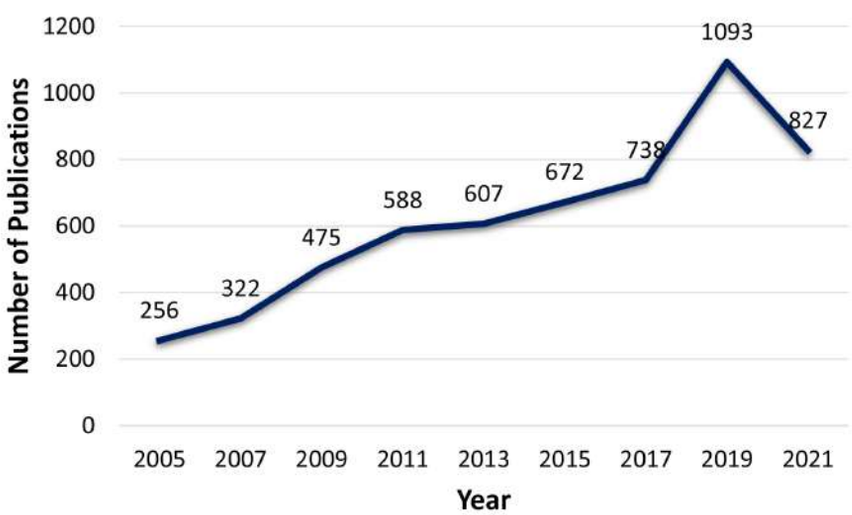


Figure 2: Number of Indian glass publications during 2005 – 2021.

Two technology institutions occupy the eighth and ninth positions, i.e., the Indian Institute of Technology-Madras (IITM) and the National Institute of Technology-Rourkela (NITR). It is noticed that only two institutions, BARC and CGCRI, are national laboratories and the other eight institutions are academic from where papers are published in the glass topic. Hence, most of the publications are from academic institutions. It is essential to mention that other premier institutions in India are also carrying out glass research but are not included in Fig. 3. Some of these institutions are IITs, NITs, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Tata Institute of Fundamental Research (TIFR), Raja Ramanna Centre for Advanced Technology (RRCAT), Indira Gandhi Centre for Atomic Research, and Centre for Materials for Electronics Technology (C-MET). It is found that there is no company in India carrying out noticeable research and publications on glass. But in other countries like the US, Germany, Japan, and France, many publications are from companies like Corning, Schott, Nippon, Saint-Gobain, etc. Hence, the glass companies in India need to focus on research which will be helpful to bring India as a leading country in terms of glass technology through innovations.

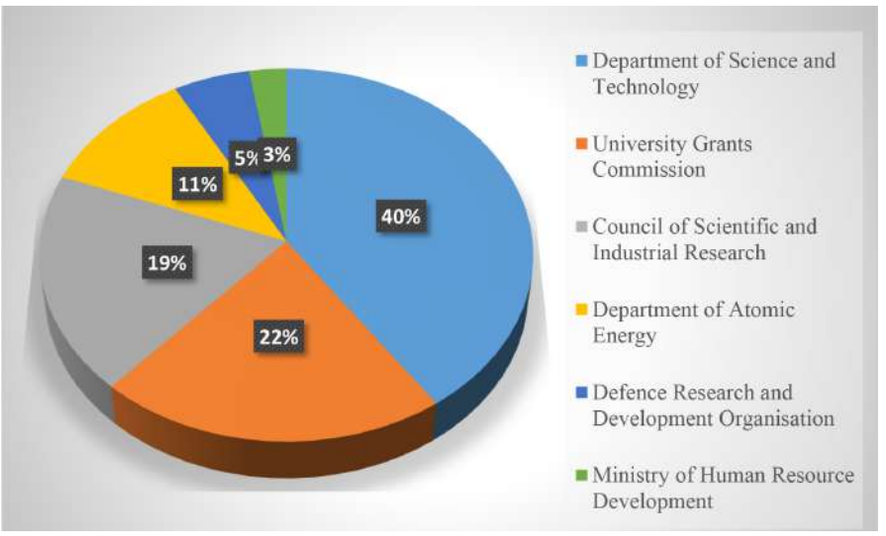


Figure 4: Funding agencies and the proportions of their grants for glass research in India during the Years 2005 - 2021.

To encourage glass research in India, several funding agencies provide financial support for state of art research facilities, fellowships for the research fellows/students, and grants for organizing conferences, symposiums and workshops on glass. Most of the funding is from the Central Government and its different agencies. Figure 4 reveals the major funding agencies of India, whose names are provided in the acknowledgements of the different publications. A significant share (40 %) of funding comes from the Department of Science and Technology (DST), Government of India. It is followed by the Council for Scientific and Industrial Research (CSIR) and University Grants Commission (UGC). DST and CSIR provide generous funding for research infrastructure, fellowships for the researchers, for and organizing conferences/workshops. These two agencies support fundamental and technology-based glass activities in broad sectors. UGC supports only academic institutions, and most of the funds are allotted towards the fellowships for the research fellows. Other organizations such as the Department of Atomic Energy (DAE) and Defence Research and Development Organization (DRDO) offer funds for research and manpower to specific areas of their interest, namely atomic energy and defence, respectively. The support of the Ministry of the Human Resource Development is mostly limited to the fellowships (GATE fellowship) for the Masters students. In the other developed countries such as the US, Germany and Japan, glass research activities are also supported to a great extent by industries like Corning, Schott, Nippon, etc. but in India, there is limited (negligible) support from the industries for glass research. Thus, there is the need to encourage more participation of the industry in research activities.

Publications on glass are classified in several areas in the Scopus search and displayed in Fig. 5. Glass is an interesting amorphous material with different applications such as structures, optics, energy, health, etc. Hence, it is evident that many publications in the field are from the area materials science. This is followed by physics and astronomy, engineering, chemistry, and chemical engineering. The glass properties such as viscosity, glass transition temperature, relaxation, optical, mechanical, electrical, etc., are fascinating for physicists. At the same time, glass structure and their chemistry to develop new glassy materials are exciting for chemists. Engineering professionals consider glass processing and manufacturing.

Related publications are in different forms such as articles, conference papers, review papers, book chapters, notes and letters. In Fig. 6, publications on glass are reported from the top ten sources. AIP conference proceedings, materials today proceedings, and IoP conference series have published papers in the proceedings of different conferences. Journal of non-crystalline solids (JNCS) is the flagship journal for glass publication and leads in article publication. Other journals are for ceramics, materials and physics, but many papers are published on glass.

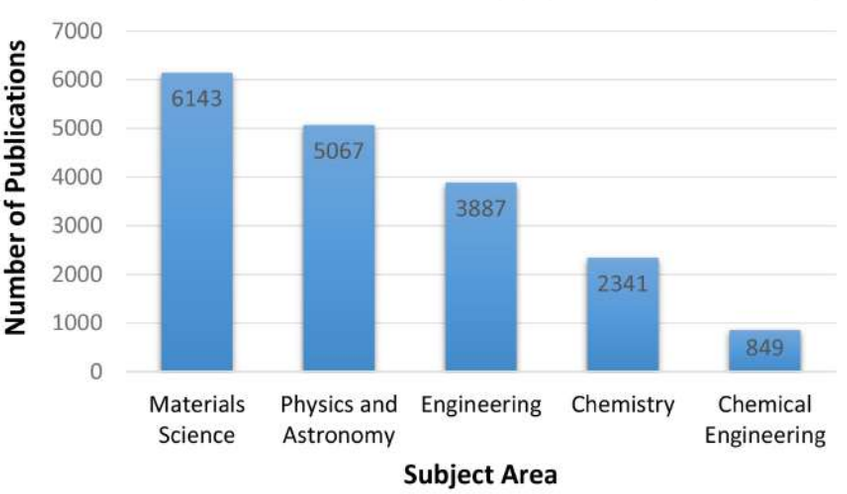


Figure 5: Glass-related Indian publications in different areas during 2005-2021.

Most of the journals are decades old that continue to publish glass articles for several years. Journal of Alloys and Compounds (JALCOM), Ceramics International and Journal of Applied Physics are reputed journals that have published articles on glass topics. However, a few Indian journals publish papers on glass areas (but are not listed here), such as Bulletin of Materials Science, Transactions of the Indian Ceramic Society, Indian Journal of Physics, etc.

INDIAN GLASS INDUSTRY STATUS

In the early days (pre-independence era), the production of glass bangles (bracelets) was the most popular glass industry in India [6]. It needed coloured glasses to produce bangles of different shades and there is still a good market for this in India. Other glass products were also manufactured at that time, such as small vials and lamps. In those days, glass materials were also imported from Austria, Germany and Japan [6]. However, after independence and industrialization, much progress has taken place in glass production in India. In terms of glass production, globally, the ten most prominent countries are China, Germany, United States, Hong Kong, France, Japan, Italy Poland, South Korea, and Belgium [9]. China itself has a share of 25 % of glass production globally. It shows that India stands far behind in glass production worldwide. However, there are several multinational glass manufacturing companies in operation in India. The All India Glass Manufacturers' Federation (AIGMF) represents the major glass industries of different types [10]. Asahi India Glass Ltd. (AIS) is one of the oldest and leading manufacturing companies in India that started in 1984 [11]. The company provides solutions for the automotive and architectural glass sectors and covers 70 % market share of automotive glass in India.

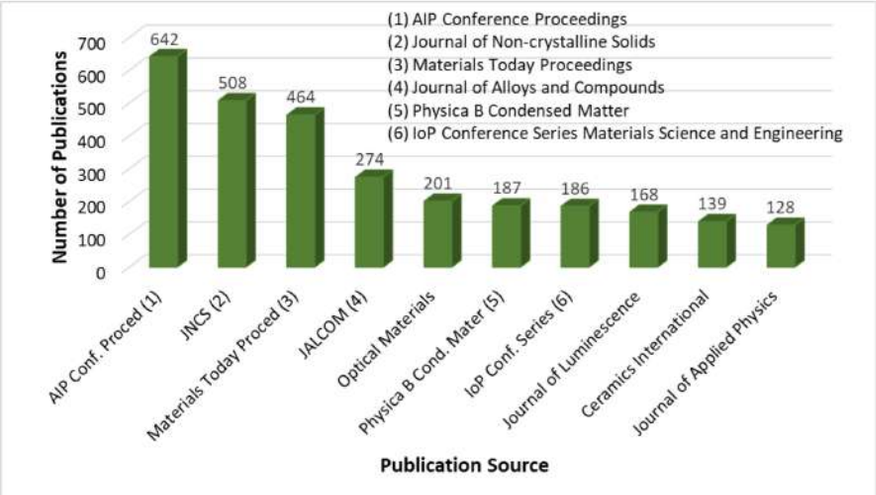


Figure 6: Number of Indian publications in different journals (sources) during 2005-2021. Abbreviations of some of the journals are provided at the top of the image.

The other top glass manufacturers in India are Saint-Gobain India, Schott Glass India, Sisecam Flat Glass India, Piramal Glass, FUSO Glass India, etc. These companies provide a wide range of glasses for the building, architecture, decoration, container (packaging), pharmaceutical and glassware sectors. It is expected that the glass industries will grow exponentially as there will be substantial progress in sectors such as automobile, electronics and displays and architectural buildings in the coming years. Hence, companies should invest considerable funds in research and development (R&D) activities for more innovations and developments in glass products. There are several challenges for the Indian glass industry to produce high-quality glass, e.g., availability of high purity raw materials, process parameters, and cost-effectiveness of the final products. But these challenges can be addressed if the industries adopt a systematic R&D approach. India is an economically fast-growing country. Hence, glass industry have a great future if they promote innovation through R&D efforts.

FUTURE DIRECTION OF INDIAN GLASS RESEARCH

It is observed that the number of publications in the field of glass has increased in the past years. Most of the publications from India are related to the optical properties of the glasses doped with rare-earth or transition metal oxides. A few publications are addressing the real glass problems that are relevant to glass science and technology. Hence, Indian glass researchers need to focus on the emerging fields of glass research. One of the evolving and exciting glass science and technology areas is Additive Manufacturing, also known as 3D printing, which will be employed to fabricate complex structured materials. Substantial research has started in other countries on glass additive manufacturing (3D printing) and the work is being published in highly reputed journals [12–14]. Other interesting areas are the preparation of glasses under extreme conditions such as high pressure and low temperatures, modification of the glass surface, laser and microwave-assisted glass melting and the study of their properties, thermal and electrical conductivity of glass, glass transition and relaxation, liquidus temperature and viscosity, etc., [15,16]. Nanostructured glass is another area of interest for many exciting properties and includes plasmonic glasses, semiconductor doped glass nanocomposites,

nanoglass, etc., [17-20]. Glass-ceramics and bio-glasses are other glasses promising for superior properties such as mechanical, electrical, and bio-activity. Metal-organic framework (MOF) glass is a new type that is fascinating for its chemical and physical properties [21,22]. Since pre-independence, India has put in much effort to promote the glass industry to fulfil its domestic demands. At present, India's glass demands have increased many fold to address its ambitious goals related to space, defence, energy, health, environment, communication, and overall industrial growth. The Indian glass community needs to focus seriously on the above areas and emerge as a pioneering and exciting avenue for glass innovations.

CONCLUSIONS

In this article, a detailed search on publications, institutions, funding agencies and different areas involving glass-related activities in India is presented. It is observed that overall, India stands the fourth position in terms of the glass publication in the world ranking. The number of publications in the field of glass continues to increase over time. Most of the publications are from academic institutions, and the participation of industries is limited. Federal government agencies mostly sponsor the required funding for glass research in India. Several international and domestic glass companies are operational here and are involved in manufacturing glass products for the international and local markets. There is limited activity on glass research by Indian companies and hence the necessity to focus attention on advanced level research activities related to glass science and technology. There is plenty of scope for Indian glass science and glass innovations with the national economic growth. The Indian glass community needs to prepare itself with state-of-the-art facilities at academics institutions, national laboratories and industries to address future demands.

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Ajit Jhunjhunwala and Sushil Jhunjhunwala, Managing Director and Chairman of La Opala respectively.

Sowing the seeds for success

Specialist Indian producer of opal and 24% lead crystal tableware La Opala RG Ltd is expanding to meet demand by opening two new plants. Managing Director Ajit Jhunjhunwala exclusively discussed his company's next steps with *Glass Worldwide,* preferred international journal of the All India Glass Manufacturers' Federation.

Since 1988 La Opala has been producing opal glass – a translucent or opaque glass made by adding opacifiers to the melt – at its original glassworks in Madhupur, eastern India. In 2007 a second facility in Sitarganj in the state of Uttarakhand (formerly known as Uttaranchal) in the north of the country doubled the size of La Opala's operations and 95% of the company's current business now comes from opal.

Running two furnaces with a capacity of 75 metric tonnes and five lines, the Uttarakhand facility has become a victim of its own success…

"We are almost at saturation point with no possibilities to expand the plant any further," explains Managing Director Ajit Jhunjhunwala, son of Sushil Jhunjhunwala, the company's founder and now Chairman. "We have used almost all of the area and are at full capacity." A decision was taken to expand close to the existing site in Uttarakhand.

"We decided that we should go for a greenfield project and we thought that Sitarganj [approximately 200 miles from Delhi] is an ideal location because we already have an operation there," continues Mr Jhunjhunwala. "The place is conducive for business as there are no problems in terms of availability of power or manpower." The new site is 2km from the existing plant and only a 15-minute walk away. "The top management will remain the same across both plants and there will be a lot of synergies between the two locations," confirms Mr Jhunjhunwala.

Threatened by Covid

Despite incurring costs from not being able to sell during the start of the global Covid-19 pandemic, the existing plant at Sitarganj remained robust due to a healthy balance sheet and its dedicated team. However, the progress of the new plant was significantly affected during the first phase of lockdown from March–August 2020 with "practically no activities at all," recalls Mr Jhunjhunwala. "But then gradually things started settling down and people started returning ▸

La Opala was the recipient of the prestigious AIGMF Balkrishna Gupta Award for Exports in 2020 following Sushil Jhunjhunwala being the recipient of the C K Somany Glass Award in 2018.

glass WORLDWIDE

Originally published in Glass Worldwide, preferred international journal of AIGMF

The existing plant in Uttarakhand runs two furnaces with a capacity of 75 metric tonnes and five lines.

to work and fortunately now we are at the stage that we are almost ready [despite] the delays to construction and the market uncertainties. We didn't want a situation where we started the new project and a lockdown would then shut the plant, which would have been very bad for the morale of the organisation. We wanted reassurance of the market dynamics before we started. Right now we don't see any major disruption as we are working on almost 100% capacity utilisation at our existing plants.

"Fortunately, our business has been consistently generating surplus net cash and today we have almost zero borrowings so whatever we are doing, even the money we have invested in the new plant, is entirely from internal funding. We don't have to worry about the high interest rates in India."

Manufacturing capabilities

According to Ajit Jhunjhunwala, La Opala's new facility in Sitarganj will have a 45-metric-tonne furnace with three lines: two spinning lines and one press line. Running the same technology as the existing plant, the furnace, press and spin machines and tempering and annealing lines have all been received and installed.

"In 2008/9, we were the first Indian glassmaker to switch to electric melting," notes Mr Jhunjhunwala. "The credit goes entirely to my father Sushil who had the vision to know it would be very hard to continue to melt with fossil fuel. We were the first in the country to adopt electric melting and also the first to come out with automated process in opal technology.

"We had good experience of our existing suppliers who had all been very supportive in the past in terms of technology provision and service and that is the reason why we decided to go with the same partners. It makes life easier for all parties because we understand each other. It also helps massively in the spare parts management. With the synergy at our existing plant, there are a lot of advantages to the new plant.

"It goes without saying that we will share expertise from the nearby plant so that the top management can look after both plants. But being a specialised industry and being a very highly technical orientated industry we do need the right people at the right place and as there are not many opal producers in the area, we have to get people from other industries and then train them. We have already started to recruit people from our new plant so they can be trained at our existing plant and once the commissioning at the new plant starts it makes it easier for them to switch.

"The machines are important but the men behind the machines are even more important," he underlines.

Expanding the opal market

The product line at the new plant will be similar to that of the existing plant, to assist with increasing demand, driven in part by a shift in consumer attitude towards glass. All of La Opala's product designs are eco-friendly and food-safe, eschewing decoration that contains any lead or cadmium.

"There is a limitation in terms of usage for opal; basically it is only used for tableware [but] we feel the market is expanding," observes Mr Jhunjhunwala. "We have seen consumers switching from plastic to glass because of obvious health reasons, and consumers are ▸

The new greenfield plant in Sitarganj, 2km from the existing plant in Uttarakhand.

Originally published in Glass Worldwide, preferred international journal of AIGMF

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switching from steel to glass because of lifestyle changes. Consumers have aspirations to use better products, especially the younger generation who don't want to use stainless steel, so there is a shift to glass in tableware-related products. People are getting more aware of the side effects of using melamine plastic.

"Within the segment, we are coming up with lots of new ranges, different designs, different shapes and different products. We feel the demand is strong and as long as we continue innovating then meeting demand should not be a challenge.

"In opal we have 55–60% market share and still we feel the market has got a lot of potential to grow further; with the new plant in Sitarganj opening we will perhaps become one of the top three producers of opalware in the world so that really excites us. And most importantly we feel that we are able to offer consumers excellent products at a very affordable price."

As the third generation, Aphyubay Jhunjhunwala recently started work at La Opala.

Sushil Jhunjhunwala is credited with La Opala's vision to pioneer electric melting technology in India.

New borosilicate plant

On 4 November 2021 La Opala announced plans to build a new borosilicate plant that will be situated alongside the new opal glass plant in Sitarganj.

"There is no producer of borosilicate product in India," says Mr Jhunjhunwala. "It's a natural extension to our opal products and will go through the same distribution channels. We have such a strong brand already that we will be able to leverage our branding to market borosilicate products.

"At the new plant in Sitarganj we have enough space so this plant will fit well," he continues. "We feel it is a great category of product that is growing – each and every house has these kind of products. This new borosilicate business will complement our opalware range and will be a totally new category for us.

"We have a lead crystal business in Madhupur which is hand blown and hand cut so we are not able to scale up that business because of the nature of the manufacturing process. So we decided we must venture into new areas.

"It's always fun to enter new sectors; there are challenges to developing a product from scratch but we feel we are fortunate to be part of the process," he enthuses. "We are looking forward to the next 18–24 months when we should have set up the site."

Family-run business

Glass Worldwide spoke to Sushil Jhunjhunwala for the November/December 2018 issue, the same year that Ajit took over as Managing Director. "My father is still very involved in the business, and although not in a hands on capacity, we take advantage of his great experience when making any major decisions," he reports. "We recently purchased a new building for our headquarters, still located in Kolkata [Calcutta], but slightly away from the main city. With the way the company is expanding, a new area was definitely very much needed and we moved from our previous 4,000ft^2 building into this 16,000ft^2 office. It's a brand new building with a very positive energy that is fun to work in. We can now provide a comfortable atmosphere for staff who have a good and comfortable place to work… We can already see that the efficiency has improved.

"My son Aphyubay (24) recently finished his education at Kelley School of Business in Muncie, Indiana in America and has started work in the company," continues Mr Jhunjhunwala. "We hope he will have a role in the business moving forward as the third generation. Right now I've asked him to learn about each and every area of the business, as I did when my father brought me into the company. We are giving him an overview of the business and I want him to work through every department so he can really get the feel of the business and prove his worth."

Global achievement

In 2018 Sushil Jhunjhunwala won the All India Glass Manufacturers' Federation (AIGMF)'s inaugural C K Somany Glass Award for Innovation and Technology, and in 2020 La Opala followed this up with the Balkrishna Gupta Award for Exports. "It's a great achievement for us to be awarded prestigious awards from the AIGMF, one in my father's personal capacity and the other in a La Opala capacity," acknowledges Mr Jhunjhunwala. "We feel honoured and it is a real matter of pride.

"Although I have not been able to be involved too much due to my other commitments, my father [a former President of the AIGMF] has always been very actively involved with the AIGMF as well as the zonal Eastern India Glass Manufacturers' Association (EIGMA) in Kolkata which is under the AIGMF.

"The kind of support we have received from the AIGMF can never be understated – any concern relating to the industry or regulations and the AIGMF are just a phone call away. As with his predecessor Manohar Lal, Vinit Kapur [General Secretary] has been extremely supportive to us. The AIGMF is a great solid platform for any sort of concern to its members and is a very friendly association."

Happily, Mr Jhunjhunwala also sees a positive benefit to *Glass Worldwide* being the preferred international journal of the AIGMF (in association with Kanch).

"*Glass Worldwide* does a wonderful job," he opines. "The content is fantastic and I make sure I go through each edition which is always a pleasure. The quality of *Glass Worldwide* enriches the AIGMF and it is an excellent partnership."

Mr Jhunjhunwala also appreciates the "fantastic effort" that event organisers such as those of glasspex INDIA make to unite industry peers from across the world on one platform. "It's a great opportunity for us and anybody in the glass business to meet suppliers," he explains. "As we have also missed out on being able to go to glasstec in Germany since 2018, glasspex INDIA 2022 will be a great platform. Although we have certain suppliers we partner with, things are changing so fast and you never know when new suppliers can provide additional ideas."

At the time of this interview in November 2021, La Opala's first new Sitarganj plant is almost ready; "90% percent complete," reveals Mr Jhunjhunwala. "I am very pleased to see the progress. We have learnt from our other plants and maximised the layout and structure, keeping in mind further expansion in the future. We are currently waiting for foreign travellers to be able to visit so that the plant can open in January or February 2022." ●

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Originally published in Glass Worldwide, preferred international journal of AIGMF

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Using sensors to achieve optimum energy efficiency

Originally published in *Glass Worldwide* (preferred AIGMF international journal in association with *Kanch*), CelSian's CelSian's René Meuleman examines advanced process control based on CO, O_2, H_2O and temperature sensors and explains how they can be used to elongate furnace lifespan, reduce emission levels and facilitate energy-efficient manufacturing.

It is unavoidable that the glass industry, specifically the commodity glass manufacturers will keep on using combustible fuels, either fossil or renewable for an extension of time. This is why it continues to be important to keep on improving combustion processes obtaining attractive energy savings, emission reductions and extended furnace lifetime. A stable combustion space environment will also have a positive impact on the glass quality and melting behaviour of the furnace. Modern CelSian sensor technology is capable of providing the missing links to achieve potential energy efficiency improvements together with CO_2, NOx and SOx emission reductions, also providing an attractive return on investment.

Combustion

Combustion is a high-temperature exothermic redox chemical reaction between a fuel (the reductant) and an oxidant, usually, atmospheric oxygen, that produces oxidised, often gaseous products, in a mixture termed as smoke or exhaust gasses.

In glass manufacturing, different fuels (reductants) are used such as oil, natural gas and recently also hydrogen. It is foreseeable that other renewable fuels will be considered as well, e.g. bio-gas, biofuels and synthetic fuels alone or in mixtures of several fossil or renewable fuels. Although the combustion processes of natural gas or oil are already rather complex mixtures, being involved in the so-called fuel switching process will likely become even more difficult. Oxygen is used as an oxidant coming from pure oxygen or air, either pre-heated or not.

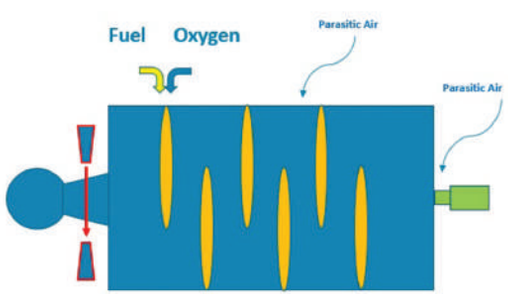

Figure 2: Suggested point of installation for a sensor in an oxy-fuel furnace.

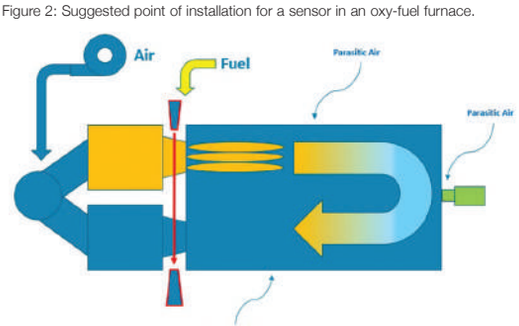

Figure 3: In a regenerative furnace, just one sensor looking through both ports is sufficient to measure CO.

All those different fuels, fossil or renewable have their properties and with them an impact on the glass melting process and furnace performance. Most likely the industry will have to proceed in reducing fossil fuels, replacing them with renewables and electrical energy in order to potentially lower their CO_2 emissions. That will take years of conversion in which probably all kinds, technically as well economically viable mixtures will be used as long as it leads to acceptable glass quality in a competitive market.

Unless you are already taking action to move completely away from fossil fuels, moving to an all-electric melting method or more sophisticated sensor and control technology should be considered.

Unwanted processes

Let's start with a very simple chemical reaction, that of oxygen with hydrogen.

In this specific combustion process, controlled very precisely, there will be no residue of either oxygen or hydrogen to be found in the exhaust gasses, but only pure water. We call this stoichiometric combustion.

Unfortunately, it is not very likely, at least not in the next decade that we will have the availability of sufficient, cost-effective pure oxygen and hydrogen. Most likely there will be an extensive period in which a gradual fuel switching will take place and during that period a variety of complex fuel mixtures [will] need to be controlled. What adds to this complexity is that furnaces will keep on showing uncontrollable, unstable air leakages, or parasitic air entering the combustion space and there is, next to decent furnace and regenerator maintenance, little that can be done about it.

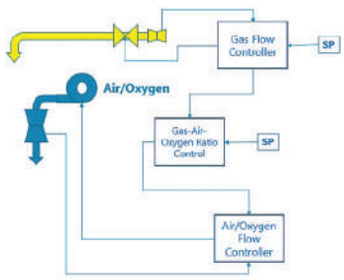

Figure 1: A simplified gas/air ratio controller with two setpoints (SPs) for the flow of gas and the ratio of gas to air.

Concluding: even if we can control precisely the volume of oxidant and reductant into our furnaces, there will still be an unwanted – either over stoichiometric or under stoichiometric – combustion processes going on.

Collecting data

In a simplified gas/air ratio controller (see Figure 1), we normally find two PID controllers. One controlling the gas flow and one controlling the combustion airflow. Two setpoints are required: the flow of gas and the ratio between gas and air. Defining the gas-air ratio is complex and needs the precise natural gas composition to calculate the amount of air (oxidant) that needs to be available to achieve ▸

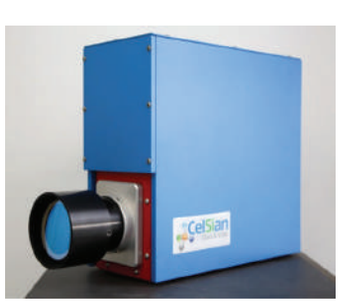

Figure 4: CelSian sensors can provide either CO or a combination of CO, O_2, H_2O and exhaust gas temperature readings.

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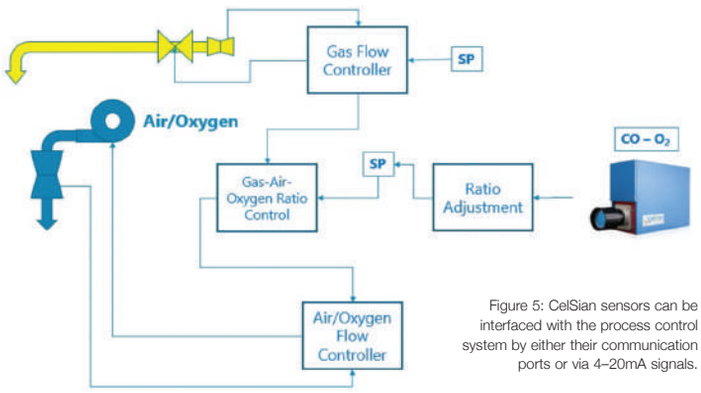

Figure 5: CelSian sensors can be interfaced with the process control system by either their communication ports or via 4–20mA signals.

stoichiometric combustion. That alone can be a challenge as the natural gas composition can be subject to change and this situation is likely to become worse as soon as hydrogen or biogas is mixed into it. Adding an expensive gas chromatograph, capable of providing real-time information on the gas composition, calculating the amount of air (oxygen) and adjusting the gas/air(oxygen) ratio dynamically will improve the combustion stability, energy efficiency and emissions. However, it will not help to control the parasitic air entering the furnace.

Note: Gas flow, as well as combustion airflow transmitters/measurements, can be extremely precise if well installed, maintained and temperature and pressure compensated (Boyle's law). More sophisticated controllers and sensors will be able to mask [under-]performing basic flow measurements but should not be used like that.

Enhanced measuring

To potentially improve the process an exhaust or waste gas measurement should be installed. To prevent the misreading of CO and O_2, the measurements should be [taken] as close as possible to the finished combustion process, hence the exhaust port(s) (see Figures 2 and 3).

CelSian sensors can provide either CO or a combination of CO, O_2, H_2O and exhaust gas temperature readings. They can be interfaced with the process control system by either their communication ports or via 4–20mA signals (see Figure 4).

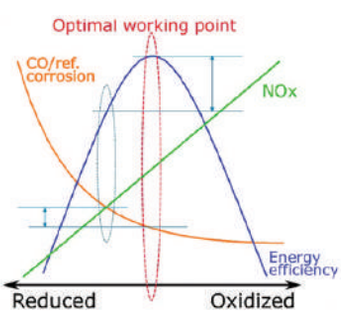

Figure 6: There is a trade-off between the most energy-efficient way of controlling the combustion process and achieving the lowest NOx and SOx emissions.

Comms or 4-20mA considerations

The sensor can be interfaced by either Modbus TCP/IP or traditional 4–20mA analogue and 24Vdc digital inputs. Modbus communication will make all parameters of the sensor available, while traditional 4–20mA loops will be limited to the number of inputs available on your process control system. However, for normal control operations, several signals will most probably be sufficient.

Once the signals are available in the process control system and validated, they should be taken into control. It is good practice to leave the existing ratio controller in place to secure a decent fallback situation in the unlikely event of a sensor failure.

The functionality that needs to be added to the process control system is another PID controller with sufficient filtering of the CO and O_2 signal coming out of the sensor. This will allow a limited adjustment of the ratio controller to achieve a reasonable level of CO and O_2 in the exhaust gasses (see Figure 5).

Note: If the gas/air ratio starts to come close to stoichiometric value, the excess of oxygen value (lambda = 1) will come close to zero and CO levels will start going up exponentially. In other words, the oxygen measurement will not be very reactive/representative anymore but the CO measurement will become very aggressive, thus better to control (see Figure 6).

Signal filtering

When a noisy signal is used in control, filtering is important for effective derivative action and for avoiding excessive movement in the controller output as we do want to keep ratio control as smooth as possible and frequent adjustments are not desired. The downside of filtering is the lag introduced, especially with heavier filtering, which can have an unfavourable effect on the timely detection of changes in the underlying signal (see Figure 7).

Unfortunately, in many cases, filtering is used in an attempt to mask the effect of an unmeasured disturbance or a problem such as a valve resolution or dead-band in the control loop. In many cases, filtering makes the problem worse. A filter will often be set and then forgotten until the loop is re-examined due to loop troubleshooting of poor performance, or when a control project is executed.

Notice: For CO control we are not looking for an aggressive reaction of the ratio controller setpoint adjustment. However, filtering the signals coming from the sensor should have the purpose of potentially reducing noise by still keeping the true CO, O_2 and H_2O signals intact. First or second-order filtering will be most suitable for this purpose.[1] The raw signal and the filtered signal could be used in real-time trending to observe the behaviour of the filter strategy settings.

Note: The single value CO sensor has a built-in filter which could be used in case the process control system doesn't provide any filters suitable for the purpose.

Interlocks

Optical transmission should be checked regularly. Transmission can be monitored continuously using the current output, mapped to the digital output for transmission. A warning should be generated to indicate that an intervention is required long before the transmission value drops below its minimum value and measurements are not reliable anymore.

Oxy-fuel furnace

In an oxy-fuel furnace, there is a constant, uninterrupted flow of exhaust gasses available at the outlet port of the furnace. This is where we advise installing the sensor, preferably the one which is capable of measuring both CO and O_2 (see Figure 2).

End-port regenerative furnace control

In a regenerative furnace, the set-up is slightly more difficult as each port will either supply pre-heated combustion air to the furnace or will lead the exhaust gasses towards the top of the regenerator. If measuring CO alone is sufficient, only one sensor looking through both ports is needed (see Figure 3). This is because the port running combustion air into the furnace will not contain any CO. Therefore the sensor's CO readings will consequently correspond with the port containing the exhaust gasses.

Note: After filtering of the signal the process control system needs to take care to split the CO value coming from the sensor to become CO-right and CO-left for further processing.

If CO, O_2, H_2O measurement is required, two sensors need to be installed

Control

The biggest advantage of having reliable measurements of CO (and O_2, H_2O) will be achieved by using them tuning the gas/air or gas/oxygen ratio controller to achieve a stable, close to stoichiometric combustion. ▸

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Nitrogen oxide

NOx is produced from the reaction of nitrogen and oxygen during combustion, especially at high temperatures (see Figure 6). Next to other measures, one of the important ones is low excess of air (LEA) firing – a simple, yet effective technique. Excess air is the amount of air over what is theoretically needed to achieve 100% combustion. Studies have shown that reducing excess air from an average of 20% to an average of 14% can reduce emissions of NOx by an average of 19% (Cooper and Alley 1986).[2] It is typical for the NOx emission to increase with decreasing CO.

Note: From the total emission standpoint, it is advantageous to run at some hundreds of ppm of CO to lower other harmful emissions and keep reasonable flue gas heat losses.

Carbon monoxide

Carbon monoxide (CO) is produced when combustion reactions are not fully completed, either through lack of oxygen or due to low mixing. As soon as combustion comes close to being stoichiometric the forming of CO will start to increase rapidly due to incomplete combustion, increasing energy consumption. Other effects could be post-combustion in regenerator leading to deteriorating regenerator chambers and increased evaporation from batch and glass melt impacting the lifetime of the furnace.[3]

The higher the air ratio and the better the mixing, the lower the CO emission. Operating with a high furnace temperature and a long residence time decreases CO emission.

Note: Because carbon monoxide emission behaves in a similar way to many other hydrocarbon emissions, it is often used for regulatory purposes as a signal for the overall efficiency of combustion. Thus regulating CO is often associated with imposing restrictions on hydrocarbon emissions.[4]

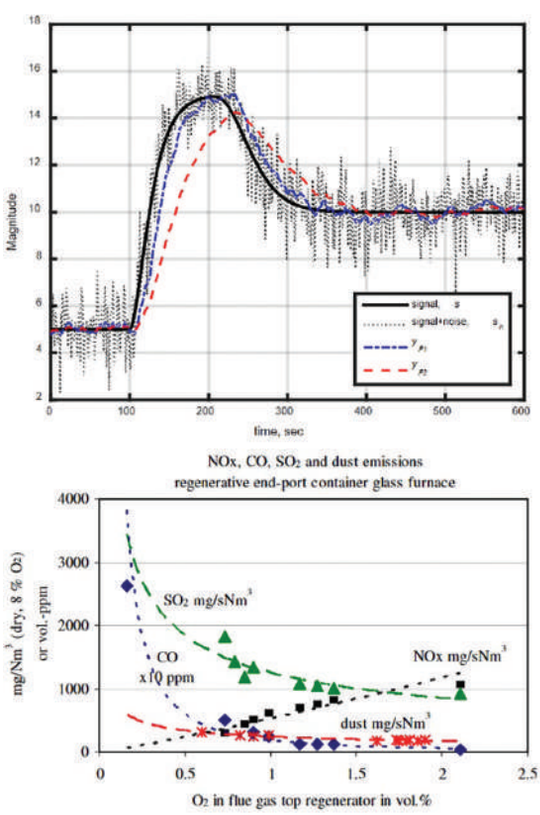

Figure 7: Results of an experiment to lower NOx emissions by decreasing excess air in the combustion process.

Sulphur dioxide and dust

Figure 7 shows the results of an experiment to lower NOx emissions by a decrease of the excess air in the combustion process carried out at an industrial container glass furnace in the Netherlands. The furnace is a full-scale end-port fired furnace with regenerators and using Groningen natural gas as fuel. The results are given as concentrations of CO, NOx, SO_2 and dust in the exhaust gases of the furnace measured at the position before the exhaust gases enter the regenerator (at 1,350–1,500°C). Downstream from the measuring point, the CO is almost completely converted into CO_2. Therefore, the CO emissions in the chimney are very low or nil. The chart shows clearly the decrease of the NOx emission as the air number is decreased (decreasing O_2 content on the X-axis). But below about 0.8% oxygen in the exhaust gas (5% excess air), the CO concentration [and] SO_2 content increases rapidly by a further decrease of the air number.[5]

Finding the optimum working point

As explained, there is a trade-off between the most energy-efficient way of controlling the combustion process and achieving the lowest NOx and SOx emissions. Moving more into reducing combustion conditions will result in lower NOx but consequently, lead to more CO, possibly more SOx by giving up a little bit of energy efficiency (see Figure 8). Since burner settings have a huge impact on, specifically, NOx emissions we advise finding and fixing their optimum setting before the sensor signals become operational.

Signal interfacing and filtering

CelSian's instruments can be either interfaced via 4-20mA analogue and 24Vdc digital signal or Modbus TCP/IP interfacing to the process control system (see Figure 5). The corresponding signals will be available for further processing either from the hardware interface software blocks or the Modbus table. We advise running all analogue signal through a signal dedicated filter first, as described above. This first filter aims to flatten out the signals [leaving] its reactivity, specifically for aligning and maintenance activities. Later, just before or in the ratio controller, averaging strategies will be used. Of course, all signals should have TAG-names according to your local TAG-name standards.

Trending

If possible, specifically for maintenance purposes, we advise having a dedicated trend for each signal showing both the raw signal and the output of its filter along with its transmission factor. A dedicated emission trending should show the actual used averaged signals together with the gas/air or gas/oxygen ratio and if available the CEMS (continuous emission measurement system) measurements (see Figure 9).

Proposed control approach – pre-processing

The first step is to make sure that the measured CO, O_2, and H_2O concentrations are measured correctly. For that, the sensor needs to operate at an acceptable and stable transmission level. The transmission level is also an analogue signal and needs some first-order filtering. The most commonly used filter is the exponential, or first-order filter[1]. A warning should be generated 10% above the minimum transmission value to initiate a maintenance interval. During maintenance, which is normally limited to cleaning the mirrors, lenses and glass screens in the port, the controller should be set to manual. Having a trend available showing the transmission factor will be useful to observe the degrading of the signal due to building up contamination of the optical parts of the measurement. If the transmission value drops below the specified low threshold, CO, O_2 and H_2O values should be considered to be unreliable and consequently, the controller should be pushed and fixed into manual and the operator should be warned.

The oxygen level in the air at 0m altitude is 20.9%. At 1,000m altitude is 20.1%; at 2,000m 19.4% and at 3,000m it is 18.6%. The concentration of oxygen does not depend on density in a well-mixed air. Temperature does not have an impact on the concentration of oxygen in pre-heated combustion air. In that respect, the measurement in the port that runs the pre-heated combustion air should show, after sufficient flushing of the regenerator, the correct percentage of oxygen (around 20.9% at sea level). It would be advisable to generate a warning if the oxygen level is not showing the correct value whilst the sensor is measuring combustion air only. ▸

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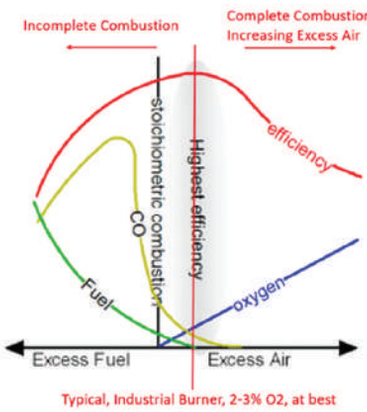

Figure 8: As soon as combustion comes close to being stoichiometric the forming of CO will start to increase rapidly due to incomplete combustion, increasing energy consumption.

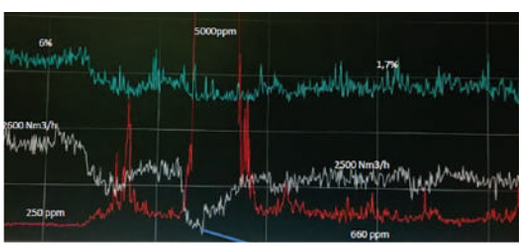

Figure 9: When a noisy signal is used in control, filtering is important for effective derivative action and for avoiding excessive movement in the controller output.

CO is very reactive and any small amount of parasitic air (oxygen) will cause CO to immediately reduce to CO_2. Therefore, the CO level measured in the port can only be compared with a manual CO measurement in the port and should not be compared with a measurement at any spot in the top of the regenerator.

Signal post-processing

The combustion process doesn't allow harsh, fast control actions. In that respect, the CO, O_2 and H_2O readings should undergo more filtering. A running average calculation is suitable but should not be activated during reversal; [allow] some additional time – for example, 180 secs after reversal – to allow the combustion process and CO, O_2 and H_2O stabilise. Each measurement would need an average calculation and should not exceed 60 seconds. Trending the output of the averaging algorithm together with the filtered raw value will help to find the correct settings.

Control considerations

The glass furnace melting process is very complex and one of the most important control considerations is: trying to control the process as smoothly as possible. Every fast control action will result in the introduction of unwanted disturbances and side effects. The control of combustion is already disturbed by the inevitable reversal sequence. However, the regenerative principle gives us an efficiency improvement of 80% so there is no way of working around that disturbance.

To improve the efficiency of the combustion process the fuel-air ratio controller has the task of finely adjusting the combustion process as close as possible to a stoichiometric value without the production of CO. Therefore the fuel/air ratio controller needs to take the parasitic air into account which is, in fact, the difference between the calculated value of air available at combustion and the actual combustion air available at combustion, measured by the oxygen probe in the exhaust. Such a combustion controller normally uses the lambda value for control which is the ratio of actual air-fuel ratio to stoichiometry for a given mixture. Lambda of 1.0 is at stoichiometry. Since parasitic air tends to vary during the time to reversal and will not be the same for both sides of firing, the controller needs to act differently for each firing side and will also need to store the historic values from the time it was controlling that specific side (see Figure 10).

Ratio adjustment controller

Since the controller inputs will be averaged values there is no need to cycle the controller faster than the averaging algorithms. The output of the controller depends on the requested ratio control strategy. Either it acts as an adjuster (see Figure 10) of the already installed gas/air or gas/oxygen ratio controller(s) or it acts like the ratio control itself. In both situations, there must be an external operator gas/air or gas/oxygen ratio setpoint SP as input for the basic gas/air or gas/oxygen ratio controller. The operator should be in control of setting the controller to automatic ratio SP adjusting mode.

Conclusions

Although an excess of air control is complex, a modern controller or process control system together with reliable and accurate sensor technology (see Figure 4) is perfectly capable of managing such a sophisticated strategy. Perhaps the most important part is to educate furnace operators so that they understand how such a control works, to monitor its behaviour and judge possible malfunctions. If applied correctly, the control will provide stable combustion, improved fuel efficiency, reduced emissions of NOx, SOx, CO and dust. Overall the furnace will perform better and will live longer. ●

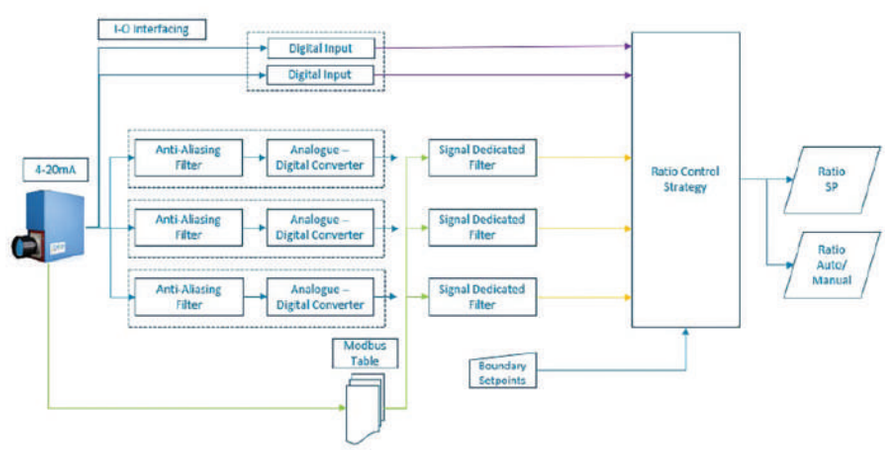

Figure 10: CelSian's instruments can be either interfaced via 4-20mA analogue and 24Vdc digital signal or Modbus TCP/IP interfacing to the process control system.

1 https://www.controlglobal.com/assets/digital_edition/2019/July/filtering.pdf
2 Nitrogen Oxides: Pollution Prevention and Control - Pollution Prevention and Abatement Handbook
3 CelSian – Glass Technology Training Course
4 https://www.sciencedirect.com/topics/engineering/carbon-monoxide
5 https://www.nederlandseglasfabrikanten.nl/wp-content/uploads/2013/06/SO2-NL-Glass-Industry-TNO-report.pdf https://www.wcrouse.com/what-is-combustion

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Originally published in Glass Worldwide, preferred international journal of AIGMF

The Wide Gamut of Glass, from the most Common use to Wound Healing Matrices and Blood Coagulants

Glass is such a common material that they are often ignored without taking any notice of their existence. It is believed that the first man made glasses must have been used to produce beads, or to shape tools requiring sharp edges. Glass utensils like bottles and jars or containers then came to use. The combination of the discovery of many new colorants with the invention of glass technology eventually lead to the magnificent stained glass windows. But the family of materials known as glass are still not taken seriously and considered a petty material. Even today if one hears the word "glass", the first things that strikes in mind are aesthetically pleasing glass ware, utensils, laboratory-ware like test tubes, beakers, decorative pieces like vases, chandelier or a fine crystal goblet.

However glasses are more than just a petty material. They have a vast scope of applications and advancement of technology have opened a vast area of opportunities so far stretched that it might be difficult for many to grasp. In fact it might be surprising if it is stated that glass is not only existing around us, but is the most compatible material to the human body and is termed as 'bioactive glass'.

This category of the glass was invented in 1969 by Prof. Larry Hench from the University of Florida and was commercialized in 1993 under the trade name of PerioGlas® (NovaBone Products LLC, USA), which could only be used as partial substitute of the bone. Presently bioactive glasses are one of the major materials used in healthcare industry. Even the Food and Drug Authority (FDA) has cleared products based on glass technology, which are now actively being used clinically for wound healing and demonstrating promising results in post-market randomized controlled clinical study.

Synthetic biomaterials have always been used to replace diseased or damaged tissues. Consequently the first generation bio materials were selected to be bio-inert and thereby minimize active interactions with the host tissues. Bioactive glasses are considered as the second generation bio materials, which provide a scope of interfacial bonding of an implant with host tissues. Presently, owing to the potential bioactivity and biocompatibility of the bioactive glasses, the scope of their usage is extended over a vast area including, reconstructive surgery, wound healing and related areas and also in the treatment of bacterial infections.

Coagulation, is a physiological process that results in the formation of a stable and insoluble plug layer at deep injury sites (like ballistic or accident wounds) while preserving blood flow normally elsewhere in the circulation. Immediate control of the uncontrolled bleeding and infection (if any) are essential for saving lives in both combat and civilian arenas. Bioactive glasses exhibit great promise for accelerating such blood clot [Fig. 3] via a mechanism called as 'glass effect' and infection control. Bioactive glasses have recently attracted worldwide attention because of their significant features of good biocompatibility, thermal stability and so on. They are also

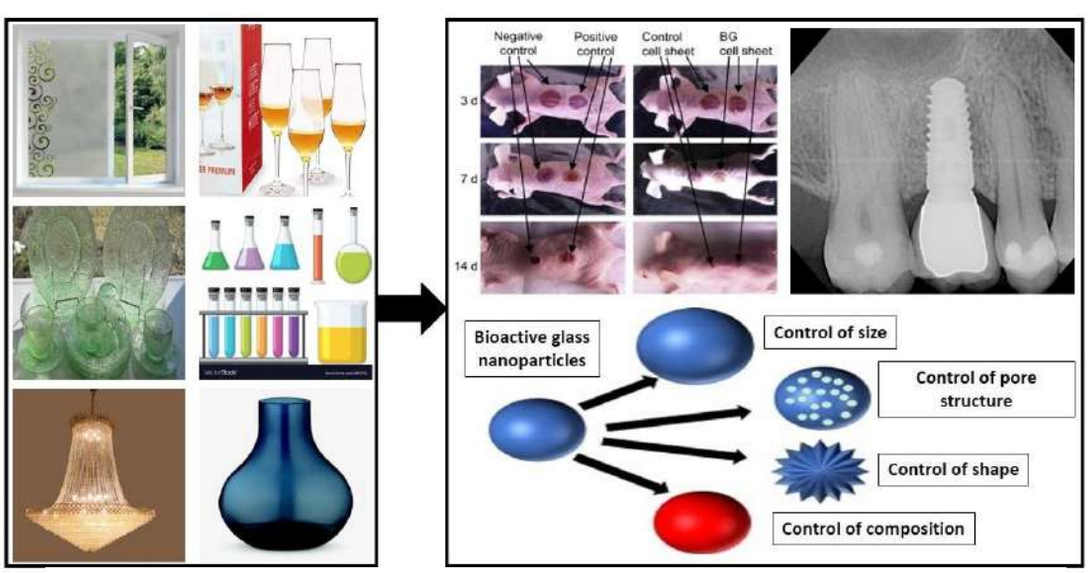

Figure 1: Conventional understanding and actual potential of glass

Figure 2: Bioactive glass nanofiber

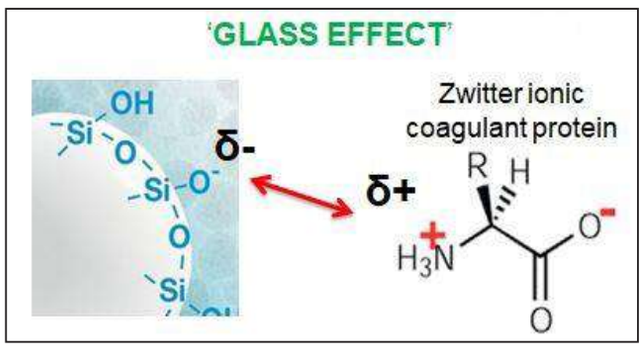

Figure 3: Effect of glass on protein fiber deposition

found to prevent infections through controlled release antibacterial elements from their frameworks.

Healing of chronic wounds is a complex process and is largely responsible for mortality and morbidity among many victims and non-availability of suitable medical interventions has prevented its complete recovery. In this regard, the antibacterial bioactive glass nanofibers [Fig. 2], prepared by sol gel followed by electrospinning technique in our laboratory, exhibits a remarkable impact on the chronic wound bed and heals the same very fast. Such a magical phenomenon lies in none other than the textural properties of the bioactive glass based composition which is analogous to the 3D microenvironment of the fibrinogen protein instrumental for tissue regeneration, also helps to control the moisture level at the wound site, leading to complete healing without any scar. Additionally, the porus nature of these glasses allow them to exchange gases and water molecules from the wound site, thereby leading to the faster healing even at the late stages.

Glass is one of the most promising and developing technical material whose properties can be tailored to meet and suit the present day requirements for various biomedical applications. Conclusively glass is a next generation versatile biomaterial, which can provide the solution for both soft and hard tissues, to meet the ample problems like damage of bone, skin and many more ■

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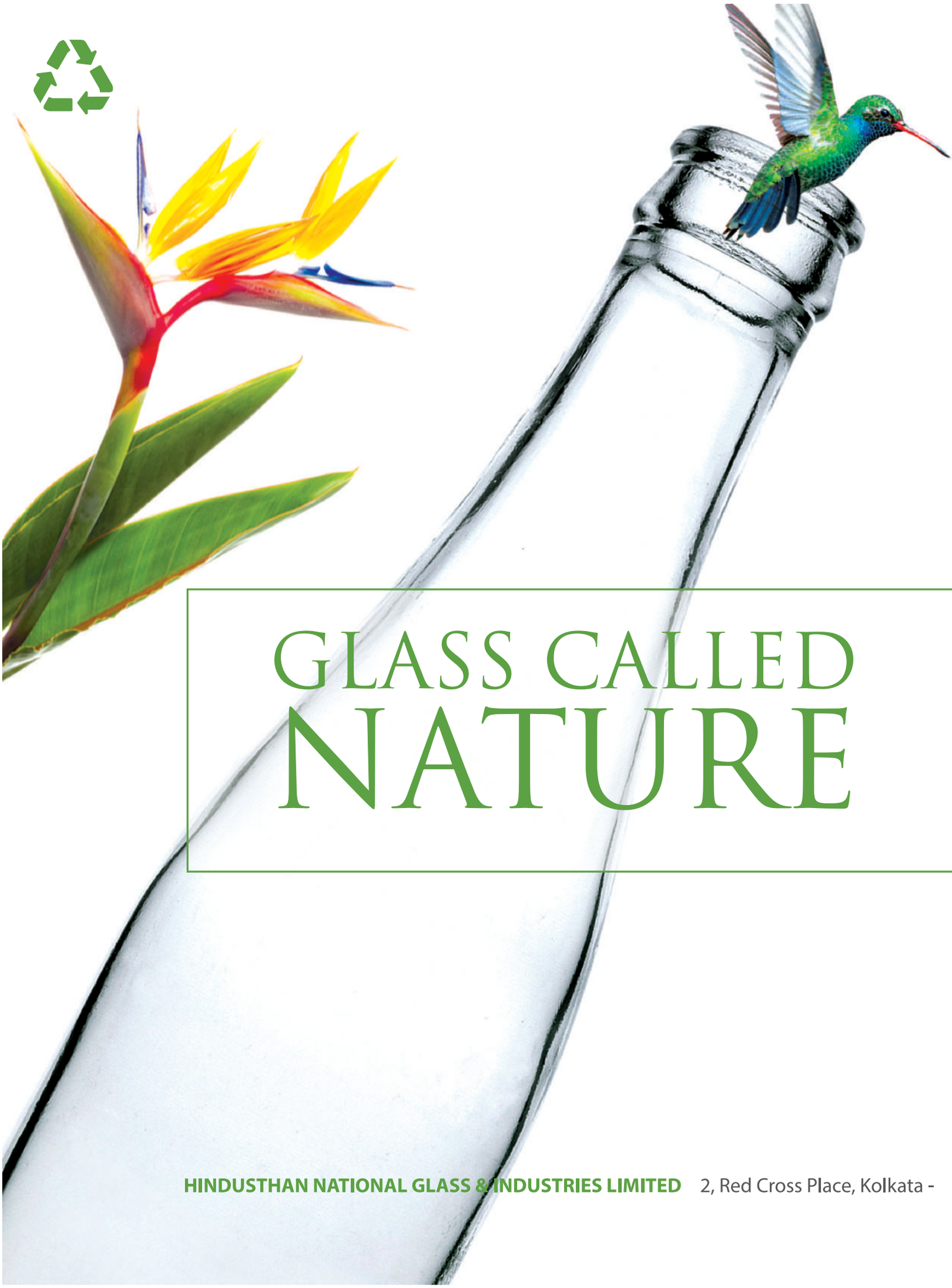

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On the Spot… Carletta Heinz

Taking over as Owner and CEO of the HEINZ-GLAS Group last year, Carletta Heinz is the 13th generation of leadership in the company's 400-year history. She spoke exclusively to *Glass Worldwide* (preferred AIGMF international journal in association with Kanch) about the latest developments.

GW: How challenging was it to take over as CEO of the HEINZ-GLAS Group in July 2020 at a time of unprecedented market conditions during the Covid-19 pandemic?
It is a challenge to take over a company at any time. That's why I have great respect for the tasks I've taken on and I am fully aware of my responsibilities. The pandemic and its negative impact on the global economy were tough, and we also had a lot to struggle with. After years of moderate growth in our global sales, there was a significant slump in 2020. This unforeseeable development showed that growth and success cannot be taken for granted and how quickly the situation can change. But still, the excitement was great because I approach my job with a lot of optimism and enthusiasm.

GW: What are the highlights of the company's performance since that time?
Our global team has achieved extraordinary things and has come together. We have focused on our strengths keeping in mind our customers, innovations and the fundamental actions necessary to remain successful in the future. We built our furnace in Peru, restarted opal glass production in Germany with a new furnace, and also started building another furnace in Poland. In China, we are currently building a new plant with glass production and decoration. Start of production will hopefully be in quarter 1 2022. What helped us a lot during the crisis was a wider portfolio. In addition to perfumery, we offer a wide range of packaging for skincare cosmetics. This market has been much more stable and has helped us in our overall result. Thanks to our Sales department for their great job on this.

Carletta Heinz, Owner and CEO of the HEINZ-GLAS Group.

GW: What are you finding to be the main challenges and opportunities of managing plants in a multinational and multicultural group?
I enjoy working in a multicultural environment. The different approaches; the different perspectives always add value to our own behaviour and decisions. Adapting to new or different cultures is key to our business. The world is getting closer together and the borders we have are disappearing. The challenge is to be flexible enough to meet the specific needs of the different regions, but also to have enough standardised products and processes to simplify the company's workflows. You have to find the right mix between global thinking and local needs.

GW: In a traditionally male-dominated sector, do you believe your role as CEO of a leading player can help encourage more women to join the glass industry?
We at HEINZ-GLAS stand for equality of gender, nationality, religion and sexual orientation. I am very happy if my role encourages more women to work not only in the glass industry but also in management positions. We filled our Board with the people we thought best suited, without using gender as a criterion. Despite this, or perhaps because of it, we now have an even gender distribution on the Board.

GW: Recently appointed as Chief Operating Officer to take over the operational lead, supervising and optimisation of the glass production and decoration worldwide, what qualities will Christian Fröba bring to the company?
Christian has been the perfect fit for the open COO position. He brings with him an excellent education; [he] learned a lot in his previous professional life at Emhart that plays a central role in our production, and knows the glassmaking business very well. He knows other glass factories from different industries than ours and can thus provide input that we do not yet have internally. In addition, he is born and raised in our area, so he was also no stranger to the mentality of the people here. I am very happy that he has come home and will now continue his journey with us in the Heinz family.

GW: Are any of the markets you serve performing better than others and if so, what is the driving force?
Currently, we are very satisfied with all the markets in which we operate. Our lines are full, and we have reached the pre-pandemic figures. Skincare dominates, but perfume is also making a comeback. Our customers are launching new developments and entering new markets together with ▸

Artist's impression of the new plant near Shanghai.

Originally published in Glass Worldwide, preferred international journal of AIGMF

The greenfield construction site in China.

us. If new variants of the coronavirus do not lead to further shutdowns, markets will recover quickly. And China of course is a big driving force.

GW: Installed in March 2021, how successful has the investment in the new 'special furnace' with Fives at your Kleintettau facility proven?
At that time, we made a very critical decision. By investing 15 million euros in this furnace, we have secured 120 jobs in our plants and another 120 with suppliers. We kept our promise to our customers and delivered. After the expected start-up difficulties, we are pleased to say that we have been able to operate opal glass production to satisfaction. From September, we were able to produce flint glass with this furnace as well. The production of opal glass will then take place again at our Polish site.

GW: Do you plan to replicate the technology elsewhere within the group?
Even more than the furnace itself, the feeder technology is special. We are constantly thinking about improving the core technology as well, together with our suppliers, and therefore we would also replicate technologies elsewhere if necessary. Let's see what else we will achieve, and then we will decide how to proceed.

GW: Following HORN's recent announcement that it is working on the HEINZ-GLAS furnace in Piesau, what are the latest updates on that plant?
We will start the construction of our furnace in Piesau next year and finish it in the first half of the year. At the same time, we will have our 400th anniversary celebration. We will be celebrating our founding in 1622, and I think that's incredible. The planning is going well. We do not expect any difficulties and will also use the construction period to make some important changes in the production environment, such as preparing for a GMP-compliant area.

GW: With SORG rebuilding and restarting the electric furnace in Dzialdowo and EME undertaking a turnkey project, what are the latest developments at your Polish operations?
I am very excited about this project because the opal production will be moved back to Poland, where it had been until March 2020, until the furnace broke. From today's perspective, we can start production [at the] end of this year. We are very satisfied with our suppliers and are looking forward to the next months.

GW: Are there any other major investment projects at your plants in the pipeline and if so, where?
This is already a lot and we now must focus on realising all these projects before making the next steps. We are ▸

The HEINZ-GLAS Executive Board (from left to right): Christian Fröba, Carletta Heinz, Virginia Elliott and Frank Martin.

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also continuously expanding our capacities in the decoration plants and developing further in existing and new technologies. Compared to a new furnace, these investments are of course relatively moderate.

GW: How would you summarise the company's investment strategy across the operations?
We are proud to be one of the few, maybe even the only supplier, who can deliver high quality and individual glass as well as standardised products. Our plants in Kleintettau, Piesau, Dzialdowo, Kosamba and Lima can cover all needs and have a wide range of decoration possibilities to offer. Our investment strategy is based on the strengths of the individual sites to set even clearer accents there. Automation and digitalisation will be one of the most important challenges for us and as a pioneer in sustainable production we will do everything necessary to help our planet by reducing our carbon footprint as much as possible.

GW: What is the status of the proposed greenfield investment in China?
Our construction site is going well. At the time of this interview, we are waiting for our technical team to get to China to take the next steps. The current travel restrictions are stringent, so we are waiting for the green light from the local authorities to send them off without keeping them in quarantine for too long. The co-operation with the local construction company is very good and we are glad we chose them. Once we start production there, which should be in the first half of 2022, we could have some interesting projects underway with our customers.

GW: What was the motivation for the Chinese investment and how will the operation there complement your existing business?
My family has been a world traveller for so long. My ancestors were already travelling through Europe and beyond in the 17th century by ox and cart. So, there is no doubt that we also want to enter new markets worldwide like China. We go where the demand matches our glass manufacturing capabilities, and China is a fast-growing market that is participating in the global trend and developing its own interesting brands. We want to be part of that. Together with our existing customers and with new local players, we want to have another foothold for our Group. We will provide glass and decoration. We will use the technical and development know-how of the headquarters and the ambitious skills of the local staff. This is exciting and promising.


Opal production is due to be moved back to Dzialdowo plant in Poland.


15 million euros was invested recently into a new 'special' furnace at the Kleintettau plant.

GW: Looking ahead, will the HEINZ-GLAS Group continue growth via further investments in greenfield projects or acquisitions?
As already mentioned, we first need to complete the big investments that we have already started. After that, of course, we will keep our eyes open for new interesting opportunities. Growing too fast also carries risks. That's why we always stabilise ourselves first and check the current status before taking the next step.

GW: Across the operations, how is HEINZ-GLAS investing in its workforce and how important are your people to the company's performance?
Our employees are our most important resource. The technical know-how they have and the passion they show at work makes me proud. [Occasionally] we face difficult times, but so far we have come through them together and left stronger. We have several career programmes on offer and more in the pipeline, and we want to promote talent and high potential even more. At the same time, it is important for us to be an attractive employer for production lines day after day so that we can supply our customers with high-quality products. We see that it is becoming increasingly difficult to find skilled workers. We understand that change affects us all, so we try to keep up with these changes and be ready for the future.

GW: Are you particularly pleased with any recent product launches?
I am very happy about Phantom de Paco Rabanne [new men's fragrance in a robot-shaped bottle]. Together with [brand owner] Puig we have done an incredible job. This design is really ▸

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During the 400th-year anniversary celebration in 2022, construction of the furnace in Piesau in Germany will commence.

something special! But of course there are many more launches that I'm excited about.

GW: Are further product launches in the pipeline and if so, in which sectors?
Product launches are driven by markets and customers. We are a partner for them and [undertake the journey] together. From our side we are providing new-standard products with new ideas regarding design and sustainable solutions. In decoration we are working on some really nice things. Have a look at our 'Haute Couture de Décoration' series. I love it.

GW: In general across the group, what are your expectations for the business in 2022?
That depends very much on the course of the pandemic. If we can get this under control, I am optimistic about 2022. The signs from the market are positive and we are prepared for this.

GW: How does the company benefit from membership to trade organisations such as FEVE and BV-Glas? Are you personally active with any committees at such associations?
Membership is very important and we benefit a lot from it. Trade organisations help our industry to support our interests and also to make special aspects of the industry understood, both in politics and with our customers. I am personally a member of the FEVE and BV-Glas boards together with two colleagues. Other experts from our company sit on the specialist committees.

HEINZ-GLAS has invested in the operations in Peru.

GW: In general, what are the main challenges facing HEINZ-GLAS?
Climate change and the resulting consequences will have a huge impact on our world and of course also on our industry. Dealing with this and adjusting production accordingly will be a big challenge. But we have already taken the right steps and are pioneers in our industry when it comes to sustainability. We were the first in Europe to use climate-friendly electro furnaces 50 years ago. Our purchased electricity in Europe is already CO_2-free and we can offer PCR glass and lightweight articles at all our sites worldwide. Having the right people in the right positions is becoming more difficult every year. It is already a challenge to find qualified craftsmen or even young people who are willing to undergo vocational training in the field of glass manufacturing. That's why we train our skilled workers ourselves with excellent programmes and show young people how great a job at a glass factory can be. As for everyone and every company, digitisation is another key to success. We are currently in the process of introducing SAP [software] at our German sites. In the following years, this will be followed by the rollout at our locations worldwide. In addition, various digitisation projects are underway in the administrative area, in production and also for our customers. For example, our customers can now accompany pilot series without having to enter the plant.

GW: And the main opportunities?
In all challenges there are also opportunities. If we can overcome these challenges quickly and better than our competitors, we will be in a good position. Another opportunity is to make the right use of our global positioning and offer the markets what they want and what we can do. ●

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Breakability and Performance of some Safety Glasses

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Abstract

In any major application of glass, i.e. soda-lime-silica glass, silica plays the role of the base material, i.e. network former. This is mixed with several other components, i.e. network modifier, for melting, refining, forming or casting, etc., various types of glasses are fabricated. After such fabrication, some glasses, mainly sheet glass or plate glass or even float glass, are subjected to different types of treatment (e.g. heat treatment for toughened glass) for various other applications such as building construction, automotive windows, aeroespacial parts, etc. Here, there is a risk of breaking such glasses during use that makes life difficult for engineers involved in material design and generating specifications. Some of these issues will be discussed here in this article in terms of some misconception about them and explanation thereof for the critics to know the truth.

INTRODUCTION

It is known to all concerned that glasses are versatile materials for various applications - i.e. from very ordinary use such as container glasses, float glasses for building windows to some special applications such as safety glasses for a very wide range of use. In all such designs, various points are of importance. An intimate knowledge of the material as well as specifications are necessary for the marketing people so that correct delivery can be made. For example, in Airports glass panels in the passenger lounge, there are some manufacturers who did not make the correct delivery causing some of the panels to be shattered with time. This could be easily minimized by strict 'quality control' by engineers.

There are some points for consideration [1-4]. For example,

1. Meeting building codes and providing strength
2. Sound damping
3. Solar control
4. Visual beauty, and
5. Impact resistance for safety and security

With the provision of a) storm protection, and b) post-breakage performance. These are all attainable with laminated glass when using proper design. Generally speaking, some of the above considerations are important for float glasses used in the building construction industry. However, the last one is important for all types of safety glasses, such as laminated glass (i.e. sandwich glass) and toughened glass (i.e. heat treated glass) for the automotive industry wherein there is a huge market. This is also true for "wired glass" that is used mainly in the construction of factory sheds and buildings for safety as well as allowing more light inside the factory. So this type of glass has a dual purpose and is quite important for such construction.

For layering of safety glass in the automotive industry, the multifunctional capabilities of Saflex and Vanceva PVB interlayers could help meet changing guidelines and building safety codes. Many years ago, in the event of Hurricane with strong wind, the impact resistance of laminated glass demonstrated its protection capability. Now, due to superior performance of Saflex and Vanceva, there are important implications, such as for example:

1. Capability with Sound Control
2. Colour Options, and
3. Solar control

are enhanced. Structural and security performance in a multifunctional glazing is not just easy to do — it is a desired option that continues to grow in popularity. Now, some misconceptions can be described with required answers as below:

(a) The first misconception is that the only safety glass is "fully tempered" glass. The answer to this point is: Laminated glass is safety glass in the correct configuration. Laminated glass does not need to incorporate tempered glass to be considered for

safety glazing. The laminated glass simply needs to meet the appropriate safety glazing impact standard for the region it will be used in. Some typically referenced safety glazing standards include: for example:

1. ANSI Z97.1
2. AS/NZs 2208
3. CPSC 16 CFR 120
4. EN 12600, and of course
5. ISO 39584

The building codes reference a performance criteria, not a glass type, except when glass fallout post-breakage is a matter of concern. In glass fallout cases, building codes specifically reference and, in many cases, require laminated safety glazing, e.g. skylights, overhead, balcony, etc.

(b) The second misconception is that laminated glass cannot be used in exposed external applications. An answer to this point of concern is: Laminated glass is ideal for both exposed and external applications. PVB interlayers produced about 25 years ago tended to be more susceptible to visible delamination. This was mainly due to environmental influences such as high moisture. When viewing laminated glass that was created and installed before this time, it may be easy to assume that laminated glass is not capable for this particular use. The reality is interlayers have changed over time, and specialty products with ever-evolving durability and capability have been and continue to be introduced. All materials should avoid standing water or chemicals at the edges, but it is important to note that PVB interlayers today — when properly laminated and installed — are not the same as those used decades ago.

(c) The third misconception is: PVB is PVB. An answer needs to be given as: there are several types of PVB interlayers. Most PVB interlayers are a highly engineered adhesive intended to provide basic safety glazing performance. However, they can be modified or layered to provide other value-added and desirable characteristics, such as example,

1. Safety and Security Impact Resistance
2. Noise Reduction (i.e. nearly sound-proof)
3. Solar control, and
4. UV Screening

as well as structural performance and color options. They are designed so that various formulations from the same supplier can be combined to help meet project needs. For instance, an acoustic interlayer can be combined with color to provide security and way finding to a school.

(d) Another myth is that PVB is for automotive applications. An answer could be given as: While laminated glass was first introduced for use in automotive windscreens in 1937, it has successfully transferred over for use in the architectural market. Laminated glass is no longer a one-size-fits-all product. PVB interlayers have been specially engineered to provide the characteristics demanded by the markets they serve. In the architectural market, that means keeping the ability to act as a safety glazing; retaining glass shards for some time when broken and wet; providing a mechanism to keep a building envelope intact and its occupants safe and comfortable; and protecting the property. For architectural beauty, a small building is shown in Fig. 1.

Why do these misconceptions exist? Perhaps it is due to how the products have been introduced and marketed. Often, informational brochures from some associations and organizations reference safety glass (fully tempered) or tempered safety glass as the only material for complying with building codes. It's a habitual and generic term.

Prior to the late 1990s, there was essentially one base formulation of polyvinyl butyral interlayer for glass lamination to achieve safety performance, be it in automotive or architectural applications; and specialty formulations existed for aircraft-type applications. Like the increase in the variety of brands, flavors, and strengths of different consumer products, new versions of PVB interlayers created for specific uses have been introduced. However, PVB continues to be generic in nature, leading to the previously mentioned misconceptions.

In this connection, it is pertinent to mention some elements of high-performance building envelopes. A typical facade of a building envelope is shown in Fig. 2. A facade should not just dictate how a building looks, but how it works — especially in the harsh climate of a very hot country with deserts, e.g. Saudi Arabia. With every project, architects and engineers should strive to design unique, high-

Fig. 1: A typical building with architectural speciality on the top

Fig. 2: A building facade is shown to highlight the envelop

performance building envelopes that are appropriate for their context. The envelope must be able to withstand the forces of the local environment and facilitate efficient maintenance. There are case studies that illustrate four important points which can be easily remembered as the first letter starts with P:

- Performance (function and sustainability)
- Price (affordability)
- Prefabrication (ease of construction)
- Post-occupancy (durability and maintenance)

Some considerations have to be given on the above points pertaining to the performance in the building construction industry.

CONCLUSIONS

Safety glasses of various types have been mentioned in terms of performance of such glasses. There are some misconceptions concerning such safety glasses and related materials that are again related to their actual performance in various industries for sound reduction, solar control, colour options, etc. For the purpose of marketing, it is not congenial to have confusion or doubts about certain issues and they need to be resolved as early as possible. This is the reason why such misconceptions have been mentioned and answered to the point. If such misconceptions are removed or made clear to the eyes of both the user and manufacturers of safety glasses, then the future of this industry will be bright.

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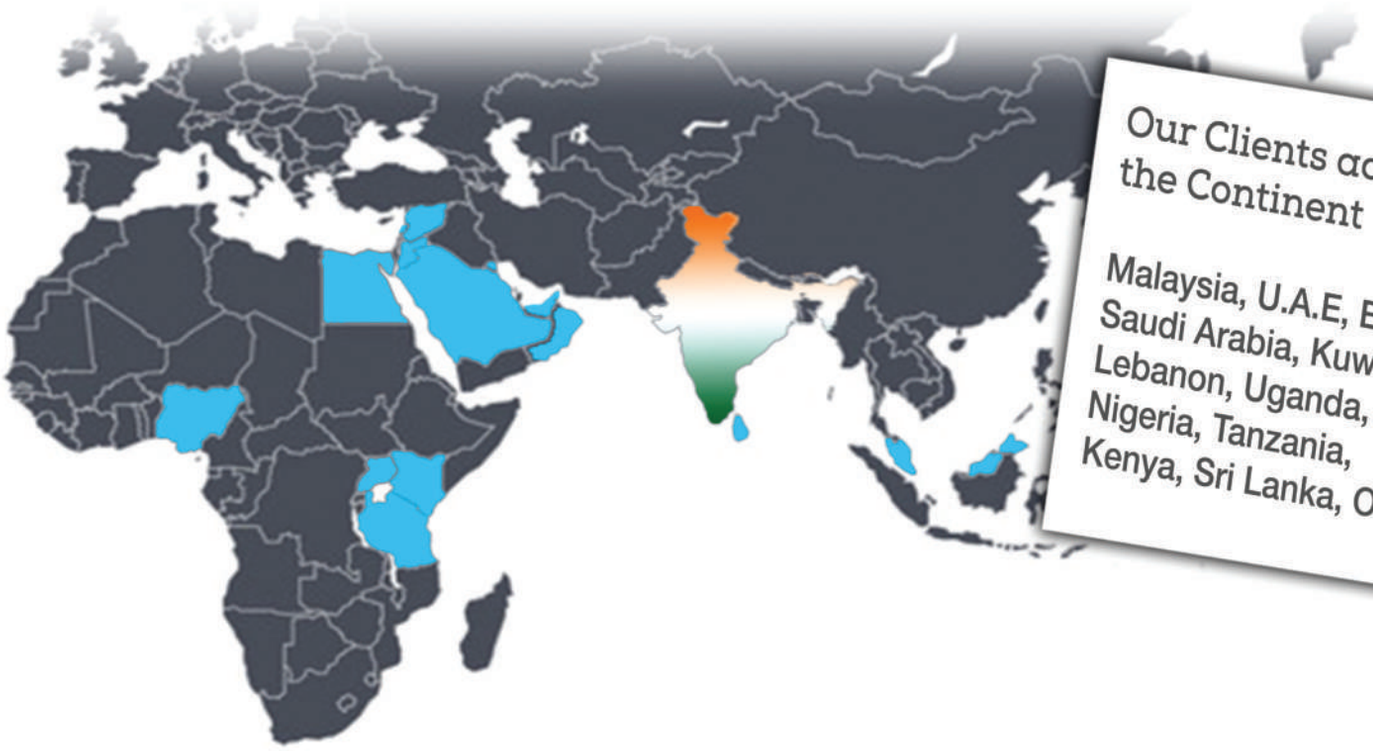

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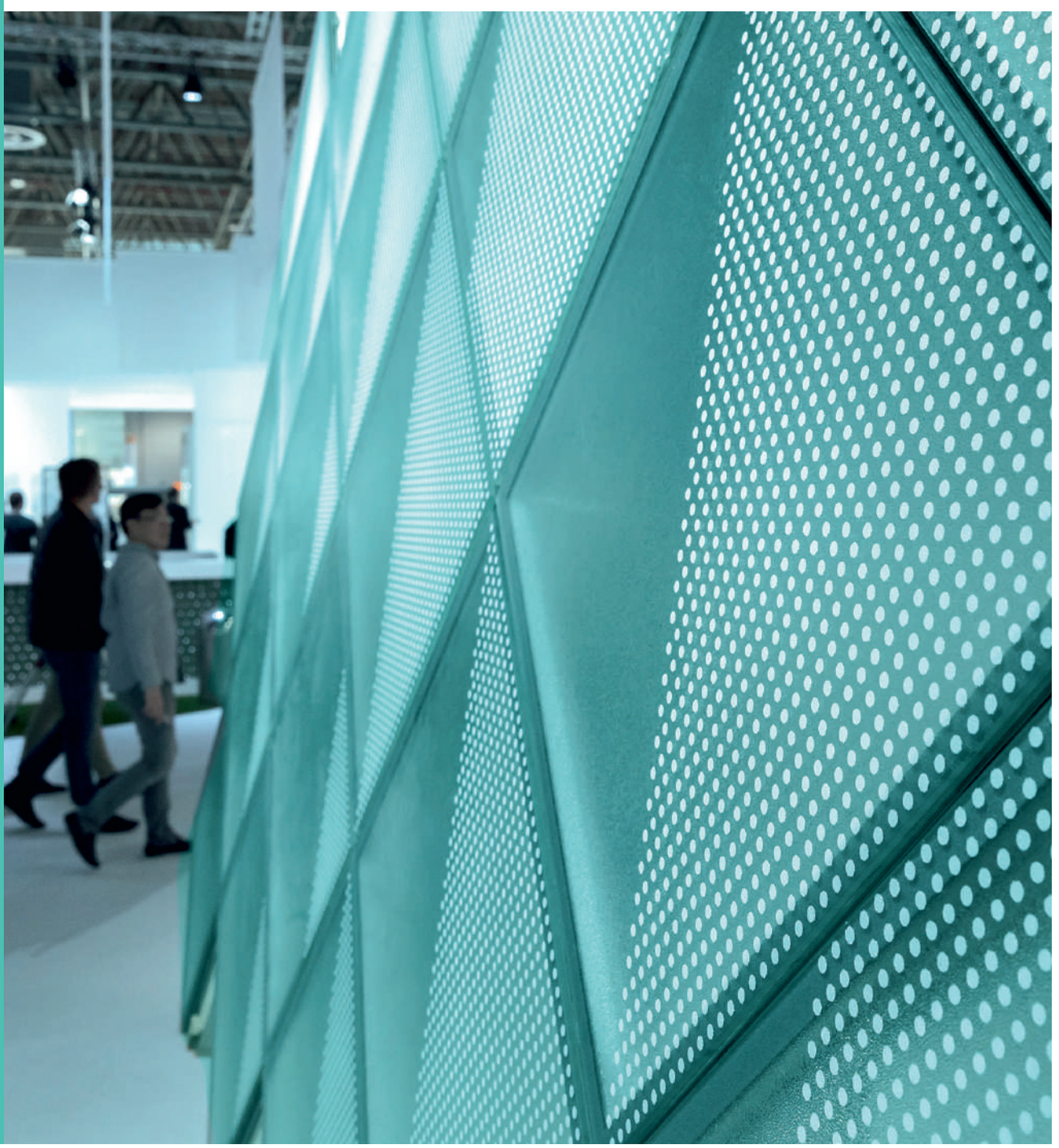

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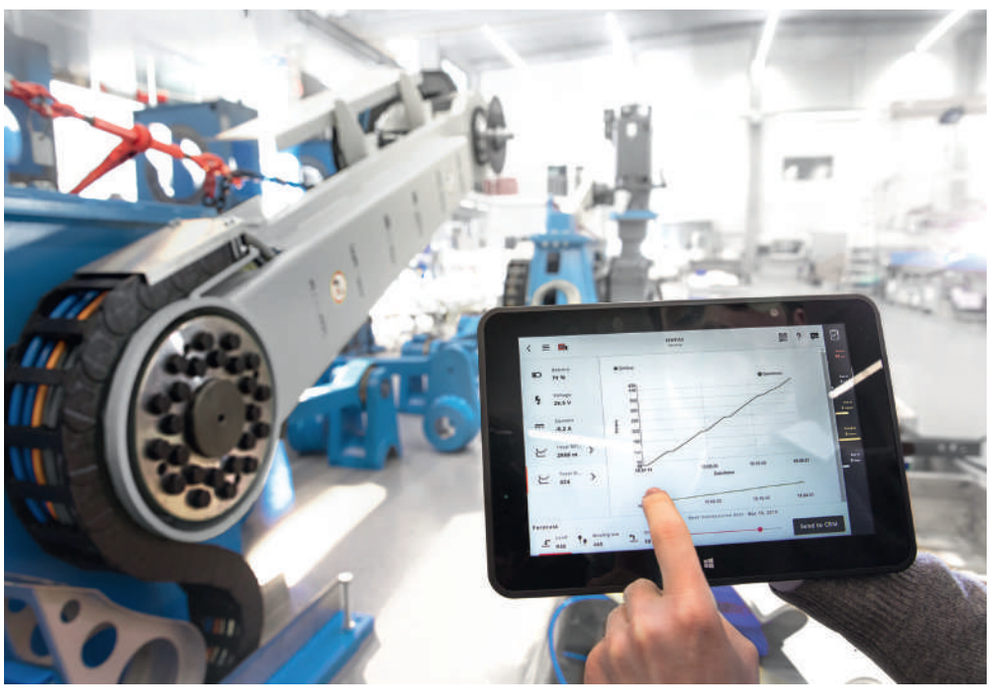
OPC UA - The Dawn of a new Interface Generation

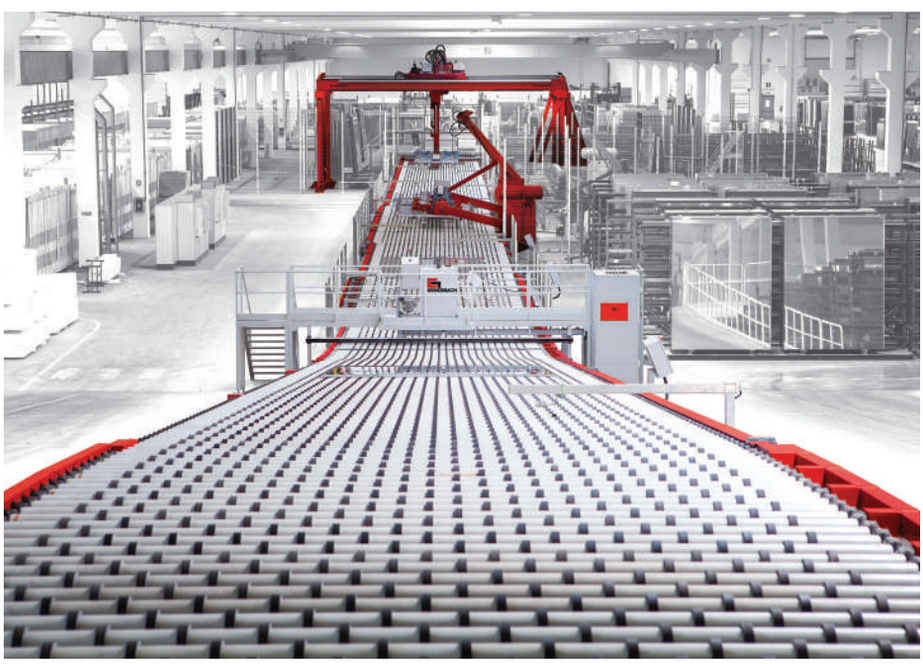
Digitalisation creates added value. How the manufacturer-independent communication standard OPC UA can contribute to this will be illustrated at glasstec from 20 to 23 September 2022 in Düsseldorf at the glasstec conference, among other events.



"OPC UA supports operators in communicating with machines."

Digital transformation has long since taken hold of the flat glass industry and is progressing rapidly. People increasingly just monitor manufacturing processes rather than doing the jobs themselves. Skilled labour shortage, growing demands made on the flexibility of machinery and equipment as well as increasing sustainability requirements require intelligent monitoring of production processes.

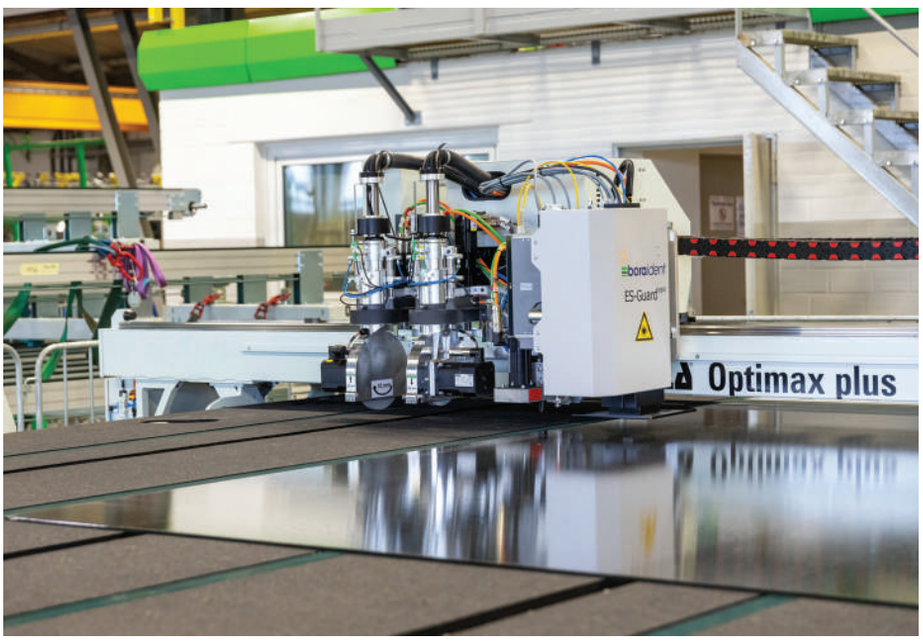
Producers can generate particular added value by pursuing a mechatronic approach. It is therefore worthwhile focusing on data and intelligent man-machine, machine-man communication and – last but not least – on the communication between machine and software. Especially since a growing number of machines and the operating software of different manufacturers need to communicate with each other. Currently, most interfaces required for this are still implemented as custom solutions for the respective application. But rather than investing a lot of time and money in programming individual interfaces, a standardised, manufacturer-independent, inter-operable communication standard, as offered by the Open Platform Communications Unified Architecture –or OPC UA for short – would provide a solution offering high potential along the value chain.



"Also at the cold end – here a float glass line – OPC UA raises the potential in machine communication."

A STANDARD "PICKS UP SPEED"

OPC UA transmits machine data such



"The float glass cutting line will in future communicate with the laser marking systems and even external plants ever more easily thanks to OPC UA."

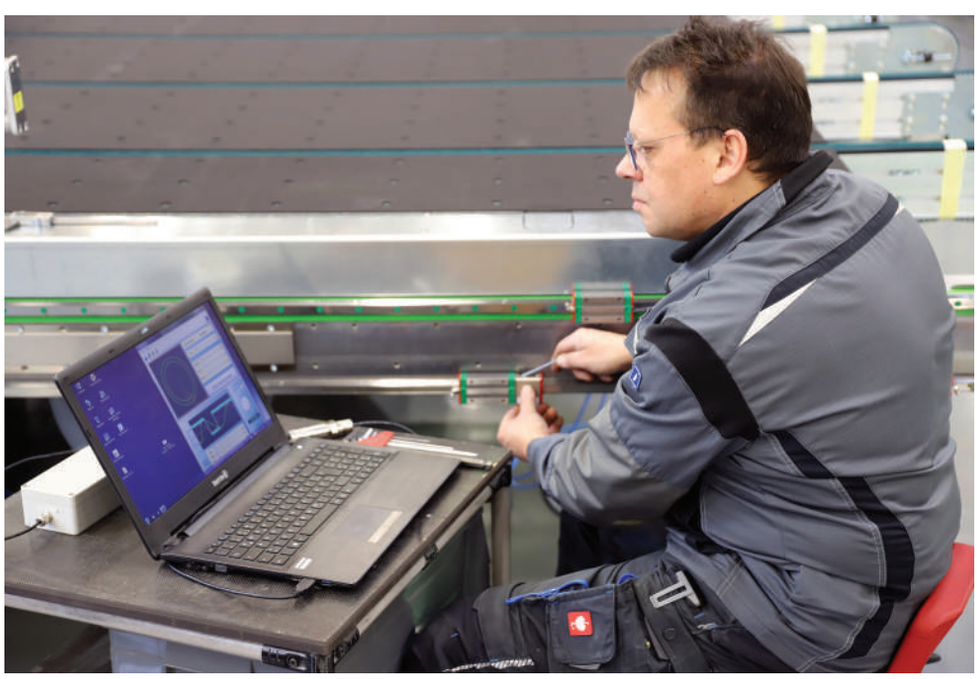
as controlled variables and measured values and has the ability to describe these semantically in a machine-readable format. Developed in the USA, the standard is now gaining increasing importance in Europe. A cross-sectoral study published in 2021 by the VDMA e.V. (German Engineering Federation) illustrated the relevance of interoperable interfaces and the associated standards in companies: over 90% of those surveyed saw a need for interoperable interfaces. According to the survey, the dissolution of proprietary interfaces is of the greatest strategic importance, as this is what makes plug and produce possible in the first place.

According to estimates, some 10% to 12% of plants in the glass industry are equipped with this platform. Demand for OPC UA, however, also depends heavily on the target market. *"Our lines are already fitted with this communication standard. However, demand for it in Asia is still of secondary importance compared to Europe,"* says Mr. Peter Seidl, Head of Product Management Business Unit Glass at Grenzebach, describing the current situation. In addition, integration of OPC UA without the associated Companion Specification cannot exploit its full potential. Interoperability is only achieved when the connected machines and systems understand the interface content due to this Specification – in order words, speak the same language.

To define this and make it work for the flat glass industry, manufacturers and software providers are involved in a Joint Working Group (JWG) of the VDMA and the OPC Foundation. The latter has worked out the first Companion Specification for the flat glass processing, which was published at the OPC Foundation in November 2021. This Specification is applied in production management. *"With this Spec we no longer have to worry about how we communicate but only what we communicate,"* says Mr. Seidl, who advocates the introduction of OPC UA in the JWG, looking to the future of interoperability.

KEY TO MORE VALUE ADDED

Dr. Markus Schoisswohl, General Manager at Hegla New Technology and a chairman at the JWG, adds: *"If we succeed in replacing the proprietary protocols by OPC UA, we can eliminate enormous investment not only in terms of money and time for programming but also for individual tests during*



"OPC UA simplifies the installation of machines and equipment."

commissioning." Especially as employees are confronted with growing plant flexibility demands. *"Manufacturers are required to adapt their production to new orders with varying batch sizes at ever shorter intervals,"* reminds Mr. Tobias Wachtmann, Head of Vertical Glass & Solar at Siemens. It is precisely this setup that OPC UA facilitates, as manual programming is eliminated and the number of different interfaces is greatly reduced. It also makes the integration of machines or components into existing production lines much easier and faster, thus increasing plant efficiency.

"Forming an important basis for the successful communication along the complete process chain is the manufacturer and platform-independent exchange of data as offered by OPC UA."

Furthermore, OPC UA markedly simplifies the generation of a digital twin needed for adding new facilities or expanding capacities. Current production data in a standardised format assist in planning maintenance and improve resource efficiency while cutting response time in the event of errors. And data protection is also ensured: OPC UA boasts a wide variety of security mechanisms. Messages, for example, can be transmitted in an encoded format across various levels and signatures and authentication are also possible.

"DIGITALISATION MUST BE MANAGEABLE"

At present, the use of OPC UA in the glass industry is still a small piece of the puzzle. The flat glass industry is setting off to news shores. According to Dr. Schoisswohl, digitalisation must be manageable.

"We must not leave our co-workers behind but make them understand the benefit that the data transmitted by OPC UA brings." Mr. Wachtmann suggests: *"Just marketing proprietary solutions is too short-sighted these days. Interface standardisation, developed in close cooperation with suppliers and users generates the biggest benefit for the supply chain."* By introducing the first Companion Specification JWG has created a solid base. In future, it will get further specifications underway for more variables and production areas. Experts expect OPC UA to become established in the glass industry in a few years.

With a view to making the benefits of this interoperable standard accessible, the companies involved in the JWG plan to exhibit a Demonstrator at their glasstec 2022 stands. This will show how OPC UA positively impacts plant efficiency as well as resource consumption ■

GLASSTEC, 20 – 23 SEPTEMBER 2022 IN DÜSSELDORF, GERMANY

International Trade Fair for glass – Production, Processing, Products

The high proportion of international exhibitors and large number of top decision-makers among its visitors have distinguished glasstec for years. The trade fair is the platform for premieres of innovations in all areas of the value chain, from production to processing and finishing to final application. A feel for trends and future topics is also reflected in its extensive ancillary programme. Thus, glasstec maintains its position as the leading global trade fair for the material that is glass.

From 20 – 23 September, glasstec 2022, the world's leading trade fair for all things glass, will be held at the Messe Düsseldorf exhibition center.

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Glasses for Healthcare

Prof. Julian R. Jones

Prof. Delia S. Brauer

INTRODUCTION TO THE TYPES OF GLASSES USED IN HEALTHCARE

When glass is selected as the optimal material for a particular application, it is usually chosen for its transparency and optical properties, or for its ability to resist corrosion. In healthcare, these types of glasses are still very important, but another, more unusual type of glass is also used, which is designed to dissolve or "biodegrade". Bioglasses are unique materials that can actively promote healing of tissues, such as bones or skin lesions, and they have thus changed the way clinicians think about biomaterials. They can also kill bacteria where antibiotics have failed.

"Conventional" glasses and "bioglasses" all play important roles in healthcare, some impacting our lives daily, others enabling lifesaving or life changing surgery. This chapter will begin discussing the application of traditional glasses in healthcare provision before moving to bioglasses in regenerative medicine.

INERT GLASSES

We are all familiar with eyeglasses, or spectacles, which a long time ago revolutionised the quality of life of our ageing population by enabling us to see clearly when our own lenses have deteriorated. Nowadays, many people of all ages, including small children, wear glasses to help them see better. The social and economic impact of eyeglasses is far more difficult to imagine, but it is clearly global and invaluable. Glass lenses work by bending light to a focal point, correcting our vision. Optical fibres, like those used in high-speed data transfer such as fast broadband internet, also work by bending light. Those same fibres are used in keyhole surgery and endoscopic diagnoses. The thin glass fibres enable surgeons to see clearly around corners to carry out procedures through very small incisions. This not only reduces scarring but also the chance of infection. The flexibility of the fibres means clinicians can insert the arthroscope in a safe entry point, such as the thigh, and navigate their way to the critical organ where to perform surgery, including life-saving heart surgery.

Another serious risk to life is severe allergies that can cause anaphylaxis and fatal collapse of upper respiratory tracts. Approximately 20% of the European population suffer from chronic allergies, and another million people are estimated to have allergies unbeknown to them which can develop at any time. Commonly known by a brand name "EpiPen®" (Figure 1), syringes can rapidly administer a dose of life-saving adrenaline (epinephrine). The action of injection is a jab into the upper thigh, usually through layers of clothes, as rapid administration is critical in severe cases. This requires not only a high-strength needle but also a shatterproof cartridge that contains the drug (Figure 1). The cartridges are made of borosilicate glass for its chemical stability, so it does not alter the chemistry of the drug, but conventional borosilicate glass would shatter in about 10% of applications. The use of high-strength chemically toughened glass, made using a process similar to chemically tempered cover glass production for mobile phone screens, means that fracture is almost impossible when the EpiPen® is used.

At the time of writing, the world is suffering a global pandemic where

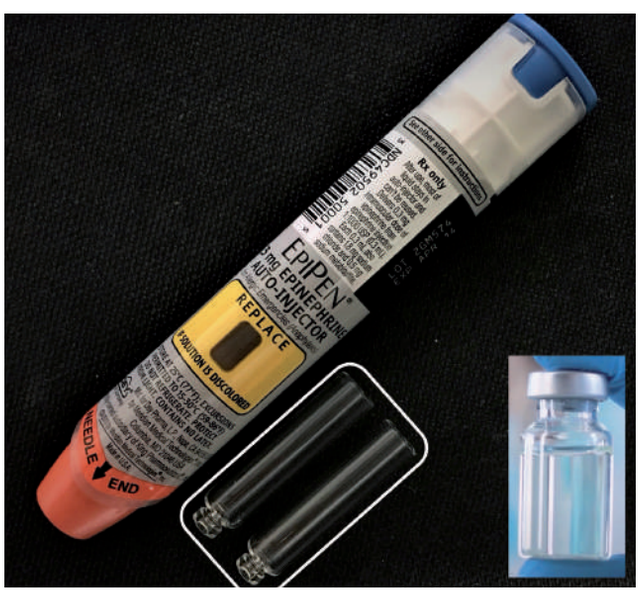

Figure 1. An EpiPen© with its Chemically toughened glass cartridges (white box); inset: a vaccine vial.
Source: EpiPen courtesy of Saxon Glass Technologies (US); inset courtesy of GIMAV/ (Italy)

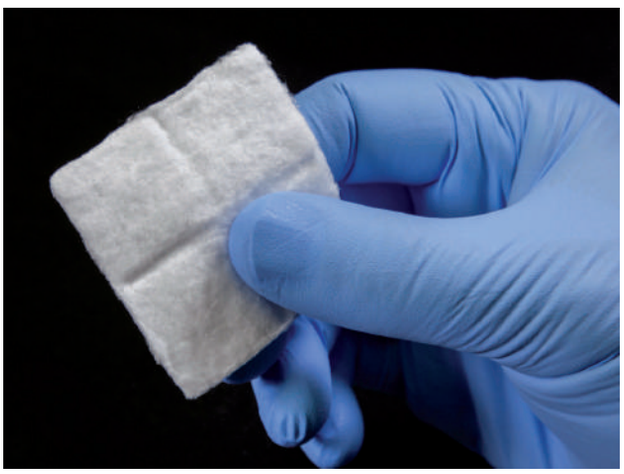

Figure 2. Mirragen© cotton-like glass for healing chronic wounds.

Source: ETS Wound Care, MO, USA

efficacy, safety and distribution of vaccines have been in the spotlight.

Like many pharmaceuticals, vaccines contain sensitive molecules that must be kept in containers which preserve them and do not interact with their contents. Corrosion-resistant borosilicate glasses are the material of choice for COVID-19 vaccine vials, and chemical strengthening can ensure minimal loss of their valuable cargo. Increasing vial production without reducing quality or quality control was one of the many challenges during the early stages of the pandemic.

Another serious medical condition that afflicts a large proportion of the global population is diabetes. While the glucose level in the blood can be regulated through insulin injection, diabetic patients live with other effects of their condition, such as inhibited wound healing. Skin wounds take longer to heal for diabetic patients, often not healing at all. Glasses can help here, too, as we will see below.

BIOGLASSES

Bioglasses are not corrosion resistant, but rather they are designed to undergo safe dissolution inside the human body, assisting with the body's natural repair mechanisms.

Chronic wounds are those that do not heal under conventional treatment, and they are a serious problem as open wounds are prone to infection. Chronic wounds are more common in diabetic patients, due to disruption of the multi-stage wound healing cascade, impaired blood vessel development in the wound for example. If infection takes hold, it can ultimately lead to amputation. A medical device called Mirragen® (ETS Wound Care, US) has been shown to heal chronic wounds in diabetic patients [1], including venous ulcers with yeast infections that had not healed during many months of conventional treatment. Consisting of spun borate-based glass fibres (Figure 2), Mirragen® has the appearance and flexibility of white cotton candy. The bundles of fibres are inserted into the wound before a more conventional barrier dressing is applied on top. The fibres biodegrade in a matter of days, but during that time they provide their dissolution products of borate and calcium ions to the wound bed.

The ions seem to kill some pathogens and actively stimulate wound healing, most likely by accelerating angiogenesis (sprouting of blood vessels). However, the morphology of the fibres is also likely to play a role in accelerating the wound healing process, as the fibres have similar diameters to the collagenous extracellular matrix of skin. They can act as a framework (scaffold) for migration of cells, which may well have been dormant, into the wound bed. When the dressing is replaced after a day or two, the fibres will have biodegraded and a new matt of

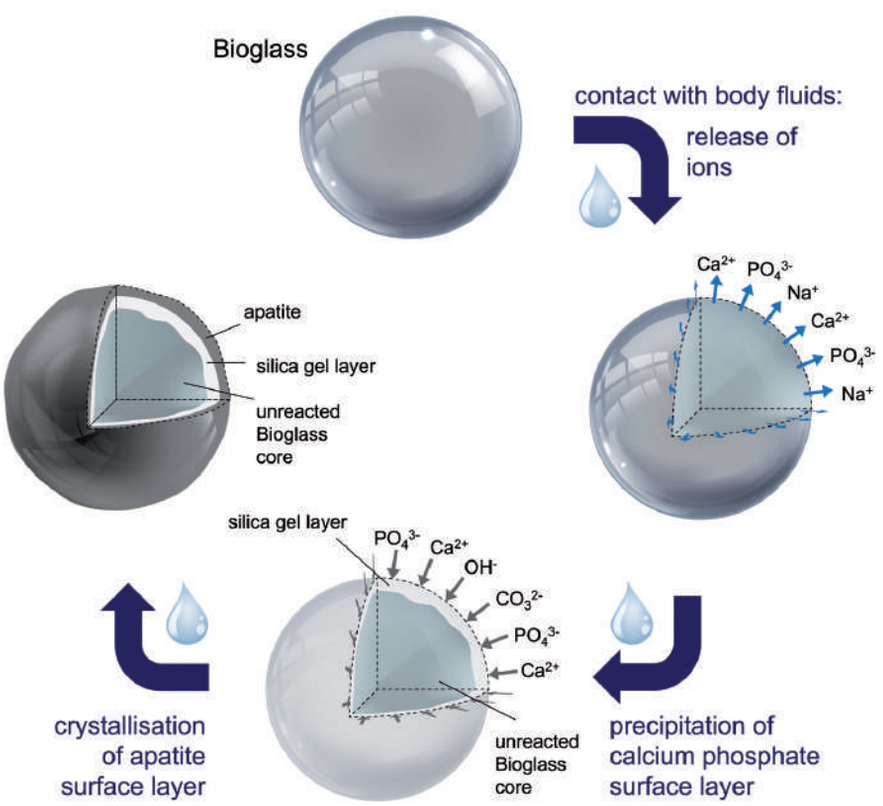

Figure 3. Schematic of Bioglass reactions with water.

Source: P. Wiemuth, University of Jena

Figure 4. Bioglass products for orthopaedic applications: NovaBone particulate (left), BonAlive granules (top right) and BonAlive putty (bottom right).

Source: Julian R. Jones

Mirragen® fibres can be placed into the wound.

The concept of a glass's dissolution ions activating cells was established more than a decade before they were used in wound healing in studies designed to understand the mode of action of the original "Bioglass®" in bone regeneration. The name "Bioglass" specifically refers to the first bioactive glass composition invented by Larry L. Hench in 1969 [2]. It was a silicate glass of the composition 46.1 mol% (45wt%) SiO2, 24.4mol% Na2O, 26.9mol% CaO and 2.6mol% P2O5, later termed 45S5 Bioglass. This composition was Hench's first attempt at making a glass that might bond with human bone. Amazingly, it worked. His clinical colleagues tested it in animal studies and found that it bonded to bone so well that it was difficult for them to remove it to be able to study the bonding! This changed the way clinicians thought about biomaterials, as previously biomaterials were selected from materials that were corrosion resistant, such as titanium alloys, high density polymers and alumina-based ceramics. If an inert (and sterile) piece of window glass was implanted next to a patient's damaged bone, it would be encapsulated by fibrous tissue and sealed off from the rest of the body by the immune system dealing with this foreign object. When a Bioglass implant comes into contact with blood, it undergoes surface dissolution, releasing calcium, phosphate and soluble silica (Figure 3). Bonding with damaged bone occurs because a bone mineral-like calcium phosphate layer forms on the surface of the glass [2]. As it is so similar to bone mineral, the cells of the body's immune system do not see it as foreign, so fibrous encapsulation does not occur. As this calcium phosphate layer grows, it integrates with collagen fibrils of the damaged host bone and is incorporated into the healing bone. The effect of the dissolution ions was discovered when Hench, his co-workers, and the company wanting to market Bioglass at the time (NovaBone Products, US), started to investigate why BIOGLASS worked so well in terms of encouraging high quality bone repair. In cell culture experiments, they found that the dissolution products, particularly silica species and calcium ions, stimulated human bone cells at the genetic level to produce more bone matrix [3].

We are now celebrating more than 50 years of its invention, although many fewer years of clinical use. The original 45S5 Bioglass has been implanted in more than 1.5 million patients who were suffering from bone defects, usually as a result of surgery removing abscesses or tumours, but sometimes due to fractures not healing by conventional treatments. In these clinical applications, Bioglass as a "medical device" is usually a white powder in a sterile and hermetically sealed sachet (Figure 4). Surgeons tend to blend the microparticles with blood, and once the blood begins to clot, the mixture can be pressed into the hole in the bone.

Since bioglass particulate was launched to market, several rival products have been released, such as Biogran (Orthovita, US), Unigraft® (Unicare Biomedical, US), GlassBone (Noraker, France), which are alternative 45S5 Bioglass products, and BonAlive®, which has the S53P4 composition (53.8mol% (53wt%) SiO2, 21.8 mol% CaO, 22.7mol% Na2O, 1.7 mol% P2O5, BonAlive Biomaterials, Finland).

Most have been used in a similar manner, but BonAlive® has also shown benefits in patients with deep bone infections, known as chronic osteomyelitis. The infections are termed "chronic", as they are not responding to treatment by antibiotics alone. However, when the bioactive glass was implanted into the bone (along with the antibiotics), the infection subsided [4]. These findings are particularly important as many bacteria are becoming resistant to existing antibiotics.

Glass particles alone can be difficult to handle, therefore many orthopaedic clinicians prefer to use bioactive glass in the form of a putty. So, putties have been developed consisting of polyethylene glycol (PEG) carriers packed with Bioglass that can be

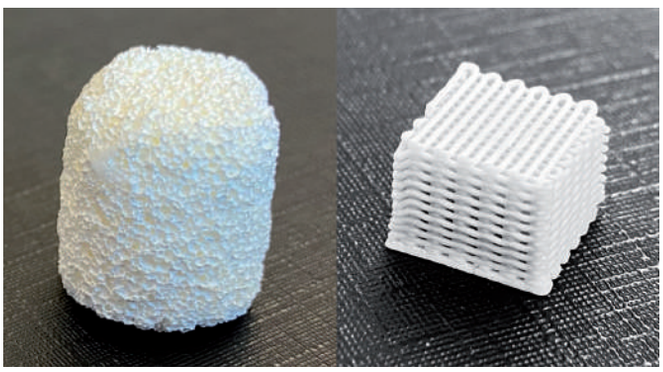

Figure 5. Photographs of bioactive glass scaffolds: a sol-gel foam scaffold that mimics the pore architecture of porous bone (left) and a 3D- printed scaffold (right).

Source: Julian R. Jones

delivered using syringes (Figure 4). When bioactive glass particles are used to repair bone defects, they act as stepping stones, encouraging the bone to cross the gap before they biodegrade. For many bone defects, a more robust three-dimensional template (scaffold) is needed to act as a framework for bone growth. Importantly, the pores must be open to allow bone and blood vessel ingrowth. However, producing a porous scaffold from the original Bioglass is challenging, because the conventional strategy for making a porous architecture from a glass or ceramic would be to sinter particles together and heating Bioglass to the temperature required for sintering causes crystallisation [5]. There are two ways to prepare bioactive glass scaffolds that do not crystallise: altering the glass composition to one that does not crystallise or using the sol-gel process. Adding more components into the glass composition can increase the crystallisation temperature, thereby opening the processing window, and thus allow for sintering without crystallisation occurring. Figure 5 shows photographs of bioactive foam and 3D-printed bioactive scaffolds. The foam structure mimics the architecture of porous bone and can be created using vigorous agitation with surfactants, either by foaming glass particles in a water-based slurry prior to sintering, termed gel-cast foaming [6], or by introducing a foaming step into the sol-gel process [7].

The sol-gel process forms the silicate network through chemical synthesis, wherein nanoparticles form in solution and assemble as covalent bonds form a gel. The gel is usually heated to drive off the water, which leaves a nano porous glass of large surface area. As the sol-gel process does not involve melting, sodium, which lowers the glass melting temperature, is not required in the composition, so the bioactive glass compositions can be more simple [8]. Foamed sol-gel and gel-cast foam scaffolds both result in spherical pores connected by circular interconnects or pore windows. Those 'windows' are key for 3D bone ingrowth.

Glass powders can be 3D-printed if they are mixed with a binder, or carrier gel, that can undergo shear thinning [9]. The grid-like 3D structure can provide high strength in compression, similar to that of dense bone, while maintaining pore channels suitable for vascularised bone ingrowth (Figure 6b). Direct comparison of bone regeneration in foam and 3D-printed scaffolds was performed in a rabbit model. The pore window (interconnect diameter or channel width) were matched, at just over 100 μm, which meant the foam had a much higher total porosity than the printed scaffold (Figure 6a, b). At 11 weeks in vivo, the foam scaffold had biodegraded and the defect filled with new bone (Figure 6c), while the 3D-printed scaffold remained (Figure 6d). However, the bone growing through the 3D-printed scaffold was of higher density and could therefore be considered of higher quality, while the rapidly formed bone in the defect with the foam implant was similar to that of the control. A degradation time of 11 weeks may be too rapid in a human patient, so the 3D-printed scaffolds may be preferred. Despite their promise, porous bioactive glass bone scaffolds have yet to make it to clinical be use.

Perhaps surprisingly, bioactive glass has had an even greater impact in consumer healthcare. The largest commercial use of bioactive glass, and perhaps any bioactive biomaterial, is in toothpaste designed to treat hypersensitivity of teeth (Figure 7a). While many of us know the sharp pain one can feel when biting into cold ice cream or taking a sip from a hot cup of coffee, for many the pain is chronic and needs treatment. The pain is thought to be caused by exposed tubules in our dentine (Figure 7b). Our teeth are covered by hard enamel, underneath which is the dentine. Enamel and dentine are very similar to bone, in that they contain calcium phosphate mineral and collagen, and the tubules in the dentine lead to the nerves in the pulp chamber in the heart of the tooth. Early toothpaste for hypersensitivity delivered anaesthetics during brushing, but now toothpastes have been developed that can occlude the tubules by promoting formation of new calcium phosphate mineral. This occurs because the bioactive glass dissolves in saliva, releasing calcium and phosphate [11]. As saliva is already rich in calcium phosphate, saturation occurs, and this natural

mineral is deposited on the surface of the teeth (Figure 7c, d).

The first bioactive glass to be used in toothpaste was the 45S5 Bioglass composition. As fluoride is known to be greatly beneficial for remineralising teeth, a new fluoride-containing bioactive glass composition, BioMin® F (BioMin Technologies, UK), is now on the market. It releases fluoride ions in addition to calcium and phosphate when in contact with saliva, resulting in a tooth mineral that is less likely to dissolve in acids, for example when we consume lemonade or fruit juices.

Bioglass is also used in several cosmetic creams, particularly as Vitryxx® (Schott AG), a very finely ground particulate. Vitryxx is thought to have anti-ageing benefits, such as reducing redness and wrinkles.

GLASS-BASED MATERIALS IN DENTISTRY

When glass is heated above a certain temperature, it crystallises, forming a glass-ceramic. Glass-ceramics can show interesting combinations of properties, such as transparency and high strength. We know them for example from cooker tops, where they can survive drastic changes in temperature without shattering. In the field of dentistry, glass-ceramics are used with great success to replace teeth [12], as they are strong enough to withstand the forces during chewing and can be made to look just like natural teeth. They are also chemically durable and survive constant exposure to saliva, low pH during the drinking of juices or changing temperatures when we eat ice cream or drink hot beverages. Glass-ceramics are used to make dental inlays, crowns and bridges, and often consist of a combination of different glass-ceramics. For example, lithium disilicate is strong enough to be used as the main framework in bridges, while leucite or fluorapatite glass-ceramics give the appearance of natural tooth (Figure 8).

But even in dentistry soluble glasses are used. A certain type of glass that contains aluminium ions, referred to as aluminosilicate glass, can dissolve rapidly when in contact with acids. When a fine powder of such a glass is mixed with an acidic polymer, for example poly(acrylic acid), the glass dissolves and releases ions such as aluminium and calcium. These ions then bond to the polymer, and together ions and polymer form a strong cement (Figure 8). These cements, called glass ionomer cements [14], have been used in dentistry for several decades now to treat minor cavities, as adhesives ("glue") or as sealants to prevent new caries forming in the grooves (fissures) on the top of our teeth. As the glass used also contains fluoride ions, glass ionomer cements also release fluoride and help to prevent caries. Glass ionomer cements are used regularly by dentists, and most of us have this material somewhere in our teeth. One great advantage of these glass ionomer cements is that for setting they do not require special equipment such as UV light. So, they can be used easily even in rural areas of developing countries, helping dentists to bring dental care even to remote spots.

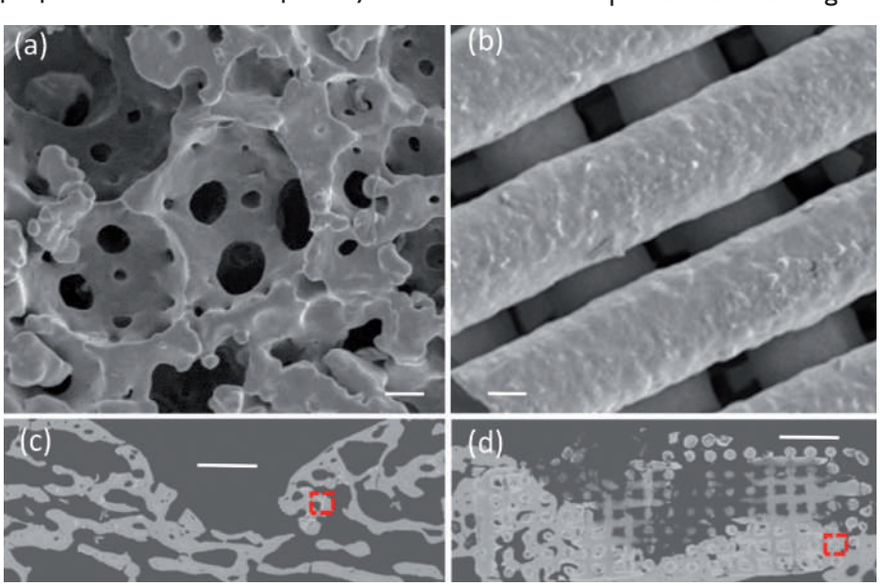

Figure 6. Comparing bone regeneration in a rabbit between foam and 3D- printed bioactive glass scaffolds of similar pore channel sizes; scanning electron microscopy images: (a) interconnected pores in the glass foam, scale bar= *100μm*, (b) pore channels in the 3D- Printed scaffold, scale bar= *100μm;* (c,d) new bone formation at 10 weeks after implantation of (c) the foam and (d) the 3D-Printed scaffold (scale bar=1 mm). The red boxes show examples of new bone formation.

Source: Modified from shi et al. [10]

THERAPEUTIC NANOPARTICLES

While not really considered a bioactive glass, radioactive glass spheres are used to treat liver cancer, whereby they are injected into the blood stream, become lodged in the liver and emit radiation from inside the liver to destroy the tumour. They are used when externally applied radiation is not effective. There are many experimental cancer treatments that use nano-porous glass nanospheres (Figure 10) that aim to deliver chemotherapy drugs only to the cells that are targeted. It is well known that conventional chemotherapy has drastic side effects, which is due to it killing useful cells at the same time that it kills the cancer cells. Silica nanoparticles can carry the drug inside the pores and the particles are small

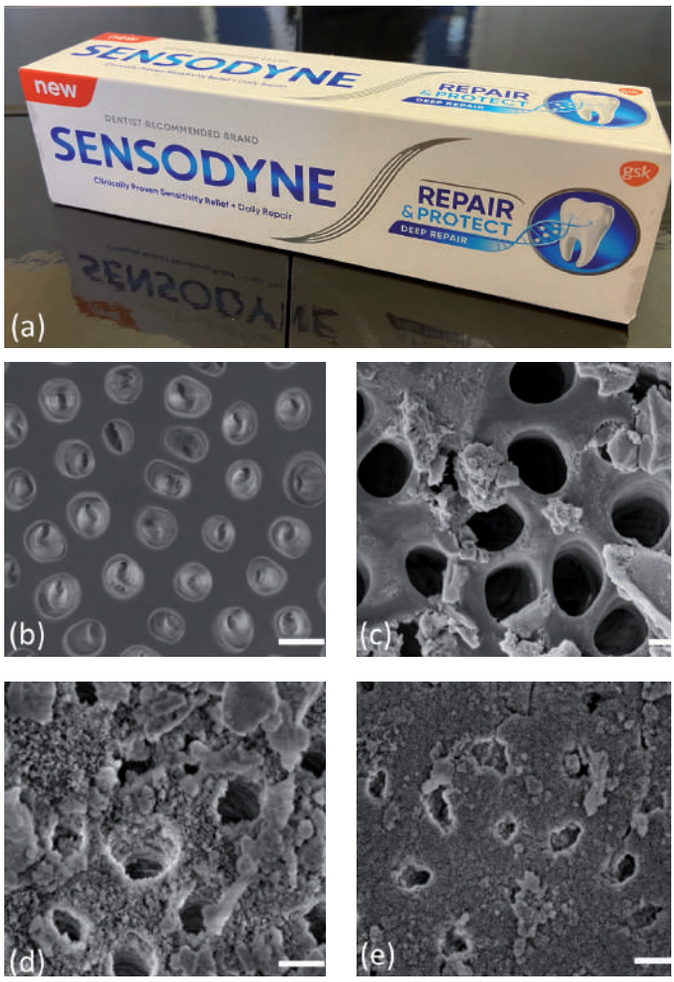

Figure 7. (a) Photograph of Sensodyne Repair and Protect toothpaste packaging, which contains NovaMin©, fine Bioglass particules; and (b-e) scanning electron microscopy images of tooth dentin [11] (bar=*1μm*): (b) untreated, (c) immediately after application of Bioglass in artificial saliva; (d) 24 h after Bioglass application; (e) 5 days after application.

Source: (a) Julian R. Jones; (b-e) modified from Earl et al. [11]

enough that they can be made to pass by cells without interacting with them so they only interact with the target cancer cells [15]. Then, the cancer cells take them in and when they are inside, they release their cargo. Once the efficacy of the targeting is perfected, these strategies are likely to revolutionise cancer therapy.

While targeted chemotherapy is challenging to deliver, bioactive glass nanoparticles could also deliver therapeutic ions, for example nanoparticles delivering zinc ions were found to kill breast cancer cells without killing healthy equivalent cells [16]. Therapeutic benefits may extend beyond cancer. A disease that affects most of us as we age is osteoporosis, where the cells that take our bone away are working faster than the cells laying down new bone, resulting in loss of bone density. Figure 11 shows bone marrow stem cells that have internalised bioactive glass nanospheres that are delivering strontium ions inside the cells. The combination of silica, calcium and strontium promoted stem cell differentiation down a bone pathway, whereas those that were given nanospheres without the strontium remained as stem cells [17]. The possibilities for bioactive glasses seem endless, but medical device companies have to prove every new device is safe and effective for each individual clinical application before they can be used.

SUMMARY

Biomedical glasses are key contributors to the Glass Age. Strong, corrosion resistant glasses enable storage and delivery of life saving medicines, optical glasses allow for key-hole surgery. Glass-ceramics and glass ionomer cements are used to repair our teeth after caries damage. Bioactive glasses, which are designed to dissolve and biodegrade in the human body, have improved the quality of life for millions of patients, regenerating bone and skin faster and in some cases healing tissue that would not heal by any other means. The number of healthcare applications of glass will likely continue to increase in the future.

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2. Hench, L. . *et al.* (1971): "Bonding mechanisms at the interface of ceramic prosthetic materials",

Figure 8. Application of a dental inlay made from a leucite glass-ceramic: (a) initial amalgam filling, (b) preparation of the molar for inlay restoration, (c) final state after adhesive luting and polishing of the inlay.

Source: Ritzberger et.al. [13] (CC BY3.0)

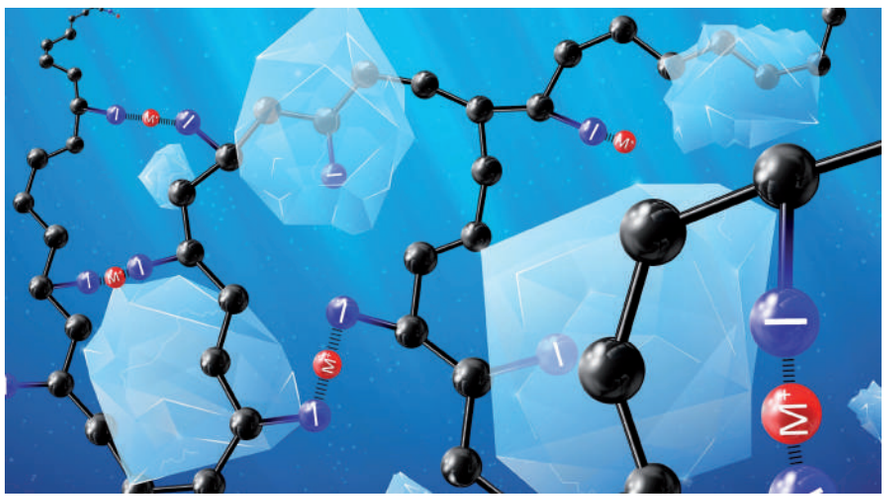

Figure 9. Shematic of the atomic structure of a set glass lonomer cement: ionic cross-linking between functional groups (e.g. carboxylate groups; blue) attached to polymer chains (black) and metal cations (red).

Source: P. Wiemuth, University of Jena

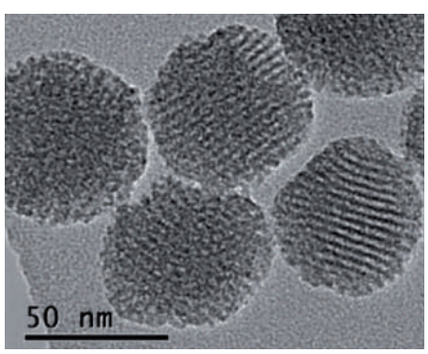

Figure 10. Transmission electron microscope image of nanoporous silica nanospheres that can be loaded with chemotherapy drugs and functionalised with molecules that can target specific cancer cell.

Source: Modified from Chen et al. (16)

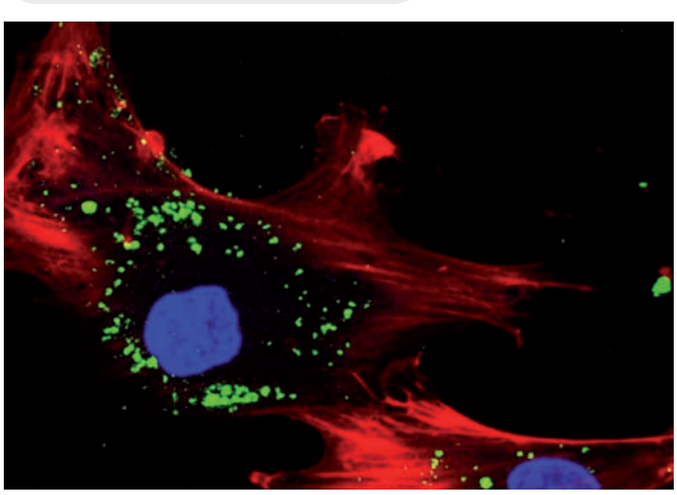

Figure 11. Confocal fluorescence images of human bone marrow derived stem cells following 24 h exposure to 80 nm bioactive glass spherical nanoparticles containing 10 mol% strontium (red: nanoparticles), Scale bar is 75 *μm*.

Source: Modified from Naruphontjirakul et al.[17]

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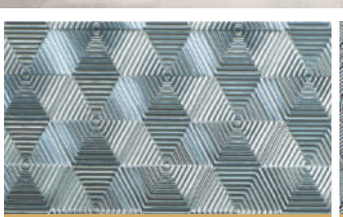
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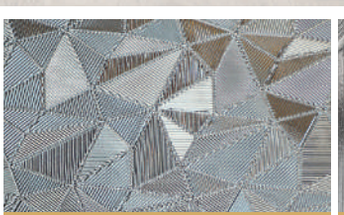
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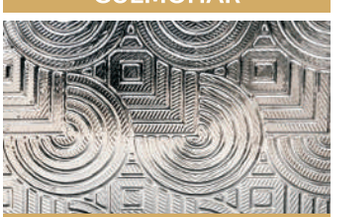
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Glass History and the Arrival of the Glass Age

Prof. John C. Mauro

Prof. John M. Parker

This chapter explores the history of glass making and its role in advancing civilization throughout recorded history, highlighting the enormous contribution glass has made to human society over millennia and how it still plays a vital role, perhaps more than ever. It builds on the arguments in Chapter 1 (Creating a United Nations International Year of Glass) that we now live in the 'Glass Age' and many themes introduced here are expanded in later chapters. Typically, glass is a material we look through, so its importance is often unseen and unnoticed; this book aims to redress that imbalance.

GLASS COMPOSITIONS

Using the term 'glass' is a little like calling a steel girder, a copper wire, an aluminium can or a brass doorknob simply 'metal'. Glassy products have many compositions and fabrication routes according to their end use. Mostly, glasses are made by melting appropriate raw materials, then shaping and cooling back to room temperature without crystallization. The composition and chemistry define what wavelengths of light are transmitted; the melting process is designed to create a bubble- and crystal-free homogeneous product with no internal boundaries where a refractive index step would scatter light and destroy transparency. Consider for a moment how effectively finely ground icing sugar hides the imperfections of the cake underneath because of those boundaries between the many small but individually transparent sugar grains. Most common glasses have silica (sand) as a significant component and this chapter begins with silica-based products. They readily form glasses because their melts are viscous, and their interlinked atomic components cannot easily re-arrange into regular crystal structures. Their high viscosity also makes shaping into containers, sheets, fibers and tubes possible (see Chapter 'Glass beyond Glass' in the later issues).

GLASS MAKING, ITS ORIGINS

Society has used glassy materials for millennia. Initially these were naturally occurring, particularly obsidian, a rapidly cooled volcanic lava which had failed to crystallize. It was sculpted into arrowheads which could be used to catch food and axe heads which could shape wood. Smaller pieces became jewellery and larger pieces were even polished to make mirrors.

As human society developed and learned how to control fire, the skills of the metallurgist were developed giving the Bronze Age. Somewhere someone discovered that the same heat sources could melt sand if a flux was present. The early fluxes used particularly by the more advanced societies in the Middle East were white salts rich in sodium and potassium, although they didn't know that! Such materials are found on the shores of dried-up lakes (Wadis) in the Nile basin for example and in the ashes from burning plants. These were actively traded because of their value in medicine, as detergents and in dyeing. The metallurgists and glass makers would also no doubt have shared their skills in furnace technology.

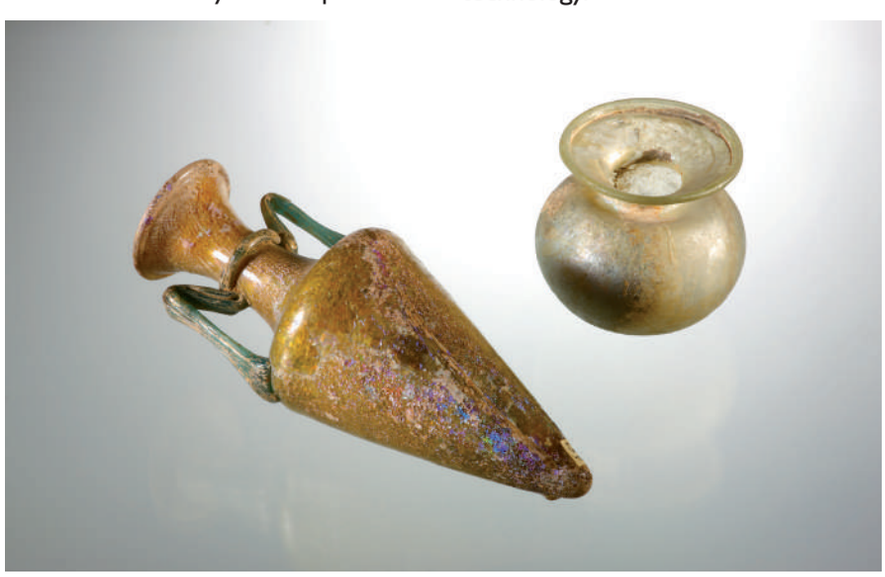

Figure 1. Egyptian container.

Source: Turner Meseum of Glass (Simon Bruntnell)

Over the centuries, the raw materials used evolved. Purification/ beneficiation processes improved, compositions changed to introduce color, increase chemical durability, and create products with optimized characteristics over a wider range of properties. Archaeologists now use compositional information (elements and their isotopes) to uncover ancient trade routes, to identify the sites of glass works, the source of their raw materials, and the distribution of the finished products.

SHAPING GLASS HOLLOWWARE

History is full of milestones, turning points where advances in glass stimulated change: Over 3000 years ago, exquisite Egyptian glass bottles were made for expensive perfumes by trailing molten glass around a solid core; just before BC became AD, glass-blowing was developed, probably in regions that now lie in Syria, and quickly spread throughout the Roman world. Before long, this approach was creating intricate and collectable objects. Surface decoration could be added perhaps using a rotating wheel and abrasive on a foot-operated lathe. 4th century Romans at the pinnacle of their glass-making skills probably used this approach to make the posts which supported the complex coloured glass cages around luxurious '*diatreta*' vases. Appropriately, ancient writers equated the glassblower's breath with the wisdom of the philosopher Seneca.

Dating the different steps in the development of production processes is often by association. For example, glass vessels were used as burial urns and contained items needed in the after-life such as dated coins or personal memorabilia. It is now 100 years since the opening of King Tutankhamun's Tomb in Egypt. He reigned for a short period around 1330 BC, and glass items were discovered in his tomb. A millennium ago, elaborate goblets celebrated dynasties, while decorated mosque lamps spoke of a patron's generosity.

From the time of discovery until the 19th century, glass blown containers went through many changes. Color, for example, was introduced for artistic effect, to identify ownership and warn of dangerous content (blue medicine bottles). Another key change has been the method of sealing. Hand-blown glass has to be attached to a 'blowing iron' until almost the end of the shaping process; the neck is formed as a final step and requires re-heating. Creating an accurately and repeatably shaped 'finish' is difficult and impinges on the quality of the final seal; a poor seal means diminished 'shelf life'. Of course, historically the introduction of corks went part way to solving this. But it was not until machine forming came along towards the end of the 19th century and beginning of the 20th century that screw top seals could be used. Such considerations were vital in the development of glass containers for perishable foods. Indeed, the screw top 'Kilner' jar underpinned the preservation over winter of fruit in jams and in syrups at a time when sugar taxes were being abolished in the UK, making the process economic.

The modern glass container industry has machines creating hundreds of bottles a minute from a single furnace, with an accurately profiled shape, excellent resistance to attack and 100% recyclable. It remains a major force in the marketplace with global sales near US$ 53 billion, split between beverages, cosmetics, food, pharmaceuticals and others. Beverage packaging is dominant and wine bottles are two thirds of this total. Market expansion is driven by exports and continued demand for packaging made of glass.

A vital attribute of glass is the capacity for designing unique profiles identifying a brand. Other factors are transparency and chemical inertness, ensuring long-term preservation of taste and visual impact. Weight is a disadvantage, but the industry is working hard on light-weighting. It is also investing in new products, increased energy efficiency and improvements in the environmental performance of glass products throughout their lifecycle (To be

Figure 2. Glass blower at work, shaping a blown sphere before 'cracking off'.
Source: Pixabay

Figure 3. A glass container with a seller's seal for identification (17th/18th Century),
Source: Turner Museum of glass

covered in detail in the Chapter 'Sustainable Glass Production with Carbon Reduction'). Future success will require companies to adopt 'smart technologies' that improve consumer experience and maintain product integrity across the supply chain.

Such trends are universal. For example, Chinese colleagues report that glass is becoming the packaging material of choice for their government. The Chinese glass container manufacturing industry has experienced continuous growth in recent years. Aggregate operating revenue in glass-packaging container manufacturing industry was 61 billion RMB in 2019. As a green product, the glass container surely offers extensive development possibilities.

Of particular significance are the chemically resistant glass containers for pharmaceutical use (vials, ampoules, syringes, cartridges) obtained by converting neutral borosilicate glass tubes (300,000 tons in 2019 growing rapidly at 10-20% p.a.). This has been driven recently by the world's quest to deliver a vaccine to fight the COVID-19 pandemic.

Glass is still a unique commodity in today's materials market. Used every day by billions of people, glass containers present countless advantages for both consumers and the environment. Being 100% recyclable, glass can be melted and reformed an infinite number of times (This will be covered in detail in the later issues, under the Chapter 'Sustainable Glass in a Circular Economy').

GLASS FOR WINDOWS

Early glass makers were unable to produce a flat glass product suitable for glazing and the first evidence for its availability is from early Roman times. Although glazing allows light to enter while keeping bad weather at bay, it is a weak point under attack and so needs a stable society. Until the end of the Middle-ages glazing was a luxury and panes were small. By this period two early methods used by Roman Glass Makers were becoming popular —crown and cylinder glass. Both began by blowing, a process that, without intervention, tends to create spheres. In crown glass a hole is created in the 'bubble' which is then spun rapidly so that it opens out into a disc with characteristic circular markings. In cylinder glass a large sphere is allowed to extend vertically under the influence of gravity to create the required shape. Once made, the cylinder can be opened into a sheet by making an extended crack along one side and opening the cylinder up inside a hot furnace using long wooden rakes. Such methods were incapable of creating distortion free unblemished flat glass surfaces of large size. Hence the use of lozenge shaped pieces no bigger than the palm of a hand in earlier architecture and small rectangles with elegant fine glazing bars in Georgian times.

At the turn of the 19th/20th centuries, just as automatic bottle production was beginning, so were machine methods for flat glass manufacture introduced. One example was the Fourcault method where a long refractory boat with a slot along the bottom was pressed into the hot glass surface and as the melt welled up through the slot it was taken and drawn vertically by edge gripping rollers. This gave much larger sheets.

Some applications, though, required better quality surfaces than any of these methods could achieve, for example, carriage windows and

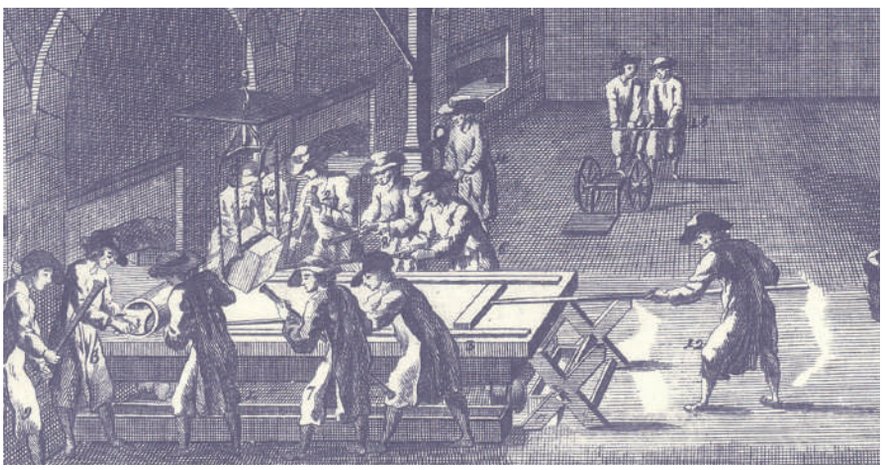

Figure 4. Early production of large glass sheets.

Source: Diderot and D' Alambert Encylopedia

mirrors. Such products required the grinding and polishing of cast sheets. This was labor intensive, so the products were expensive and only available to the rich or very rich, particularly in earlier centuries. Now though the mass production of mirrors, each reflecting a clearer personal image, has stimulated the international cosmetics trade.

A major breakthrough came with the creation of the Float Glass process patented in 1952, 70 years ago. This creates one free surface and an undersurface floating in molten tin. Both are effectively distortion free. Float methods were able to give glass thicknesses from 25 mm down to one millimeter. Of course, development never ceases; the screens of mobile phones are just 0.5 mm thick and prompted the invention of yet another sheet production technology. A millennium ago, glass windows flooded our sacred buildings with light, and now we view the world and ourselves through glass —our phone screens, our mirrors and our architectural skyline.

In transport, glazing allows unimpaired vision and contributes to safety and security, as well as style. Airplane cockpit windshields are chemically strengthened. Innovative designs offer thermal comfort; improve fuel efficiency by light-weighting; and integrate display features.

Two-thirds of flat glass production is used in architecture, while most of the rest is for the transport industry. These applications often involve secondary processing, for example cutting, grinding and polishing. Surface treatments add considerable value by conferring characteristics such as self-cleaning, chemical resistance, light and heat transmission control for thermally efficient glazing, electrical behavior, and increased mechanical strength (To be covered in detail in

Figure 5. Stained glass window from a church.

Source: Pixabay

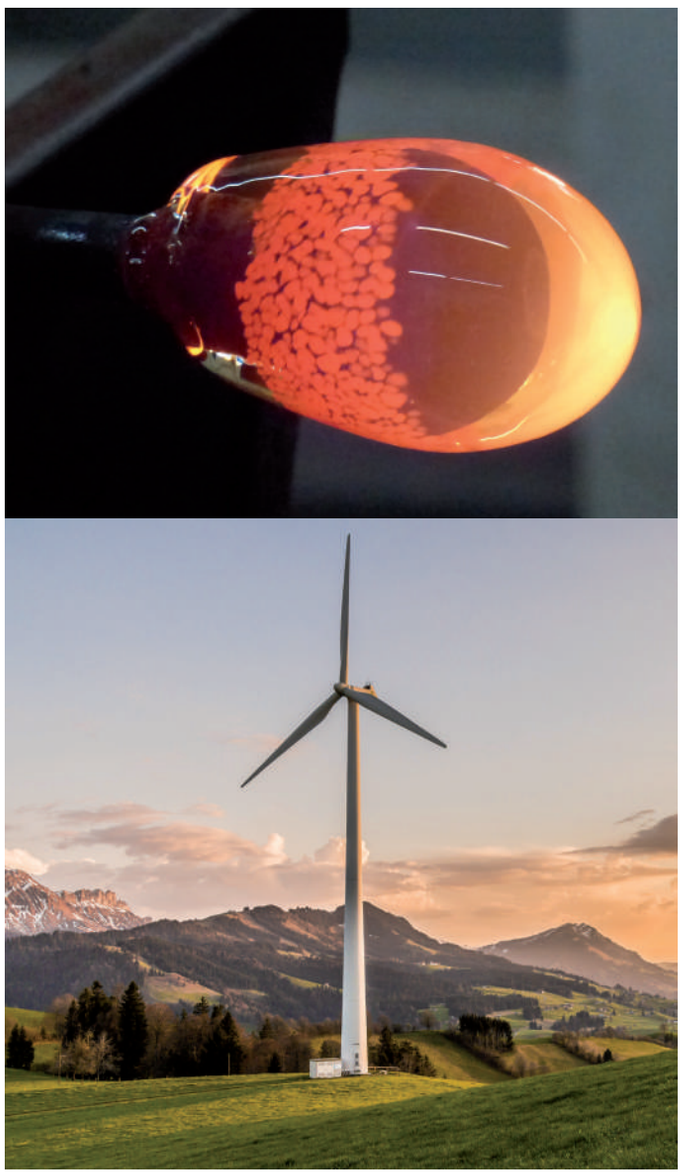

Figure 6. The blades of wind turbines are reinforced plastics using glass fibers with a high Young's modulus.

Source: Pexels

the Chapter 'Affordable and Clean Energy Provided by Glass'; and in the Chapter 'Reflections on Reflection: Glass in Architecture').

Plant construction is capital intensive, needs appropriate expertise and has traditionally been limited to a few major players, but markets now influence the location of new facilities. After the 2008 recession, fewer than 200 factories and 400 production lines remained, but then entry barriers fell and expansion began in emerging markets such as the BRIC countries (Brazil, Russia, India and China). In the last 15 years, Russia has quadrupled its production plants to 8 while India has almost doubled to 7. Other developing markets are Asia, Africa, the Middle East and South America. Algeria, Kyrgyzstan, Malaysia, Syria, Ukraine and Vietnam have all recently built furnaces.

Since 2015, China's flat glass production capacity has grown particularly rapidly, mirroring its economic development; in 2019, capacity exceeded 60% of the global total, causing a significant surplus. China's environmental protection and capacity replacement policies were subsequently tightened, restricting new production capacity. This required rapid industrial structural adjustment and diversification to higher-quality products.

Now, China's building and transportation industries are growing rapidly again and fundamentally changing to energy-saving, safe, and lightweight products. Green building is adding 1.6-2 billion m^2 annually to 60 billion m^2 existing floor area, 90% of which is in high-energy-consumption buildings that urgently need transformation. So the processing of energy-saving insulating glass, tempered vacuum glass, electrochromic glass, flameproof glass and other products will expand rapidly.

China is now the largest car producer and consumer worldwide. In 2019, it manufactured almost 26 million vehicles, more than 40% of the global total. The operating mileage of high-speed railways is almost 35,000 km, 2/3 of the world's total. Such developments offer new opportunities for glass. China is also the largest producer of Ultra Clear Photovoltaic flat glass, with 3 million tons in 2016, over 70% of global market share.

GLASS FIBERS

Glass fibers exist in nature and are called Pele's hair. They arise when strong winds catch a hot lava flow and create thin glass strands. Glass fibers have been made commercially by pulling thin strands singly from heated glass rods and indeed have been woven into cloth. But glass fiber made as multifiber bundles (rovings) is valuable in construction, particularly for reinforced plastics; the global market currently is approaching US$ 10 billion p.a. A key application is pipe work for transmission of water and other strategic liquids; storage tanks and baths for water are also important. Such applications are particularly significant in the Middle East where atmospheric conditions are extreme, and soils often saline; both cause rapid corrosion of alternative materials. China again is a dominant player with a 30% market share; the Middle East has key manufacturers and the USA market for these products is expanding too.

In 2019 China's total glass fiber output was 5.27 million tons, up 13% year on year, with a product yield of 4.5 million tons. With increased globalization of glass fiber products, up to 20% of Chinese glass fiber and relevant products are being exported.

In the future glass fiber products are expected to displace steel, aluminum, wood, PVC, and other traditional materials. Building, transportation and electronics industries offer enormous potential. According to the Trend Forecast and Opportunity Analysis of Global Glass Fiber Composite Market Report, the overall global glass fiber composite consumption will grow at 8.5% p.a., with the market size in 2022 expected to be up to 108 billion RMB. In the next five years five key fields — auto firmware, building decoration, safety protection, aerospace and liquid filtration— will take up 80% of glass fiber composites.

The glass fiber market has many other sectors based on novel glasses (chemical resistance, elastic moduli) and different fiber formats. A vital market is wind turbine blades, a low carbon source of almost 20% of the world's electrical energy; another is insulation (To be covered in the later issues under the Chapter 'Affordable and Clean Energy Provided by Glass'). Optical fibers are the subject of Chapter 'Glass in Information and Communication Technologies (ICT) which will be covered in the later issues.

GLASSES AND LIGHT

Long ago tailors realized that a glass globe filled with water could focus the light of a candle to aid stitching after the sun had set. More recently glass light bulbs provided an impervious envelope for incandescent lamps, preventing filament oxidation, and a vacuum for electrons to flow in fluorescent lamps; these developments have encouraged reading as well as extending the working day and earning potential of poorer families. For 200 years, glass Fresnel Lenses in coastal lighthouses have beamed the light from huge lamps to distant vessels, warning of danger using a lightweight structure.

Monks realized that eyeglasses eased the strain of creating illuminated manuscripts and 2022 is the 670th anniversary of the first depiction of eyeglasses in a painting. Many famous scientists such as Faraday studied glass lenses and their focusing power and Galileo's telescope opened our eyes to the wonders of the cosmos; the latest developments in telescopes with glass lenses in space are allowing scientists to see back to the very beginnings of the universe. Microscopes have let us study cells and microbes and so understand diseases. Behind such developments since the 19th century have been major research studies on the relationship between glass properties and composition and these have led to the capacity to design compositions to fit a particular property profile. Important players in glass optical property development have been the Germans and it is appropriate that 2022 celebrates the centenary of the German Glass Society.

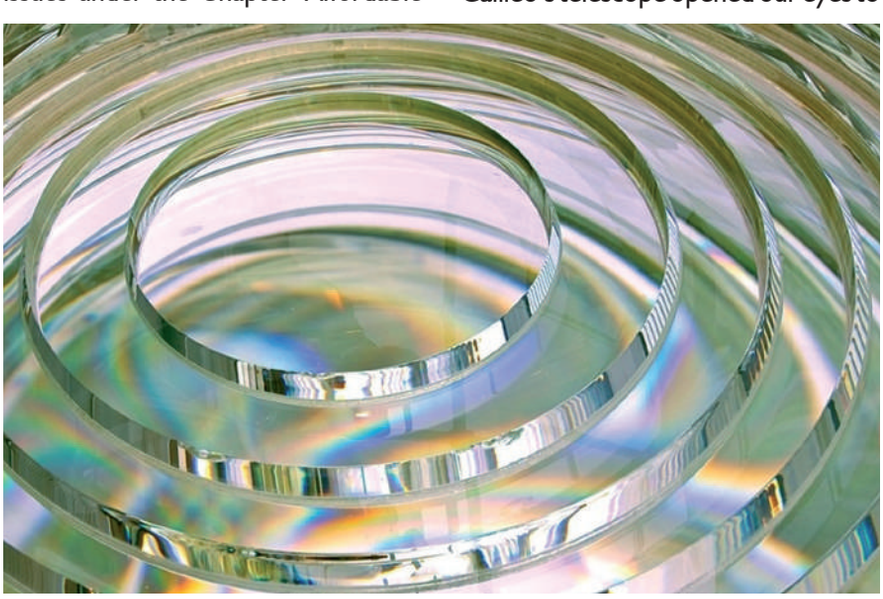

Figure 7. 3D printed optical glass artefact.

Source: iStock catalogue

GLASSES AND MEASUREMENT

Glass being transparent, hard and inert has allowed the creation of many different instruments. Important examples are the thermometer and barometer, which in turn initiated an understanding of weather forecasting and even chemical thermodynamics.

GLASSES, WATER AND ENERGY

In the last century, billions of people have experienced an unprecedented rise in living standards, but many still live with little access to clean water. Sufficient fresh water exists but damaging economics or poor infrastructure cause millions to die annually from diseases linked to inadequate supplies, sanitation, and hygiene. Similar issues impact adversely on food security, life choices and educational opportunities.

Industrial discharges, excess agrochemicals and domestic waste landfill contaminate surface and groundwater. Glass can mimic current water treatment processes. Porous foam glass or phase separated glass filters can aid sanitization (and purify air, another global issue). Sunlight on coated glass immersed in solutions

of organic pollutants can oxidize many into non-toxic products and likewise restore drinking water. Most cost-effective is a combination of porous glass filters with titania-coated glass.

Energy with water epitomize the opportunities and challenges the world faces. Universal access to energy is also crucial to build more sustainable and inclusive communities and in turn entails more efficient generation, renewable energy sources and ways to store it. This theme will be taken up in the Chapter, 'Affordable and Clean Energy Provided by Glass'.

GLASSES AND MEDICINE

Scientific endeavor has also relied heavily on glass. The alchemists of the Middle Ages made complex glass equipment to pursue their dreams of chemical transformation and incidentally created a tool-box for apothecaries (Figure 8). In the last few decades glasses have themselves become the biocompatible and bioactive products that have been universally life changing for patients; much more can be found in the Chapter 'Glass for Healthcare'.

GLASSES FOR COMMUNICATIONS AND ELECTRONICS

The use of glass envelopes for lighting revolutionized our capacity for making lamps and fluorescent tubes during the late 19th century. Similar technology led to a revolution in electronics. In the UK many disabled soldiers were trained in lamp working at Sheffield University and the electronics industry between WW1 and WW2 grew largely based on such technology, only subsequently to move to solid state electronics. The key property of glass was that it could hold a high vacuum over many years but also that a leak tight electric connection to the outside could be achieved.

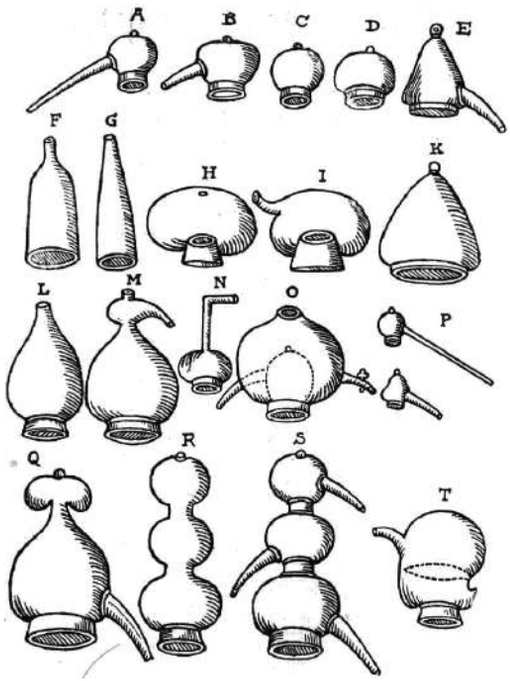

Figure 8. A variety of glass objects made for the Alchemists of an earlier age.
Source: Andreas Libavius

This required an understanding of the thermal expansion behavior of both metal and glass.

In the middle of the 20th century, as the load on the hard-wired electrical telephone increased, scientists begin to question the possibility of encoding electrical signals into a light beam and using the transparency of glass for transmission over long distances. This led to widespread use of glass products in the communications and electronics industries as will be described in the Chapter 'Glass in Information and Communication Technologies (ICT) and Photonics'.

GLASSES AND EDUCATION

Education is central to the progress of our society and links closely to the storage of knowledge. Both are at the heart of the International Commission on Glass (ICG) and will be considered under the Chapter 'Education! Education! Education!'.

SHAPING THE WORLD THROUGH GLASS ARTISTS/ MUSEUMS

The Island of Murano, Italy is a go-to places for glass art, and its economy is heavily reliant on artefacts whose price can range from a few to many thousand dollars. But rich and developing countries alike now and throughout history have had businesses making and selling glass souvenirs of local tourist attractions and producing beautiful glass objects such as beads, necklaces, earrings, even cuff links as well as glass sculptures and decorated windows for churches, gardens and public places. Indeed, international

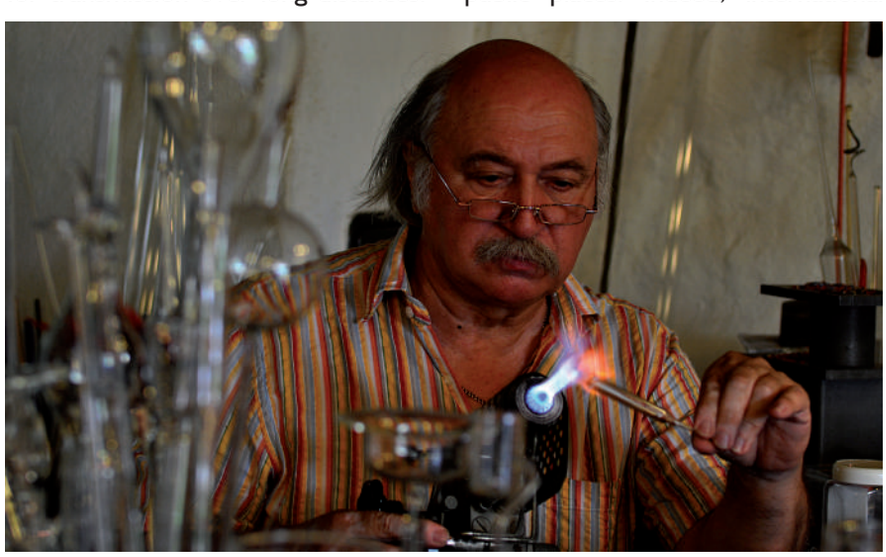

Figure 9. Lampworking, used both by the scientific and arts communities for secondary processing.
Source: Pixabay

trade in glass beads was already widespread several millennia ago. The equipment needed can be less sophisticated than for other areas of glass making and may be accessible to the amateur community. For example, sea glasses, unlike plastic waste, are prized by beachcombers; created by the incessant tumbling action of waves on discarded glass fragments, their rounded shapes with translucent delicate colors are much appreciated for jewellry. The Studio Glass movement, whose 60th anniversary is in 2022, is but one vibrant area within this picture. These subjects will be expanded under the Chapters 'Social Cultural and Environmental Sustainability within the International Art Glass Movement'; and 'Museums and Society'.

SUMMARY

With its unparalleled versatility and technical capabilities, glass has fostered numerous cultural and scientific advancements. Its history is shared with the evolution of humankind. Its future will contribute to the challenges of a sustainable and fairer society. Let's drink a glass to that!

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On the Spot… Vitaliano Torno

President of O-I's Business Operations and O-I Europe, Vitaliano Torno was recently re-elected President of FEVE, the EU container glass federation. Leading an organisation that represents 60 corporate members belonging to groups with manufacturing plants located across 23 European States, Mr Torno outlined the federation's objectives to *Glass Worldwide,* preferred AIGMF international journal in association with *Kanch*.

GW: What does it mean to you personally to be elected as FEVE President 2021–2023 following your initial spell in 2015–2017?
I am honoured that I get a second run at the Presidency during a crucial moment in glass packaging. I will be working very closely with FEVE members and the national associations, we have a great opportunity to capitalise on the societal trends towards health, well-being and sustainability – all of which strongly favour glass. We have the privilege to work with a material that has unique inherent sustainability benefits: it is endlessly recyclable and ensures quality and safety no matter how many times it is recycled. Glass is virtually inert and preserves the taste of the foods and beverages it protects. It adds prestige and the premium look and feel that supports our customers in nurturing their brands. And we are working towards glass as a climate-neutral and fully circular packaging.

GW: Following unprecedented conditions during the pandemic, how is the container glass industry currently performing in general in the European countries covered by FEVE members?
The industry is doing very well despite the pandemic. For many industries, 2020 was really challenging but since the food, beverage and pharma sectors are essential, the glass container industry supporting these sectors was classified as essential by extension. Our figures for 2020 are just out and sales were almost flat in units which is quite remarkable considering the environment. Our food and beverage container sales still remain above 2018 levels. In the flaçonnage sector, the Covid-19 pandemic had a diametrical effect on the different sectors. Pharmaceuticals increased by more than 4% in volumes (thanks to the glass vials for Covid vaccines) while cosmetics and perfumery fell strongly by 18% due largely to shut downs in the traditional retail channels for these products.

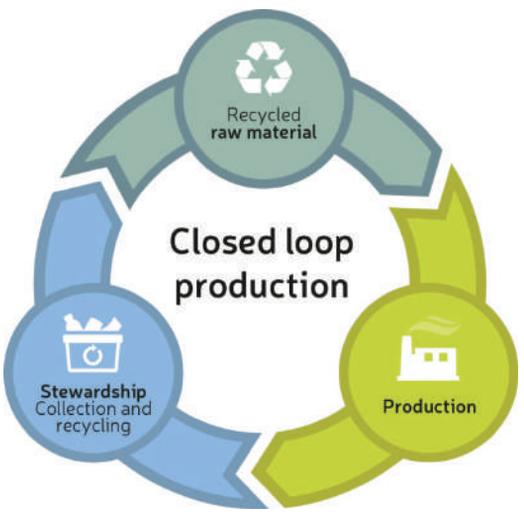
GW: How is the Furnace for the Future (F4F) initiative progressing?
First off, it is important to note that this is a project by a consortium of glass manufacturers; it is not a FEVE project. The consortium has applied for an EU grant under the Innovation Fund of the Emission Trading Directive; 311 projects were in competition; 70 were selected for the second phase of the selection procedure, and F4F is among them. The full application was submitted in June, and the Commission will take a final decision by November this year. Seven to 10 projects are expected to be selected at the end.

If the project is selected, the consortium will create a new legal entity to oversee the project (we work with 19 glass companies). Then the furnace will be built in 2022 and commercial bottles are expected to be produced by 2023.

The furnace has been conceived to demonstrate that melting glass with 80% electricity is feasible. A second generation may then go up to 100%. If successful, this concept then could be one of several options that glass container manufacturers have to reduce their carbon footprint.

Along the way, the consortium will work with furnace suppliers on further technology developments.

Last but not least, scalability also depends on sourcing enough renewable electricity at an affordable price. This is why we call on authorities to speed up the development of green power generation, but also to develop the necessary infrastructure to transport and deliver it where it is the most needed.



A multi-stakeholder partnership that brings together the public and private players involved in the glass collection and recycling circular economy, Close the Glass Loop aims to increase the recycled content used in glass production.

GW: Does FEVE have a policy for supporting other carbon reduction led initiatives such as the planned glass manufacturing pilot facility by Glass Futures or any of the collaborative hydrogen focused research programmes from other industry bodies?
F4F is a sectorial project grouping 19 different container glass companies, working together with FEVE on this hybrid technology. However, our members (individually or as part of other consortia) are also developing their own solutions and technologies. We are not directly involved as FEVE, but we follow these developments closely. The huge energy transition in front of us requires a multi-faceted ▸

Created by FEVE in 2008, the Friends of Glass awareness campaign has been extremely successful in raising support for glass packaging.

Designed to highlight the environmental and health benefits of choosing products packaged in glass, the Glass Hallmark is being promoted to consumers, brands and glass industries.

FEVE
The European Container Glass Federation

The EU container glass federation, FEVE represents 60 corporate members belonging to approximately 20 independent corporate groups with manufacturing plants located across 23 European States.

Originally published in Glass Worldwide, preferred international journal of AIGMF

glass WORLDWIDE

answer. We need to explore the potential of electrification, but also hydrogen, biomass or other measures bringing us in the direction of carbon-neutrality. The situation and the framework can be very different from one country to another. It is therefore safer to have several solutions in the pocket to be able to adapt to each scenario and geographic situation.

GW: Since launching the 'Close the Glass Loop' action platform last year, what are the current priorities of this multi-stakeholder circular economy partnership?
On 30 June, we celebrated the one-year anniversary of the Close the Glass Loop platform (www.closetheglassloop.eu), a multi-stakeholder partnership that brings together the public and private players involved in the glass collection & recycling circular economy – municipalities, brands, producers, recyclers and extended producer responsibility schemes. Together we want to reach an EU average of 90% 'collection for recycling' rate by 2030 (up from the current 76%) and to increase the quality of collected glass so that more recycled content can be used in glass production.

The past year has been like no other but despite the unique context, our European and national partners have demonstrated a very high level of commitment.

One of the key goals of Close the Glass Loop is to provide a forum to help resolve common problems and share best practices. To give you an example, hotels, cafés and restaurants (the HORECA sector) have been a major focus of our activities as it is a distribution channel where many products packed in glass are consumed and disposed. In order to increase the overall quantities and quality of glass collected, it is crucial to address the specific challenges of HORECA operators.

GW: What is FEVE's approach to Deposit Return Schemes?
As I explained, our aim is to have people recycling more and better. We do not believe a Deposit Return Scheme is the right collection system for glass recycling. Data and evidence across Europe shows that including glass in a DRS is suboptimal in terms of both, quantity and quality of recycled glass. Instead, it could have a range of negative consequences and put existing and highly successful collection and recycling systems at risk.

The glass recycling statistics clearly show that the highest recycling rates for glass can be achieved when there is a separate single glass collection system, consistent kerbside and bottle bank collections, and effective public communication initiatives, under a system of Extended Producer Responsibility. The solution is to improve Extended Producer Responsibility schemes and municipal waste management systems that make collection simple for the consumer and optimal for the recycling value chain, not a new parallel DRS.

The situation is different when it comes to refillable glass. Here, the DRS is the best mechanism to get back reusable glass for refill. But the same system should not be used for recycling where bulk collection of all glass is paramount.

GW: What was the motivation for FEVE launching the Glass Hallmark recently (reported in *Glass Worldwide* January/February 2021, p.100) and how receptive have brands been?
All over the world brands are working with supply chains to improve the environmental and social footprint of products and services. When they choose recyclable glass they reduce waste, CO_2 and energy consumption and they avoid migration of chemicals into their products. We want to capture this in one symbol that brands can put on their bottles or labels to convey these messages to consumers. That's why we've created the Glass Hallmark. Brands welcome such symbols. The industry is putting them on standard bottles and convincing brands one by one to do a pilot test. We hope to have the first brands to do this very soon. This will also be accompanied by a marketing campaign in 2022 to consumers which we are very excited to work on right now.

GW: What are the next steps for the Glass Hallmark?
We are working on a marketing campaign to promote the symbol to consumers, brands and glass industries inside and outside Europe. Some people have expressed an interest in the universal symbol of glass and what it stands for so we will be following up on all these leads. 2022 is the UN International Year of Glass so watch out for the symbol to feature strongly!

GW: Does the well-established Friends of Glass campaign continue to have a key role to play?
Yes indeed, this is an extremely successful campaign that has been running for 13 years now and ensured that glass packaging is very popular, supported and followed by literally millions. The figures reached are astounding and a credit to the industry, FEVE and the national associations.

GW: Are the multitude of proactive programmes and initiatives from FEVE clear evidence of the federation's integral role in ensuring Europe remains a cost effective manufacturing hub for container glass production?
We believe FEVE as convenor of the industry has provided an excellent platform to bring the industry leaders together. Of course any one company needs to operate alone and compete with [others] but when it comes to the common good like sustainability, it's really no good if we don't also act as a sector. We have to evolve and adapt together to ensure that glass packaging continues to be the most popular packaging in the world. And that it also continues as the most sustainable. That will not happen on its own. So FEVE is a great vehicle along with the national associations to develop and test out ideas together but also to address problems collectively. The Close the Glass Loop platform is vital to increase collection of our main raw material. This is a good example where companies working together can achieve more than working alone.

GW: *Glass Worldwide* is FEVE's longstanding preferred journal. How does this co-operation benefit proceedings?
We appreciate the long-standing collaboration; the magazine is very attentive to ensuring our industry has a channel to communicate to many glass stakeholders. It enables us to highlight what we do but also to ask for help and learn from the glass community that *Glass Worldwide* brings together. ●

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Green Hydrogen Economy–Options before the Indian Glass Manufacturing Industry

Abstract

This article focuses on how the hydrogen gas is blended with natural gas, which is subsequently used in glass industry furnace for melting and refining process and also provide a brief introduction on energy transition, energy intensive industries especially glass industry, role and mandates involved in using green hydrogen, NTPC plans on green hydrogen, blending setup, Green House Gases (GHG) emissions at glass city of India (Firozabad) etc., critics to know the truth.

NEED OF ENERGY TRANSITION

An emission of Green Houses Gases (GHGs) triggers a global warming which causes a climate change and poses series of threat to an earth atmosphere. To respond on this, immediate action needs to be taken on climate change mitigation and adaptation. As world recognises the need of climate change mitigation in many forums like Kyoto Protocol, Paris Agreement etc., and climate change adaptation through an accelerating the transition of energy. An energy transition is a transformation of an energy sector of its energy production and consumption from a fossil-based energy sources to renewable energy sources. Energy transition also aims to reduce energy-related greenhouse gas emissions through various forms of decarbonization.

Transforming the fossil fuel-based energy system to one that is sustainable and decarbonized is one of the greatest challenges. It also represents one of the greatest opportunities to make energy supplies more available and affordable than ever before.

ENERGY TRANSITION IS ALREADY UNDERWAY

At a global level, energy transition has already started and shows signs of acceleration. Global energy production and consumption is shifting from coal and oil dominated to the renewable and natural gas dominated. Global energy consumption is growing at much faster rate on renewable and slower rate on natural gas.

Understanding the importance of global warming on climate change, India fostered in creating energy transition and to provide clean energy technologies by taking various actions and its implementation.

India set its aims to reach net zero emissions by 2070 and to meet 50% of its energy requirements from renewable energy sources by 2030. India's ambitious targets for 2030, includes installing 500 gigawatts of renewable energy capacity, reducing the emissions intensity of its economy by 45%, and reducing a billion tonnes of CO^2.

ENERGY INTENSIVE INDUSTRIES

Energy-intensive industries are important sectors for all the countries and its economies. Nearly two-thirds of that GHGs emissions were related to oil, gas and manufacturing industries, emitted either through the industry's extraction, processing, transportation and refining activities or, more significantly, at the point of consumption.

Energy-intensive industries are operating in a rapidly changing climate policy context and commitment made, they are striving on a number of factors – the capacity to develop and deliver innovative, high-quality products that meet the needs of the customers reliably, on time, and at affordable cost.

GLASS INDUSTRY

The glass industry in India is quite old and well established. It represents one of the largest markets and the manufacturing capacity for glass products in Asian region. The glass industry is highly energy intensive and energy consumption is a major cost driver. Energy costs include power consumption and running cost of furnaces. The average energy cost as a percentage of manufacturing cost is about 40 percent.

Major energy consuming and energy intensive portion of the glass-making process, regardless of product type, is melting and refining. This portion of glass manufacturing accounts for 60–70 percent of the total energy use in the glass industry.

At this present condition, to combat the climate change and adapt for the energy transition, glass industry needs to transform the energy consumption portfolio to a completely carbon free emission methods or low carbon free emission methods. For this, glass industry needs a complete shift

in melting and refining process with electric furnace or using green energy fuel and this shift requires replacement of furnace with additional investment. There are also concerns related to future economic viability of using electricity and the CAPEX associated with it. So those factors pose a major challenge in glass industry for its implementation.

In India and at a global level, primary source of energy consumption in most of the glass making furnace has been changed and operating with natural gas firing in their furnace. There is an urgent need for low carbon energy, which can be implemented fast and with minimal impact on established processes. So, it is very much essential to find a solution on a cost-effective way and to adapt for the energy transition. Here is where the blending of hydrogen gas with natural gas at a particular composition level will help us for this transition by reducing the GHGs emissions without change in the infrastructure.

GREEN HYDROGEN

Hydrogen plays a vital role and it is part of a comprehensive energy portfolio that can enable energy security and resiliency and provide economic value and environmental benefits for diverse applications across multiple sectors. Hydrogen has unique properties such as high gravimetric energy density (MJ/kg) and versatile energy carrier where it can be stored and converted in multiple forms.

Hydrogen is a key energy vector on the pathways to achieving global climate goals. In the IEA's net-zero emissions (NZE) by 2050 scenario, global hydrogen use expands to 200MT in 2030 and to 530MT in 2050.

"HYDROGEN IS GETTING REAL' BOTH AT NATIONAL AND GLOBAL LEVEL"

Green hydrogen is envisaged to contribute to India's climate actions in a significant way. The Hon. Prime Minister of India announced the National Hydrogen Mission and sets a target of energy independence for India before 2047. This mission aims to develop India into a global hub for manufacturing of hydrogen and fuel cell technologies across the value chain. Government's intent to scale up annual green hydrogen production in India to 5MT by 2030.

In the race to decarbonisation, the low cost of electricity from renewable sources, encouraging technology readiness levels for production cost of hydrogen gas will reduce around 80 percent according to IRENA and is expected to be a low-cost hydrogen market going forward.

NTPC STEPS UP PLANS IN GREEN HYDROGEN

NTPC has been playing a major role in the energy transition of the country. It is taking various steps to make its energy portfolio greener by adding significant capacities generated from renewable energy sources. By 2032, the company plans to have 60 GW of capacity through renewable energy sources, constituting nearly 45% of its overall power generation capacity.

NTPC is undertaking many initiatives in the hydrogen segment, including production of green methanol, deployment of green hydrogen production and hydrogen refuelling stations, green hydrogen blending, microgrids and backup power with hydrogen storage, and green ammonia. NTPC will also help the pristine Ladakh develop a carbon-free economy based on renewable sources.

NTPC has also taken up the initiative of blending green hydrogen in the Piped Natural Gas (PNG) network of GGL (Gujarat Gas Limited) at NTPC Kawas Township. NTPC has inked its pact with Gujarat Gas Limited (GGL) to blend Green Hydrogen in Piped Natural Gas on 05-04-2022.

For this project, Green hydrogen will be produced by using electricity from the existing 1MW floating solar project of NTPC Kawas. This will be blended with PNG in a predetermined proportion and will be used for cooking applications in NTPC Kawas Township. Initially, the percentage of hydrogen blending in the PNG shall be around 5% and after successful completion, it shall be further increased.

A step towards the decarbonization of the cooking sector, the hydrogen blending project at NTPC Kawas is a pioneering effort and the first of its kind in the country.

NTPC is also keenly exploring the production of green hydrogen and ammonia to decarbonise the energy intensive industry and possibly fulfil the government's upcoming mandate of using a certain percentage of green hydrogen in the manufacturing, fertiliser and refinery sector.

MANDATES ON GREEN HYDROGEN BLENDING WITH NATURAL GAS

Government of India is planning to implement blending of 15-20% green hydrogen with piped natural gas (PNG) for domestic, commercial and industrial consumption which

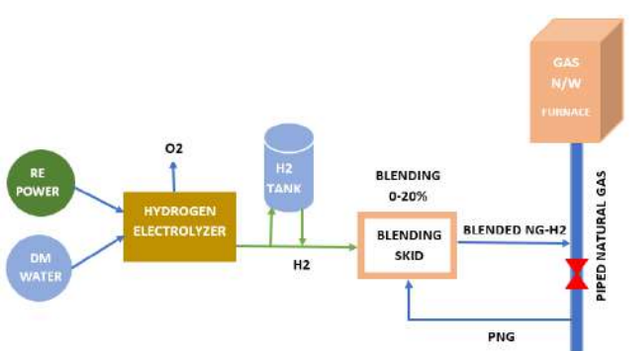

Figure 1: Hydrogen gas blending flow diagram

is technically viable option. This initiative will be a part of the government's National Hydrogen Energy Mission.

Government is on the verge to introduce Green Hydrogen purchase mandates, similar to Renewable Purchase Obligations, to cover industries like manufacturing, refineries and fertiliser plants. Hydrogen produced can be injected into natural gas pipelines, and the resulting blends can be used to generate heat and power with lower emissions than using natural gas alone.

GREEN HYDROGEN BLENDING WITH NATURAL GAS

Blending setup is intended to provide a continuous supply of green hydrogen gas required for blending with natural gas at various proposition levels. For this purpose, renewable power will be sourced from either grid or locally generated renewable power and water is converted into hydrogen and oxygen in an electrolysis process. Subsequently, hydrogen is intermediately stored in pressure storage tanks up to a certain amount to ensure a constant hydrogen volume fraction in the fuel mixture for constant combustion properties. This is crucial, as unexpected and sudden fluctuations in the fuel composition is to be critical on the constant heat input into the molten glass and consequently on glass quality. Hydrogen is carefully blended with natural gas to the required composition levels and supplied to the already established natural gas infrastructure. Blending levels would be increased in steps till it reaches 20% by vol with daily hydrogen requirement.

In India, natural gas production during the year 2020-2021 stood at 28.67 BCM, out of which industrial and manufacturing sector consumption is around 555 MMSCM and city/local natural gas distribution network is around 9230 MMSCM.

Table 1: Hydrogen gas blending project at global level

Sl. No.	Project	Blending of Hydrogen Gas
a.	Hydrogen Park South Australia (HyP SA)	5%
b.	ATCO's Western Australia Project	5%
c.	HyDeploy, UK Phase-1 & 2	upto 20%
d.	SoCalGas, USA	upto 20%
e.	Dominion Energy, USA	5%

In a glass industry piped natural gas (PNG) is widely used as fuel in boilers, furnaces, etc., and it has replaced many conventional fuels. PNG has the least carbon foot print of all fossil fuels at about 54 kg/MMBtu which is lesser than LPG, Diesel and Furnace Oil by about 12%, 25% and 30%, respectively.

Considering the Firozabad (Taj Trapezium Zone) natural gas cluster, there are around 342 industrial and 18000 domestic piped natural gas (PNG) connections under M/s GAIL Gas Limited. On an average glass production of small and medium industries from that cluster is around 1500 tonnes per day (TPD). With no hydrogen blending, total CO^2 emissions from that cluster is around 516 TPD and with blending of 20% vol/vol hydrogen, emission level is reduced by six percent to ~ 485 TPD (annual reduction in CO^2 emissions is around 10000 TPA).

At a global level many countries and institutions implemented the system of blending of green hydrogen with natural gas and were successful in operations for years with no changes to existing domestic appliances; and safe use of green hydrogen blends within existing infrastructure. Some of the projects or references at global level are detailed in the Table 1.

Blending green hydrogen with natural gas will reduce the GHGs emissions of using blended fuel in the furnace, boilers etc. With lifetime cost of hydrogen blended fuel used in furnace and boilers will be less than the natural gas fuel alone. It provides low-cost option for primary source of energy consumption in glass industry.

CONCLUSION

India has entered a major transformational phase in its economic, climate change, social etc., and it will continue to be one of the fastest growing energy markets in the world. Green hydrogen offers all the benefits of natural gas – it responds instantly when demand peaks, it is easily stored and delivers high temperature heat for industrial needs. With these outcomes, blending of hydrogen gas with natural gas is economically viable option to incorporate in glass manufacturing and it will help us to support the India's commitment at global forum and fulfils the hydrogen purchase mandates set by the government for industries, manufacturing sector etc.,

Now more than ever, consumers are acutely aware of the interconnected nature of businesses and its impact on our planet. Consumers are demanding products that are more sustainable and made with minimal impact on the environment. That is why many businesses are working to transform the way they are working and inspiring positive change for the planet and people. There is a focus from all the stakeholders whether their businesses or products are adapting to the 'energy transition' in a sustainable and affordable manner ■

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Mexican Glass Manufacturer selects Heye SmartLine 2 Check Inspection Machine

Mexican glass manufacturer, Vidrio Formas has successfully installed Heye International's latest SmartLine 2 including Ranger 2 check inspection equipment to deliver high performance at its new production site in Lerma.

Developed in Germany as an inspection and sorting machine for the global hollow glass community, the SmartLine 2 device incorporates Heye's latest cold end equipment innovations. These include a high speed outfeed belt, multi servo drives, high precision check detection and multi-point non-contact thickness detection.

The equipment is required to service an expansion of production capacities at Vidrio Formas, which has recently opened a second glass packaging facility with a new furnace and two additional production lines.

High performance inspection, a reduction of spare parts inventories, reduced operating costs and the SmartLine's 2 digitisation capabilities were essential elements in Vidrio Formas's purchasing decision. The SmartLine 2 was manufactured entirely at Heye's Nienburg factory in Germany. Due to the coronavirus pandemic, users were trained by Heye personnel on site in Mexico. The customer commissioned the machines supported remotely by Heye staff.

"*We have known Heye International as a reliable partner for many years. The inspection machines meet all of our requirements. Reliability and failure safety are particularly important to us, based on good experience of the Heye professionals.*", says Mr. Alex Schneeweiss, Operations Manager at Vidrio Formas, *"For these reasons we have ordered two more inspection machines."*

ABOUT HEYE INTERNATIONAL

Based at Obernkirchen, Germany, Heye International GmbH is one of the international glass container industry's foremost suppliers of production technology, high performance equipment and production knowhow. Its mechanical engineering has set industry standards for more than five decades. Extensive industry expertise, combined with the positive attitude and enthusiasm of Heye International employees is mirrored by the company motto 'We are Glass People'. Its three sub-brands HiPERFORM, HiSHIELD and HiTRUST form the Heye International equipment portfolio, addressing the glass industry's hot end, cold end and service requirements respectively.

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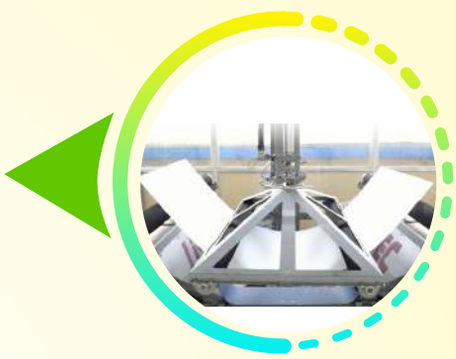

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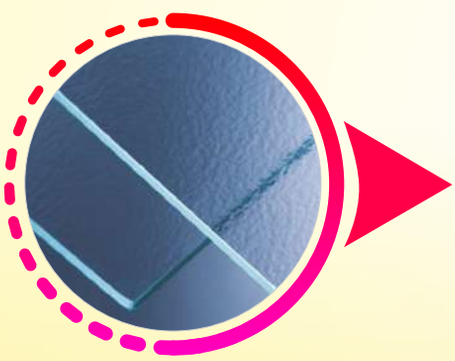

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