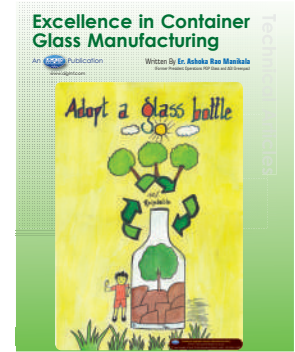


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Quarterly Journal of The **All India Glass Manufacturers' Federation**

Bilingual

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Workshop on Future of Security Glasses



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- Glass News
- Highlights of the Union Budget of India 2026-27
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- Glass Science at KMV: Empowering Women
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Quarterly Journal of the 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 by New United Process, A-26, Ph-II, Naraina Indl. Area, New Delhi-110028

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Complimentary copy for Members / Government Departments / NGOs and those connected with Glass Industry

Free online version at: www.aigmf.com/kanch.php

Charges for Print issue:

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. 13 | No. 4 | January-March 2026

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From the President's Desk

Parallel to the AIGMF Executive Committee meeting, a workshop on the Future of Security Glasses was organised on March 27 at K R Mangalam University, Sohna GURUGRAM.

The program was organised in association with the Federation of Safety Glass (FOSG) and the Glazing Society of India (GSI) with stakeholder participation from all segments of glass and related associations.

The keynote address was delivered by Mr. Aashish Tyagi, Director of Gold Plus Glass Industry Ltd. Technical presentations followed on Burglary Resistance Glasses by Mr. Rishabh Patel, Technical Manager, AIS; Bulletproof Glasses by Ms. Pallavi Mungekar, Country Sales Manager – Security, FG Glass Industries Pvt. Ltd.; Blast Resistant System by Mr. Ashwin K B, Technical Engineer, Vetrotech Saint Gobain and Transparent Glass-Ceramics for Armour by Dr. Atiar Rahaman Molla, Sr. Principal Scientist, CSIR-CGCRI.



The interactive session included over 100 participants covering students, faculty, and industry members from AIGMF, FOSG, CCPS, ICG, GSI, BIS, uPVC, IIT, CGCRI, K R Mangalam University, Glass Bulletin magazine, Alfred University USA, Glass manufacturers, and affiliate members via hybrid mode.

Overseas participants from the USA, Japan and Iran were noteworthy. A brief tour of the University was also organised.

All participants received a glass memento specially made by AGI Greenpac and La Opala from 100% recycled glass. The presentations and select photos of the event are available under past events at www.aimf.com

In view of the evolving geopolitical situation in the Middle East and its potential implications for global supply chains, energy markets, logistics, and trade flows, the AIGMF Secretariat organised meetings with DPIIT, Ministry of Commerce, CII, ASSOCHAM, FICCI, Media and other stakeholders. These meetings were aimed to assess emerging concerns and gather structured industry inputs for various Ministries and Departments of the Government of India.

The continuous manufacturing issue was flagged to all stakeholders requesting assurance of uninterrupted Natural Gas supply for glass manufacturing units related to the sector's critical downstream linkages, particularly: Pharmaceutical glass products (vials, ampoules, cartridges and tubing); Food and beverage glass packaging; Solar glass, linked to renewable energy projects and national infrastructure programs; Float Glass used in automobiles, metro trains, airports, hospitals, window/facade, and glass partitions. These issues will continue to be raised seeking support under essential manufacturing ■

Rajesh Khosla

President AIGMF and CEO/President AGI Greenpac

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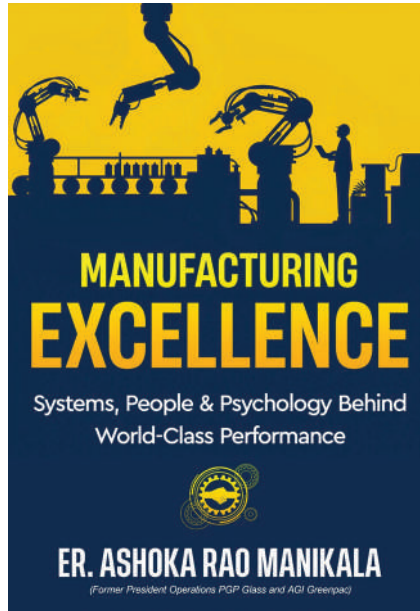
GLASS News

MANUFACTURING EXCELLENCE: SYSTEMS, PEOPLE AND PSYCHOLOGY

Manufacturing Excellence: Systems, People and Psychology by Er. Ashoka Rao Manikala (Member Editorial Board KANCH) offers a distinctive and deeply practical perspective on building world-class manufacturing organizations by integrating technical systems, human capability, and industrial psychology into one coherent framework. Drawing from more than four decades of leadership experience across complex manufacturing environments, the author demonstrates that sustainable excellence cannot be achieved through technology and systems alone; it requires disciplined processes, engaged people, and a culture shaped by purpose, responsibility, and continuous learning.

The book explores critical dimensions of manufacturing success including productivity improvement, quality assurance, reliability enhancement, cost optimization, safety, maintenance effectiveness, and operational leadership. What makes this work unique is its emphasis on the psychological and behavioral foundations behind shop-floor performance, how attitudes, habits, trust, motivation, and leadership influence outcomes as strongly as machines and methods.

Through practical examples, structured



insights, and experience-based reflections, Er. Ashoka Rao Manikala presents manufacturing excellence as a living system where systems thinking, human commitment, and managerial wisdom must operate together. The book serves as a valuable guide for industrial leaders, engineers, plant managers, consultants, and students seeking to create resilient, competitive, and people-centered manufacturing enterprises in a rapidly changing global environment.

This book is available in India and overseas through Amazon as well as Flipkart in India.

NEXT GENERATION INDUSTRY CONFERENCE SHOWCASES THE FUTURE OF AI AND DIGITALISATION

Nearly 150 delegates attended in person or joined online as Glass Futures hosted the Next Generation Industry Conference on March 18 2026, bringing together industry leaders, academics and technology providers to explore how AI and digitalisation are transforming the foundation industries.

Held at Glass Futures' state of the art facilities in St. Helens (UK), the conference offered a unique forum to share real world applications, emerging research and future focused thinking across the glass and wider foundation sectors.

Delegates were welcomed by Mr. Justin Kelly, CEO of Glass Futures, who emphasised the importance of cross sector innovation and the role digital technologies will play in accelerating competitiveness and decarbonisation.



With AI now firmly established as a key industry focus, the conference agenda reflected the pace of change across the supply chain and the growing need for data driven decision making.

Morning sessions highlighted how AI is already delivering impact at scale:

- Dr. Gökce Yüce (Digital Technologies & Simulation Services Manager, Şişecam) demonstrated how one of the world's largest glass manufacturers is embedding AI across its operations. From autonomous furnace control to predictive quality and defect detection systems, AI is delivering tangible reductions in waste and emissions.
- From a systems and engineering perspective, Mr. Daniel Smalley (Business Manager Factory Automation Digitalisation, Siemens Digital Industries) explored the transformative potential of industrial AI, digital twins and agent-based automation, outlining how AI-enabled engineering workflows are redefining design, simulation and manufacturing performance.
- Academic insight was provided by Prof. Hujun Yin (Professor of Artificial Intelligence, University of Manchester), who gave a clear and accessible overview of AI principles, associated risks and real-world industrial applications, grounding innovation within a robust data and governance framework.
- Materials innovation featured strongly, with Mr. Stephen Forrester (Finance Director (Projects), Lucideon) highlighting the use of AI-enabled approaches in materials research and underlining the continued importance of scientific rigour and validation. Dr. Katharina Roettger (Principle Scientist,

Digital Technologies & Data Science, CPI) complemented this with practical insights into how SMEs can establish strong data foundations to unlock future AI adoption and process optimisation.

The afternoon sessions focussed on innovation at scale and long term sustainability:

- Showcasing Glass Futures' own work, Dr. Jim Scotson presented the flagship AI-GLASS Project, introducing the organisation's evolving digital twin ecosystem, multi-physics furnace modelling capabilities and operator training platform designed to support decarbonisation and operational excellence.
- Further industrial perspectives included Dr. Juraj Raič (Development Manager, F.I.C. UK), who outlined advances in furnace modelling, electric boosting technologies and AI-supported process control.
- A key technology focus was provided by Mr. Salvador Sumohano-Verdeja (New Business Development Lead, Industrial Manufacturing, NVIDIA), who explored next-generation industrial AI capabilities enabled by accelerated computing, advanced

simulation technologies and the NVIDIA Omniverse platform, illustrating how AI can be deployed at industrial scale using real-time operational and sensor data.

- Rounding out the programme, Mr. Konstantin Vikhorev (CTO, Virtual Engineering Centre – University of Liverpool) showcased cutting-edge applications of high-fidelity digital twins, immersive simulation and AI-enabled engineering tools being developed to solve real-world industrial challenges.

Delegates were united by a shared ambition to embrace digital transformation and shape the next generation of industrial innovation. The strong turnout and engaged discussions reflected the growing momentum behind AI adoption across the foundation industries. The message is clear: AI is no longer a future aspiration, it is already shaping productivity, sustainability and innovation across the foundation industries today.

WIEGAND-GLAS CHOOSES HEYE SMARTLINE 2 WITH RANGER 2 FOR SPECIALITY GLASS PLANT UPGRADE

Following a successful trial, Wiegand-Glas has installed six SmartLine 2



inspection machines equipped with Ranger 2 optical check devices for its Ernstthal plant in Thuringia, GERMANY.

Wiegand-Glas has been established for more than 450 years and makes around 8 million bottles a day at four glass plants. Its plant in Ernstthal, Thuringia makes about 1.3 million bottles a day and specialises in short runs and complex shapes for the spirits industry. As part of its furnace renovation programme this year, Wiegand sought new hot and cold end equipment to optimise performance.

The plant's high output of non-round containers was the primary reason to test Heye SmartLine 2 with Ranger 2 technology. It also has a colourant forehearth and extra flint containers. Such high-quality glass containers have very tight specifications and, therefore, require the most accurate inspection equipment to remove all defects without over-rejecting and making the plant less productive than it should be.

Heye International has a decade long relationship with the glassmakers at Ernstthal, having first installed equipment there in 2012. Over the years, Heye machines have proved to be stable and very robust.

The company installed a test line at the plant so Wiegand could assess whether or not they wanted to invest in Ranger 2. Heye engineers were confident the system could handle non-round containers better than its competitors. Wiegand tested the machines with a range of different toolings and various non-round container shapes and sizes.

"Our glassmakers are highly skilled and know what good glassmaking looks like," says Dr. Thomas Struppert, CEO of Wiegand-Glas. "We soon realized the advantages of Heye's SmartLine 2. It handles complex containers in a fast and stable manner and provides excellent

data to help us rectify problems before they multiply."

At the hot end, Heye installed a new Multi-weight assortment feeder, part of the company's Industry 4.0 Smart Plant initiative.

It uses a servo drive control, in combination with a servo plunger and dual motor shears, to deliver gobs of different weights to the same IS machine, even in NNPB format. This allows Wiegand to produce a variety of containers simultaneously on one forming line. Heye has overhauled and upgraded the line's existing servo plunger and dual motor shears as part of the contract.

The plunger and shears work in tandem to ensure less energy is used and no gob is wasted. It is perfect for samplings and short runs and means that downtime is reduced to a minimum. The manufacturer needs fewer moulds for each low volume item and fewer machine-wide job changes, so longer jobs keep running alongside several shorter ones.

At the cold end, Heye installed six SmartLine 2 machines. These are all equipped with Ranger 2 optical check detection devices. This modular system allows users to capture five images simultaneously through one camera to check different aspects of the container, such as horizontal,

vertical, bottom, and shoulder.

The bottles tested at Ernstthal were largely heavy, premium containers. Mr. Uwe Schitter, Head of Cold End at Heye International, says that *"Heye Smartline 2 is just as comfortable in this complex environment as it is in a high-speed NNPB scenario."* Wiegand-Glas sees light weighting as a key part of its sustainability strategy.

The SmartLine 2 interface controls the parameters for each job and gives the operator full visibility and detailed feedback on the check results. The SmartLine 2 can be configured to the customer's precise specifications through this intuitive graphic interface. One of its core competences is non-round containers, which is such an important consideration for Wiegand-Glas given Ernstthal's high value, specialist, short-run product mix.

SmartLine 2 with Ranger 2 addresses the key challenges of modern container glass inspection. It is fast and runs accurately at speed with different types of bottles. It offers repeatability, spotting the same defect time and again. Ranger 2 is effective at detecting defects and relaying information regarding which machine sections are affected. It is based on a fixed camera position, with a higher accuracy than other systems, which are available in the market. Ranger 2 performs reliably across



different sample types and inspection challenges.

Mr. Uwe Schitter, Head of Inspection Technology concludes, “A specialist glass plant like Wiegand Ernstthal is made for Ranger 2. We tested all its capabilities and it passed with flying colours. Now it is running on all six lines after furnace reconstruction this summer.”

Wiegand-Glas speaks of itself as a company where experience meets the latest technology and an innovative spirit. Its partnership with Heye International demonstrates all of these qualities.

INDUSTRIAL ACCELERATOR ACT: EUROPEAN GLASS PACKAGING INDUSTRY WELCOMES RECOGNITION OF GLASS AS A STRATEGIC SECTOR

On the European Commission’s proposal for an Industrial Accelerator Act (IAA), the European Container Glass Federation (FEVE) welcomes the recognition of glass manufacturing as a strategic industrial sector and the streamlining of permitting procedures for energy-intensive industry decarbonisation projects.

The proposed objective for manufacturing to account for at least 20% of EU GDP by 2035 sends an important signal of renewed industrial ambition. However, urgent action on multiple fronts is needed to get there and safeguard the competitiveness of the industry, while enabling decarbonisation at scale in a moment marked by increasing energy and carbon costs and intense competition, leading to unprecedented production decline and furnaces closures across Europe.

“Europe’s glass packaging industry is fully committed to decarbonisation and is investing to make it happen” said Mr.

Carlo Pirrone, Secretary General of FEVE. “While today’s proposal is a step in the right direction, we need bolder action to lower energy prices, boost grids development and simplify rules to maintain our competitive edge”

The European container glass industry stands as a resilient and strategically important contributor to the EU economy and to local supply chains. Glass packaging also underpins Europe’s global trade strength, supporting exports of high-value goods — from food and beverages to pharmaceuticals and cosmetics — worth over €140 billion, or 6.1% of total EU exports. With the right framework conditions, the sector can deliver fully circular, non-toxic packaging solutions while advancing towards decarbonised manufacturing—preserving industrial capacity, jobs and strategic autonomy in Europe.

FEVE is the Federation of European manufacturers of glass containers for food and beverage, perfumery, cosmetics and pharmaceutical sectors. Its members produce over 20 million tonnes of glass or more than 80 billion containers per year. The association has 24 independent group members. Manufacturing plants are located across 23 European States and include global blue-chip and major companies working for the world’s biggest consumer brands. The Container Glass sector in Europe makes a significant contribution to the EU Economy and supports essential sectors. More than 125,000 people work in the glass packaging value chain across Europe. It guarantees resilient local supply chains with a proximity of service to its suppliers and clients. Every year €610 million is invested in upgrading plants for better energy efficiency and reduced CO₂ emissions (i.e. representing a significant 10% of the operational and maintenance costs). The sector exports around €1.2

billion (empty bottles and jars) and if we take account of items almost always or often packed in glass, glass is an enabler of extra EU exports of around €140 billion.

COMPLETION OF FIRST TRIALS CAMPAIGN MARKS NEW CHAPTER IN GLASS FUTURES’ DECARBONISATION MISSION

Glass Futures has reached a significant milestone in its mission to accelerate the decarbonisation of energy intensive industries, with the successful completion of alternative fuel trial programmes testing biofuels and electric melting, and commissioning hydrogen capabilities on its 30 tonnes-per-day pilot line.

The achievement comes almost exactly seven years after the organisation secured funding for its first Industrial Fuel Switching projects from the Department for Energy Security & Net Zero, marking a new phase of innovation and momentum for the global glass sector.

These complex, multi-pathway trials that started in October 2025 have delivered groundbreaking results that demonstrate the technical potential of low-carbon fuel technologies at industrially relevant scales.

Key successes include the installation and commissioning of a bespoke biofuel delivery system, fully integrated into the site’s digital control environment which has been used to successfully fire four novel, low-cost, waste-derived biofuels for sustained periods over several days.

The Glass Futures team, supported by F.I.C UK Ltd, installed, commissioned, and trialled a custom electric-boost (e-boost) system. The work tested a wide range of power settings, including rapid switching, to demonstrate how a glass furnace could provide



demand-side response capabilities to local electricity networks.

Glass Futures also commissioned a new hydrogen fuel delivery system on the pilot line, enabling successful firing of hydrogen supplied by Ryze Power and natural-gas blends, up to 100% hydrogen.

Commissioning the world's first multi-fuel hybrid pilot-scale glass furnace involved several technical complexities, and this achievement has already attracted strong interest across Glass Futures' membership, government, and the wider foundation industries.

Mr. Justin Kelly, CEO of Glass Futures, said: *"The successful completion of these trial programmes marks a crucial milestone not just for Glass Futures, but for the industry's journey to net zero. We have demonstrated, at industrial scale, the technical viability of a number of alternative low-carbon fuel pathways that have never before been trialed in this way. It is a testament to the resilience, ingenuity, and collaboration of the entire Glass Futures team."*

Mr. Barry King, Engineering Manager at Encirc said: *"Encirc is delighted to be part of Glass Futures' groundbreaking trials in biofuels, electric, and hydrogen technologies. Collaboration and innovation are at the heart of our decarbonisation journey, and working*

together on these pioneering projects brings us closer to finding viable alternatives to fossil fuels. By exploring new energy pathways side by side with industry partners, we're helping to shape a more sustainable future for glass manufacturing and the communities we serve."

With completion of our first trial campaign around alternative fuels, Glass Futures has already progressed into detailed discussions with its members around our next campaign, exploring the next generation of raw materials and process innovations, and looking to our third campaign, to explore product innovations in both flat and packaging glass.

Our technical teams are collating the results from this first campaign to ascertain the technical readiness of each alternative fuel pathway, and how this will influence the broader policy landscape for decarbonisation.

There remain additional technical and adoption barriers to each, and we work directly with our members to explore the right combination of solutions to help decarbonise. The outcomes from these trials will act as a catalyst for further research and investment to overcome remaining technical and commercial challenges to support the energy transition and accelerate the pathway to net zero.

Glass Futures' Head of Innovation, Mr.

Rob Ireson, added: *"These results show that waste-derived biofuels, e-boosting technologies, and other emerging solutions can all play a critical role in decarbonising high-temperature sectors without compromising product quality or operational reliability. Now, we need coordinated action across supply chains, regulators, and energy providers to turn these technical successes into deployable solutions."*

Glass Futures has now commenced the next phase of pilot activity through its AI-GLASS project, funded by the Made Smarter Innovation Programme at Innovate UK, which will gather operating data to validate the advanced furnace model, allowing advanced sensing, digitalisation and intelligent control to further optimise industrial furnace performance and reduce emissions.

GLASS TECHNOLOGY SERVICES SECURES UKAEA FUNDING TO PIONEER GLASS AND GLASS-CERAMIC SHIELDING FOR FUSION ENERGY SYSTEMS

Glass Technology Services (GTS) has been awarded a contract under the United Kingdom Atomic Energy Authority's (UKAEA) Fusion Industry Programme, as part of a national £8.1 million investment supporting next-generation shielding and fuel-cycle technologies for future fusion power plants.

Working in partnership with Sheffield Hallam University, GTS is leading the project "Glass and glass-ceramics for fusion reactor shielding applications." The project investigates the potential of glass and glass-ceramic materials to serve as economical and sustainable radiation shielding solutions within fusion energy systems and associated plant environments.

The project is taking an economics and sustainability driven approach to identify materials that are both low

cost and environmentally responsible, while still meeting the stringent performance requirements of nuclear fusion.

By exploring alternatives that are holistically competitive with traditional shielding materials, such as lead, concrete, and specialist metal alloys, the team aims to deliver solutions that combine high physical performance with lower costs, reduced environmental impact, and simpler end of life management. This work aligns closely with the UK's commitment to sustainable innovation and the advancement of clean energy technologies.

As part of the programme, GTS and Sheffield Hallam University are undertaking a comprehensive programme of work including:

- Identification and modelling of high-performance glass and glass-ceramic materials.
- Simulations to evaluate radiation attenuation behaviour.
- Laboratory-scale melting trials to validate material feasibility and performance scale melting trials to validate material feasibility and performance.
- Assessment of commercial manufacturing routes, including integration of secondary raw materials.
- Lifecycle and environmental impact analysis to ensure long-term sustainability and end-of-life viability.

Dr. Owen McGann, Principal Technologist and Innovation development lead said *“Glass and glass-ceramic technologies offer a unique combination of compositional flexibility, manufacturability and radiation shielding capability.*

“This project gives us the opportunity to demonstrate how these materials can deliver sustainable, economical, high-performance shielding solutions which support the UK's long-term fusion energy ambitions.”

The outcomes of the project are expected to contribute directly to the UK's growing fusion materials capability and may offer broader benefits to sectors such as nuclear medicine, nuclear fission, aerospace, and industrial radiography.

NEW STUDY BY STAZIONE SPERIMENTALE DEL VETRO CONFIRMS STRONG RECYCLING PERFORMANCE OF OPAQUE GLASS PACKAGING ACROSS EUROPE

FERVER and FEVE welcome the publication of a new technical report by Stazione Sperimentale del Vetro (SSV), which provides robust scientific evidence on the actual recycling performance of opaque glass packaging in Europe.

The study, which was commissioned by FEVE and conducted with the operational support of FERVER members, identifies the minimum visible light transmittance threshold at which opaque glass fragments can still be correctly recognised as glass by the optical sorting systems nowadays used in Cullet Treatment Plants (CTPs). Through extensive laboratory measurements and industrial-scale trials, the research offers clear, data-driven insight into the state-of-the-art performance of Europe's glass-recycling infrastructure.

The findings of the study support the conclusion that today, in Europe, optical sorting technologies can reliably identify opaque glass fragments with an average visible light transmittance higher than 2.5%, measured according to the opacity protocol currently being defined in the European Committee on Standardisation (CEN) taking into account the input of the International Technical Center for Bottling and Related Packaging (CETIE). This confirms that, when it comes to the actual performance of glass packaging

recycling in Europe, current CTPs' capabilities significantly exceed the much higher thresholds enshrined in some national packaging laws, which under-estimate real-world sorting performance.

To ensure statistically robust findings, SSV conducted comprehensive industrial trials at nine CTPs across Europe, using 2,700 kilograms of standardised cullet from different types of opaque bottles, measuring false CSP (Ceramic, Stones, Porcelain) rejection rates under real operating conditions and across different sorting technologies.

Due to its robustness, the findings of this study are being taken into consideration in the development of the design-for-recycling technical specifications for glass packaging, currently being finalised by CEN with input from the whole value chain, including glass container manufacturers, Cullet Treatment Plants, fillers, label suppliers, closure producers, machinery providers and EPR schemes. Recyclability guidelines will require regular review and improvement to reflect innovations in design, collection, sorting and recycling.

By grounding this work in industrial evidence and full value-chain scrutiny, the study contributes to ensuring that the future work of the European Commission on design for recycling criteria for glass packaging is technically sound and aligned with Europe's state-of-the-art recycling practices, thus contributing to Europe's circular economy and industrial resilience.

FEVE and FERVER remain committed to working with European and national policymakers to ensure that the harmonized EU regulatory framework on packaging and packaging waste fully reflects the proven capabilities of Europe's recycling system.

REMEMBERING SWARN KANTA CHITKARA w/o LATE MANOHAR LAL, FORMER SECRETARY AIGMF



A very special volunteer who was always active at the AIGMF booth in the initial glasspex exhibitions in 2009 and 2011; and wife of Former Secretary Mr. Manohar Lal passed away on March 15, 2026 at Delhi at the age of 90 years.

Mrs. Swarn Kanta Chitkara was remembered at the Executive Committee meeting of the AIGMF on March 27 at K R Mangalam University.

SORG ACHIEVES 100% ELECTRIC GLASS CONDITIONING

SORG has successfully completed long-term testing of its fully electric 'Viking' forehearth, which enables glass conditioning for all tonnages.

The first installation on a glass melting furnace has successfully passed extended testing in a large-scale industrial environment.

Conditioning remains one of the major sources of CO₂ emissions in the glass manufacturing process.

While electrically heated conditioning systems have been available for some time, their use has generally been limited to special applications.

This is due to limitations such

as contamination from the heating elements, slow response times, local overheating, and wear of the heating elements.

The Viking forehearth is designed to change this standard by offering a 100% electrically heated conditioning system suited to all tonnages.

The forehearth benefits from heating elements integrated into its specially designed superstructure, which completely eradicates local overheating.

In addition, because the heating element material cannot fall into the glass bath, the design also protects the melt from potential contamination, ensuring a cleaner and safer conditioning process.

The forehearth was equipped with an emergency gas heating system for safety at a production facility. However, the forehearth's reliable performance meant it was not necessary to put the safety system into operation. With the Viking forehearth, SORG continues to advance sustainable glass production.

When combined with SORG's VSM and VSM+ fully electric melting technologies - or the Clean Melter hybrid system, which reduces CO₂ emissions by 80% - the Viking forehearth makes 100% CO₂-free glass production possible from the initial melt to the final conditioned glass.

ENERGY CONSERVATION AND DECARBONISATION TRAINING

A 5-day training programme on Energy Conservation and Decarbonisation

in the Glass Industry was conducted from March 16-20, 2026, at the Centre for the Development of Glass Industry, Firozabad. The programme was organised by the Centre for the Development of Glass Industry (CDGI), an institution established as a joint venture to support technological advancement and sustainable development in the glass sector.

The programme was conducted by Er. Ashoka Rao Manikala, Former President (Operations) of PGP Glass and AGI Greenpac and Member, Editorial Board of KANCH, who shared extensive practical knowledge from his long industrial experience in glass manufacturing and furnace operations.

More than 30 participants from various glass factories in and around Firozabad attended the programme. The training covered key aspects of furnace energy efficiency, combustion optimisation, reduction of heat losses, fuel conservation and practical measures for lowering carbon emissions in glass production.

Special emphasis was given to improving specific energy consumption, operational discipline, and adopting sustainable manufacturing practices. Interactive discussions and practical examples made the sessions highly relevant to present-day industrial challenges. The programme provided valuable technical guidance for improving competitiveness through energy-efficient and environmentally responsible glass manufacturing practices.



HIGHLIGHTS OF THE UNION BUDGET OF INDIA 2026-27

The Union Minister for Finance and Corporate Affairs Mrs. Nirmala Sitharaman presented the Union Budget 2026-27 in Parliament on Feb 1, 2026. The key highlights of the Budget are as follows:

- Restructuring Power Finance Corporation (PFC) and Rural Electrification Corporation (REC).
- Raising the STT on Futures from 0.02% to 0.05%.
- Establishment of new Dedicated Freight Corridors connecting Dankuni in the East, to Surat in the West.
- Operationalising 20 new National Waterways connecting mineral rich areas, industrial centres and ports.
- Scheme to adopt Carbon Capture Utilization and Storage (CCUS) with an outlay ₹20,000 crore.
- **Exemption of BCD on import of sodium antimonate for use in manufacture of solar glass.**
- Exemption of BCD on import of capital goods required for the processing of critical minerals in India.
- Extending exemption of BCD to capital goods used for the manufacture of Lithium-Ion Cells for batteries to be used in battery energy storage systems.
- Extension of the existing basic customs duty exemption on imports of goods required for Nuclear Power Projects till the year 2035 and expand it for all nuclear plants irrespective of their capacity.
- Exclusion of entire value of biogas in Central Excise duty payable on biogas blended CNG.
- 'Growth Connectors' - 7 High-Speed Rail corridors between cities - Mumbai-Pune, Pune-Hyderabad, Hyderabad-Bengaluru, Hyderabad-Chennai, Chennai-Bengaluru, Delhi-Varanasi, Varanasi-Siliguri - Environmentally sustainable passenger systems.
- Enhancement of duty-deferral period for Tier 2 and Tier 3 Authorised Economic Operators (AEO) from 15 to 30 days. Eligible manufacturer-importers to get the same duty deferral facility. Government agencies will be encouraged to leverage AEO accreditation.
- Individual Persons Resident Outside India (PROIs) will be permitted to invest in equity instruments of listed Indian companies through the Portfolio Investment Scheme (PIS).
- Reduce TCS rate on sale of overseas tour program package from 5% and 20% to 2% without any stipulation of amount.
- Reduce TCS for pursuing education and for medical purposes under the Liberalized Remittance Scheme (LRS) from 5% to 2%.
- TDS on Supply of manpower services to be at the rate of either 1% or 2%.
- Enable depositories to accept Form 15G or Form 15H from taxpayers holding securities in multiple companies.
- Time available for revising returns extended from 31st December to up to 31st March with the payment of a nominal fee.
- Individuals with ITR 1 and ITR 2 returns will continue to file till 31st July and non-audit business cases or trusts are proposed to be allowed time till 31st August.
- TDS on the sale of immovable property by a non-resident to be deducted and deposited through resident buyer's PAN instead of TAN.
- Introducing a one-time 6-month foreign asset disclosure scheme below a certain size for small taxpayers.
- Allow taxpayers to update their returns even after reassessment proceedings have been initiated at an additional 10 percent tax rate over and above the rate applicable for the relevant year.
- Framework for immunity from penalty and prosecution in the cases of underreporting extended to misreporting.
- Immunity from prosecution with retrospective effect from 1.10.2024 for non-disclosure of non-immovable foreign assets with aggregate value less than ₹20 lakh.
- Constitute a Joint Committee of Ministry of Corporate Affairs and Central Board of Direct Taxes for incorporating the requirements of Income Computation and Disclosure Standards (ICDS) in the Indian Accounting Standards (IndAS).
- Tax buyback for all types of shareholders as Capital Gains. However, promoters will pay an additional buyback tax.
- Single and interconnected digital window for cargo clearance approvals.
- Honest taxpayers willing to settle disputes will now be able to close cases by paying an additional amount in lieu of penalty.

भारत सरकार का केंद्रीय बजट: 2026-27

केन्द्रीय वित्त और कॉर्पोरेट मामलों की मंत्री श्रीमती निर्मला सीतारमण ने 1 फरवरी, 2026 को संसद में केंद्रीय बजट 2026-27 प्रस्तुत किया। बजट की मुख्य विशेषताएं इस प्रकार से हैं:

- पावर फाइनेंस कॉर्पोरेशन और सरल रूरल ग्रामीण विद्युत निगम कॉर्पोरेशन का पुनर्गठन।
- फ्यूचर्स पर एसटीटी को 0.02% से बढ़ाकर 0.05% करना।
- 20,000 करोड़ रुपए के परिव्यय के साथ कार्बन कैप्चर उपभोग और भंडारण (सीसीयूएस) अपनाने की स्कीम।
- बैट्री ऊर्जा भंडारण प्रणाली में प्रयोग किए जाने के लिए लिथियम आयन सेल बैटरियों के विनिर्माण में प्रयुक्त पूंजीगत सामानों के लिए बीसीडी छूट देना।
- **सोलर ग्लास के विनिर्माण में प्रयुक्त सोडियम एंटीमोनेट के आयात पर बीसीडी की छूट।**
- वर्ष 2035 तक नाभिकीय ऊर्जा परियोजनाओं के लिए अपेक्षित सामानों के आयात पर बेसिक सीमा शुल्क रियायत का विस्तार करना और यह सुविधा सभी नाभिकीय संयंत्रों के लिए उनकी क्षमता के निरपेक्ष लागू करना।
- भारत में महत्वपूर्ण खनिजों की प्रोसेसिंग के लिए अपेक्षित पूंजीगत सामानों के आयात पर बीसीडी छूट।
- बायो गैस मिश्रित सीएनजी पर देय केंद्रीय उत्पाद शुल्क में बायो गैस के संपूर्ण मूल्य को छोड़ना।
- वृद्धि संयोजक शहरों के बीच 7 हाईस्पीड रेल कॉरिडोर- मुंबई-पुणे, पुणे-हैदराबाद, हैदराबाद-बेंगलुरु, हैदराबाद-चेन्नई, चेन्नई-बेंगलुरु, दिल्ली-वाराणसी, वाराणसी-सिलीगुड़ी- पर्यावरण अनुकूल यात्री प्रणालियां।
- टीयर 2 और टीयर 3 प्राधिकृत आर्थिक ऑपरेटर्स के लिए ड्यूटी डेफरल अवधि को 15 दिन से बढ़ाकर 30 दिन करना। पात्र विनिर्माता-आयातक को समान ड्यूटी डेफरल सुविधा मिलेगी। सरकारी एजेंसियों को एईओ प्रत्यायन का लाभ उठाने के लिए प्रोत्साहित किया जाएगा।
- सीमा शुल्क पर बाध्यकारी उन्नत नियमन की वैधता अवधि को 3 वर्ष से बढ़ाकर 5 वर्ष करना।
- इंडिबिजुअल पर्सन्स रेजिडेंट आउटसाइड इंडिया (पीआरओआई) को पोर्टफोलियो निवेश स्कीम (पीआईएस) के माध्यम से सूचीबद्ध भारतीय कंपनियों के इक्विटी लिखतों में निवेश की अनुमति दी जाएगी।
- विदेशी टूर प्रोग्राम पैकेज की बिक्री पर टीसीएस दर को बिना किसी धनराशि के निर्धारण के 5% और 20% से घटाकर 2% कर दिया जाएगा।
- उदारीकृत धन प्रेषण योजना के अंतर्गत शिक्षा प्राप्त करने और चिकित्सा उद्देश्यों के लिए टीसीएस को 5% से घटाकर 2% कर दिया जाएगा।
- जनशक्ति सेवाओं की प्रदायगी पर टीडीएस को या तो 1% या 2% रखा जाएगा।
- छोटे करदाताओं के लिए नियम आधारित स्वचालित प्रक्रिया के माध्यम से कम या शून्य कटौती प्रमाणपत्र प्रदान करने की सुविधा दी जाएगी।
- अनेक कंपनियों में प्रतिभूति धारित करने वाले करदाता से फॉर्म 15 जी और 15 एच स्वीकार करने के लिए न्यासों को सक्षम बनाया जाएगा।
- संशोधित रिटर्न के लिए उपलब्ध समय को मामूली शुल्क के भुगतान के साथ 31 दिसम्बर से बढ़ाकर 31 मार्च किया गया।
- आईटीआर 1 और आईटीआर 2 दाखिल करने वाले व्यक्ति के लिए 31 जुलाई तक और लेखापरीक्षित व्यवसायों अथवा न्यासों के लिए 31 अगस्त तक की समय सीमा की अनुमति दिए जाने का प्रस्ताव है।
- किसी अनिवासी द्वारा अचल संपत्ति की बिक्री पर काटे जाने वाले टीडीएस को टैन के स्थान पर निवारी क्रेता के पैर के माध्यम से जमा किया जा सकता है।
- छोटे करदाताओं के लिए एक निश्चित आकार से कम मूल्य वाले विदेशी आस्ति प्रकटन के लिए एकबारगी छह माह की अवधि का प्रावधान किया गया है।
- करदाताओं को पुनर्निर्धारण कार्रवाई के आरंभ के पश्चात भी अपनी विवरणियों को संगत अवधि के लिए लागू दर के ऊपर 10 प्रतिशत अतिरिक्त कर दर पर अद्यतन करने की अनुमति होगी।
- आंकड़े कम दिखाने के मामलों में दंड और अभियोजन से उन्मुक्त संबंधी ढांचे का विस्तार गलत सूचना देने के मामले में भी किया गया है।
- लेखा बही और दस्तावेज प्रस्तुत न करने तथा पीडीएस भुगतान की अपेक्षा को अपराध की श्रेणी से हटा दिया गया है।
- 20 लाख रुपए से कम कुल मूल्य के साथ गैर अचल विदेशी संपत्तियों को प्रकट नहीं करने के संबंध में 01.10.2024 से भूतलक्षी प्रभाव से मुकदमेबाजी से उन्मुक्त दी गई है।
- भारतीय लेखांकन मानकों में आय गणना एवं प्रकटीकरण मानकों की अपेक्षाओं को शामिल करने के लिए कॉर्पोरेट कार्य मंत्रालय तथा केंद्रीय प्रत्यक्ष कर बोर्ड की संयुक्त समिति का गठन ■

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



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WE ARE GLASS PEOPLE

Workshop on Future of Security Glasses

(March 27, 2026, Gurugram)

Parallel to the AIGMF Executive Committee meeting, a workshop on the Future of Security Glasses was organised on March 27 at K R Mangalam University, Sohna GURUGRAM. The program was organised in association with the Federation of Safety Glass (FOSG) and the Glazing Society of India (GSI) with stakeholder participation from all segments of glass and related associations.

The event started with a welcome address by the Vice Chancellor Professor Dr. Raghubir Singh and an Opening Address on Security of Health and Environment by the AIGMF President Mr. Rajesh Khosla and CEO/President of AGI Greenpac.

Mr. Khosla gave the overview on glass packaging and how important role it plays for protecting health and environment vis-à-vis threats to the general masses from the unsustainable packaging. He said that role of the AIGMF is to impart education by taking help of the Youth to spread the message of green packaging offering security via Glass.





The keynote address was delivered by Mr. Aashish Tyagi, Director of Gold Plus Glass Industry Ltd., on developing the unbreakable Glass solutions that set the stage for academia and industry interaction.

The following technical presentations were made:

- Burglary Resistance Glasses by Mr. Rishabh Patel, Technical Manager, AIS
- Bulletproof Glasses by Ms. Pallavi Mungekar, Country Sales Manager (Security), FG Glass Industries Pvt. Ltd.
- Blast Resistant System by Mr. Ashwin K B, Technical Engineer, Vetrotech Saint Gobain
- Transparent Glass-Ceramics for Armour by Dr. Atiar Rahaman Molla, Sr. Principal Scientist, CSIR-CGCRI

The event was well organized and well collected by industry leaders. I had a great learning from the fellow dignitaries as well as from the speakers who talked about different subjects





from safety glass to bulletproof glass to the new ceramic glass. **Mr. Amit Malhotra, President of Confederation of Construction Products and Services, Treasurer of uPVC Window & Door Manufacturers Association and Managing Director of McCoy Silicones Ltd.**

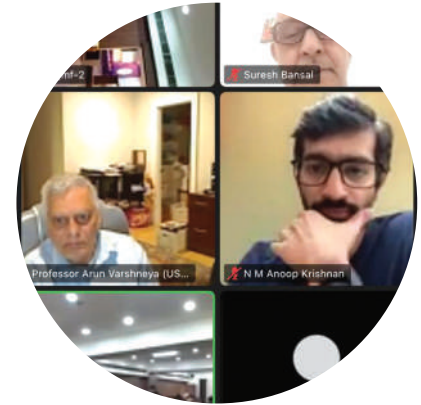


The future of security glass, particularly bullet-resistant glass, is being shaped by rapid advancements in material science and engineering. Innovations in multi-layer laminates, advanced interlayers, and lightweight polycarbonate composites are enabling superior protection while maintaining high optical clarity and aesthetic appeal.



As security requirements continue to grow across commercial, residential, and defence sectors, modern bullet-resistant systems are evolving to deliver higher ballistic performance with reduced thickness and weight. Enhanced durability, energy efficiency, and seamless integration with





Managing Committee, Federation of Safety Glass (FOSG)

- Mr. Gohul Deepak, Executive Director, Glazing Society of India (GSI)
- Dr. Gaurav Gupta, Assistant Professor, K R Mangalam University
- Mr. Amit Malhotra, President, Confederation of Construction Products and Services; Treasurer of uPVC Window & Door Manufacturers Association and Managing Director, McCoy Silicones Ltd.
- Ms. Sheetal Khanna, General Manager, Gold Plus Glass Industry Ltd.
- Dr. Arun K. Varshneya, PhD Hon FSGT Former President, The Society of Glass Technology; Professor of Management, Alfred University; Prof. of Glass Science & Engineering, Emeritus, Alfred University & President Saxon Glass Technologies, Inc., USA

contemporary architectural designs are becoming key focus areas.

Looking ahead, the emphasis is on intelligent protection, where safety meets innovation. Next-generation bullet-resistant glass will be lighter, stronger, and more adaptable, offering visually seamless solutions that meet the dynamic challenges of modern security environments.

However, high-performance glass

alone is not sufficient; a robust and well-engineered framing and support system is equally critical to ensure overall ballistic integrity and real-world effectiveness.

Ms. Pallavi Mungekar Country Sales Manager – Security, FG Glass Industries Pvt. Ltd.

The Q&A was chaired by the expert panellists:

- Mr. Sharanjit Singh, Member





Mr. Vinit Kapur Secretary, AIGMF mentioned that the industry is excited to hold this event at K R Mangalam University, which houses 10,000 students on its 38-acre green campus. He appreciated that the current and upcoming campus buildings have many glass applications which aligns with the green concept.



“It was a great experience interacting with the industry leaders, scientists and academics on addressing the grand challenges faced by the industry. Such workshops and brainstorming sessions play a foundational role in bringing the academia and industry together to develop innovative and sustainable solutions that can catapult India toward a global leader in glass manufacturing and innovation.” **Prof. N M Anoop Krishnan, Dept. of Civil Engineering and Yardi School of AI, IIT DELHI**



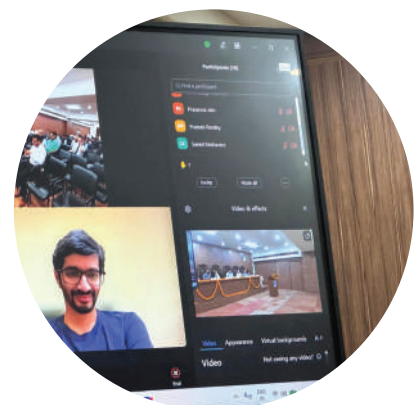
It was stated that a series of workshops are planned on Solar, container and pharma (vials/ampoules) to cover all segments of glasses

- Mr. Mohit Garg, Deputy Director & Member Secretary - CHD 10, Bureau of Indian Standards, Gol
- Mr. Lakhan Singh, Editor & Publisher Glass Bulletin Magazine
- Prof. N M Anoop Krishnan, Dept. of Civil Engineering and Yardi School of AI, IIT DELHI

offering a cost-effective alternative to conventional glass and transparent ceramics. I invite Indian industries to participate as co-development partners in technology development, demonstration, and subsequent commercialization, noting that the demand for such materials is steadily increasing while indigenous technologies remain limited in the country.

Dr. Atiar Rahaman Molla, Scientist-F at CSIR-CGCRI

Glass-ceramics are emerging as a promising class of materials for both armour systems and electronic displays,





expertise, ensuring that standards remain scientifically robust, innovative, and globally harmonized.

Mr. Mohit Garg, Deputy Director & Member Secretary - CHD 10, Bureau of Indian Standards, Gol.

before the 16th AIGMF International conference on the theme 'Developing Unbreakable Glass Solutions,' to be held parallel to glasspex and glasspro exhibitions in 2027 at Mumbai INDIA. Papers are invited on the subject covering flat, hollow, solar, vials, decorative and tableware at info@aigmf.com

The interactive session included over 100 participants covering students, faculty, and industry members from AIGMF, FOSG, CCPS, ICG, GSI, BIS, uPVC, IIT, CGCRI, K R Mangalam University, Glass Bulletin magazine, Alfred University USA, Glass manufacturers, and affiliate members via hybrid mode.

National standardization, which is vital for ensuring safety, quality, and uniform performance in the glass and glassware sector, particularly for

applications involving security and structural integrity. The Bureau of Indian Standards (BIS) has established a robust set of Indian Standards, including IS 2553 (Parts 1 & 2) for safety glazing in buildings and vehicles, IS 18158 for bullet-resistant glasses, IS 19328 for fire-resistant glasses, and IS 16978 (Parts 1 to 4) for forced entry security glazing. These standards define critical performance parameters such as impact resistance, fire endurance, and safe breakage behavior, enabling safer use of glass in modern infrastructure and enhancing trust among stakeholders.

BIS continues to strengthen this framework through ongoing work on structural glazing, advanced coated and laminated glass, and performance-based standards aligned with international practices. Academia plays a key role in this process by contributing research, testing methodologies, and technical

Overseas participants from the USA, Japan and Iran were noteworthy. A brief tour of the University was also organised.

All participants received a glass memento specially made by AGI Greenpac and La Opala from 100% recycled glass.

The workshop concluded with lunch and a group photograph.

We should understand that the words, "bulletproof", "fireproof", or "unbreakable" glass are commercial terms only. In reality, there is no material which qualifies for being "proof". Technologically, they are bullet-resistant, fire-resistant, or break-resistant. As a single component flat glass product, chemically strengthened transparent glass-ceramics are perhaps the strongest; having surface compression level at 1 GPa and a



depth of compression around 100 to 300 microns. Relative to glasses, glass-ceramics have a high fracture toughness making it possible to absorb some impacting energy pulse. However, when using any strengthened glass as armour, one needs to be cognizant of what happens when the second bullet strikes. In strengthened glasses, tensile stress in the interior can lead to web fractures causing loss of visibility for vehicle occupants. In general, armours should be made as laminates with several plies bonded using polymers such as polyvinyl butyrate which provide a tough assembly and prevent glass bits from flying. A ply of transparent ceramic such as Mg-spinel can improve performance. In this context, the framing of the armour can also help absorb some of the impacting energy. Work on transparent glass-ceramics is being carried out by Dr. Atiar Molla at the CGCRI, Kolkata. Fracture simulations studies (among other topics) are being conducted by Professor Anoop Krishnan at the IIT Delhi.

As Mr. Rajesh Khosla stated in his welcome address, “security” also includes health security. A serious



threat to human health are the cancer-causing microplastics. Use of glass containers in place of plastics is a step in the right direction. At Saxon Glass Technologies, we have been developing strengthened thin-walled glass containers in an effort to make glass containers a cost-competitive option. In addition, we regularly supply chemically strengthened borosilicate glass cartridge for autoinjector use which has reduced glass fracture probability from around 10% down to next-to-nothing, thereby help saving thousands of human lives each year. Many modern parenteral medicines are quite potent; they should be contained in break-resistant vials. Strengthened vials have been used to contain Covid-19 vaccines.

I am looking forward to developing closer working relations with glass manufacturers and R&D establishments

in India in an effort to advance towards a “Secure India”.

I thank Vinit Kapur of the AIGMF to have given me the opportunity to take part online during middle of the night from the other side of the Earth in the special AIGMF workshop on the future of security glasses.

Dr. Arun Varshneya (Emeritus Professor of Glass Science & Engineering, Alfred University, and President, Saxon Glass Technologies, Inc. Alfred NY USA)

After the workshop, the AIGMF Executive Committee met to discuss the current Gulf war situation, energy, raw materials, the ADD on Soda Ash, and other issues ■

Select photos of the event and presentations are available under past events at www.aimf.com



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Highly Efficient BIPV goes Colourful

Building-integrated photovoltaics (BIPV) are considered a key technology for the energy transition in buildings – and their installation is now picking up speed. According to “Deutsche Energie-Agentur” (German Energy Agency –dena) more than 10 gigawatts of solar power generation capacity were added in Germany in 2023 and 2024. A success that needs to be built upon because according to surveys by the Fraunhofer Institute for Solar Energy Systems, up to 1,000 gigawatt peak (GWp) could be installed on Germany’s available roof and façade surfaces; the PV needs in a completely renewable energy system would already be achieved at around 500 GWp. Glasstec asked the experts



Since 11 September 2025 Hamburg has sported a new landmark – the large-surface rainbow PV system on the roof of the north stand of the Millerntor stadium. The joint project of LichtBlick and football club FC St. Pauli links high-tech with attitude – sending out a symbol of diversity, inclusion and sustainability visible from afar.

Photo: LichtBlick SE

Prof.-Dr.-Ing. Ulrich Knaack (Technical Universities of Darmstadt and Delft) and Dr. Thomas Kroyer (Fraunhofer Institute for Solar Energy Systems – ISE) about how to deploy BIPV more often in future and the new solutions available.

Renewable energy is the most important source for rising electricity needs also in the heating and mobility sectors in transition – especially via wind energy and photovoltaics, also due to their comparatively low generation costs. However, the by far biggest growth potential for photovoltaics is held by building skins, which with their large usable expanses –when equipped with PV– would make energy supply in cities more sustainable.

Solar building skins reduce the CO₂ emissions of the building sector

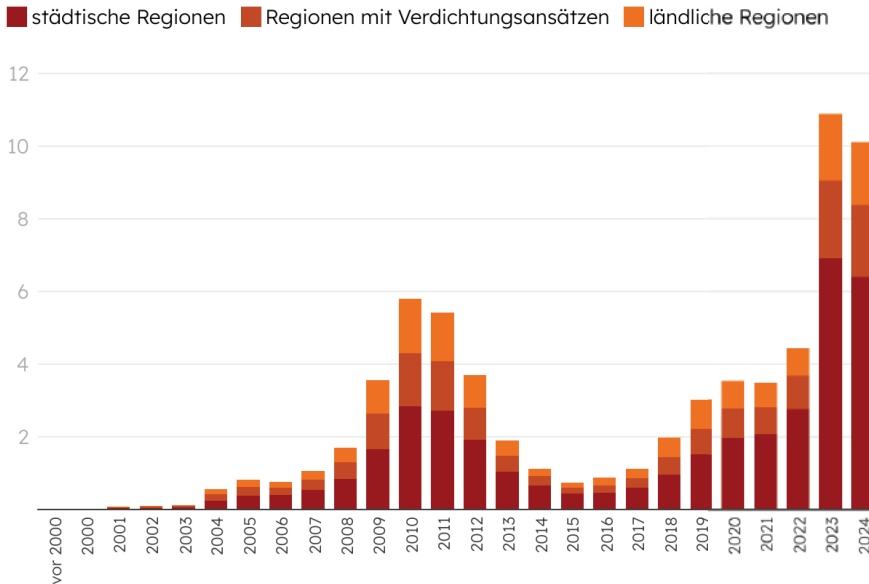


The large-surface BIPV system, which LichtBlick (Hamburg) took the lead in planning, annually generates some 285,000 kilowatt hours of green power on the roof of FC St. Pauli – enough for around 80 apartment buildings. At the same time, 135 to 140 tons of CO₂ are saved. The 1,080 coloured modules with MorphoColor technology were produced by module manufacturer Megasol with colour-coated cover glass by AGC Inter pane Architectural Glass.

Photo: LichtBlick SE

Entwicklung der Inbetriebnahme von gebäudenaher Photovoltaik-Leistung nach Siedlungsstruktur

In GWp



Stand: April 2025

Grafik: dena, Quelle: Bundesnetzagentur (2025), opendatasoft (2025), BBSR (2025)

dena

Trend in building-integrated photovoltaics in Germany: in 2023 and 2024 over 10 gigawatts of new solar-power generation capacity were installed.

Dark red = Urban regions, Red = Regions with partial agglomerations, Orange = Rural regions

Chart: dena, Source: Bundesnetzagentur (Federal Grid Agency –2025), open data soft (2025), BBSR (2025)

considerably, offer shading, avoid grid extension costs and generate sustainable added value locally. One of the reasons why BIPV is still too rarely considered for vertical installation could be the lack of creative freedom associated with PV



Prof. Dr.-Ing. Ulrich Knaack, Head of the Façade Structures department at the Technical University of Darmstadt and Head of Chair "Design of Construction" at TU Delft.

Photo: Ulrich Knaack

module design. Architectural glass with built-in PV cells (such as Sunplus BIPV, Pilkington) has made it possible to toy with patterns for some years already, but there has hardly been any colour design options for highly efficient BIPV modules so far: "In my understanding, more possibilities to adapt the colour and dimensions of modules to the desired geometry and aesthetics of the building are needed for a stronger uptake of building-integrated photovoltaics especially in façades," explains Prof. Dr.-Ing. Ulrich Knaack, Head of the Façade Structures department at TU Darmstadt and Head at the "Design of Construction" chair at TU Delft.

"Module aesthetics follow façade aesthetics. And vice versa: through colour-customisable modules architects can design the aesthetics of façades. We have to understand BIPV façade

components like bricks, clinker bricks or design panels: here we can select from a wide variety of surfaces and now also sizes and then also use these in custom patterns— with a view to achieving a desired individuality." One obstacle on the way to colour customisation has so far been the low efficiency rates of designed module glass compared to conventional black modules.

COLOURED BIPV FOR DESIGNING FAÇADES

The Fraunhofer Institute for Solar Energy Systems ISE had already been working on a solution for several years, which has now also reached market readiness for large volumes and any module dimension. Dr. Thomas Kroyer, a researcher at Fraunhofer ISE, developed the patented "MorphoColor" technology with his team: unlike colour pigments or coloured films some of which strongly shade the module, the Institute produces the desired colour by an interference layer that makes it possible to precisely select and optically reflect individual wavelengths in order to generate an intense colour. For the remaining large spectrum of sunlight the glass remains transparent and the energy



Dr. Thomas Kroyer, Division Climate-Neutral Heat and Buildings, Head of Group Coating Technology and Systems, Fraunhofer Institute for Solar Energy Systems ISE.

Photo: Fraunhofer ISE



The office building of Enerparc company in Hamburg shows the versatile applications for building-integrated photovoltaics. Here architectural glass with integrated PV cells (Sunplus BIPV, Pilkington) is used. Photo: Constantin Meyer

development was subsidised by the Federal Germany Ministry for Economic Affairs and Climate Action as part of the “PVHide” Project. The most recent, and so far biggest, project involving MorphoColor technology is the PV system on the roof of the North stand of Hamburg’s Millerntor stadium in rainbow colours; LichtBlick SE was the lead planner.

glasstec 2026 in Düsseldorf from October 20-23, 2026 will once again be the central and leading trade fair providing the impetus for exchanging on tomorrow’s topics in the glass industry – and these also include Building-Integrated Photovoltaics (BIPV).

loss remains low. Dr. Kroyer explains: “There are many well suited surfaces on roofs and façades for photovoltaics to be integrated in a meaningful way. With our solution we give architects the freedom to use PV modules as design features. Alternatively, the PV functionality can also be concealed completely. In most cases, you can still see up close that these are PV modules but seen from a few metres away you no longer notice the difference between these and normal façade panels.”

Depending on their tint, coloured PV modules with this MorphoColor coating boast an excellent 90-96% of the efficiency of comparable black modules: “With conventional solar modules the majority of the energy is converted into power from the incident photons of the long-wave red light. The short-wave blue light, by contrast, is only used to a lesser extent. This is why the power loss is lower when blue light is reflected rather than red light. A module with

a blue cover glass therefore has a slightly better efficiency rate (96% of the performance of a black module) than a red one (94%).”

Coloured photovoltaics offer new possibilities not only in façades but also where you initially might not expect them – for instance when protecting listed buildings and ensembles. Dr. Kroyer adds: “PV installation on the roofs of such listed buildings had been difficult until now. However, red modules blend very well with the cityscape for typically red roofing.” With a view to also realising large-format cover glass and extensive projects, Fraunhofer ISE has now developed its technology to market readiness in cooperation with licensee AGC Plasma; this company applies the coatings in Lauenförde using magnetron sputtering to achieve homogeneous colours and a high stability of angle and was also a funding partner alongside the Institute and photovoltaic module producer Axsun (located near Ulm/Germany). The

Read more at: <http://www.glasstec.de/>

About glasstec

glasstec is the world-leading trade fair for glass production, finishing and products and held every two years at the Düsseldorf Exhibition Centre. From October 20-23, 2026, it will bring together international decision-makers, market leaders and experts from the entire glass industry.

The trade fair is the central platform for innovations, trends and knowledge transfer uniting experts from industry, skilled crafts, research and science. It covers the complete value chain of the material that is glass – from manufacturing to processing to versatile applications. glasstec 2026 will focus on the topics of the future: Artificial Intelligence AI & Digital Technologies, Decarbonisation and Circular Economy. The trade fair provides room for in-depth expert exchange, initiation of concrete business and strategic investment decisions ■

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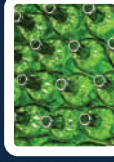
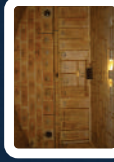
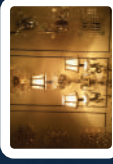
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Technology Driven Cost Management for Operational Efficiency - Linking Industry 4.0



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Abstract

The emergence of Industry 4.0 marks a fundamental shift in how organizations manage costs and drive operational efficiency. Traditional cost management approaches, which relied heavily on reactive cost-cutting measures such as budget controls, manpower reduction, and expense minimization, are increasingly inadequate in a fast-paced, technology-driven business environment. Industry 4.0 introduces a new paradigm where advanced digital technologies—including the Internet of Things (IoT), Big Data & Analytics, Artificial Intelligence (AI), Machine Learning (ML), Robotics & Automation, Cloud Computing, Cybersecurity, and Augmented and Virtual Reality (AR/VR)—are leveraged to proactively optimize resources, reduce waste, and enhance productivity.

IoT enables real-time visibility, predictive maintenance, and energy optimization, while big data analytics uncovers hidden inefficiencies and supports evidence-based decision-making. AI and ML extend these benefits by automating processes, improving demand forecasting, and enhancing quality control. Robotics and automation improve speed, precision, and safety, lowering rework and downtime costs. Cloud computing provides scalability, agility, and cost-efficient IT infrastructure, while cybersecurity protects organizations from financial, operational, and reputational risks. AR and VR further enhance training effectiveness, product design, maintenance, and customer engagement at lower costs.

Collectively, these Industry 4.0 technologies transform cost management from a defensive function into a strategic enabler, fostering operational resilience, sustainability, and long-term competitive advantage in an increasingly complex and uncertain business environment.

A seasoned Cost & Management Accounting professional with over 25 years of experience, he specializes in optimizing business processes, implementing accounting systems, and deploying ERP solutions. His experience across diverse industries like FMCG, Telecommunication Healthcare has equipped him to guide SMEs in adopting effective management accounting practices.

scale significantly lowered production costs, improved productivity, and raised living standards. Cost management during this era focused on volume-driven efficiencies and process standardization.

The Third Industrial Revolution, also known as the Digital Revolution, emerged in the late 20th century with the rise of electronics, computers, automation, and the internet. This phase introduced information systems, enterprise software, and global connectivity, enabling organizations to improve coordination, reduce transaction costs, and optimize supply chains.

Today, the world stands at the threshold of the Fourth Industrial Revolution (Industry 4.0). Unlike earlier revolutions, Industry 4.0 integrates the physical, digital, and biological worlds into intelligent, interconnected ecosystems. Technologies such as AI, IoT, robotics, cloud computing, big data analytics, and immersive technologies enable machines, systems, and humans to interact in real time.

The Industrial Revolution fundamentally altered the way societies worked, produced goods, and organized economic activity. Each phase of industrial transformation not only reshaped production systems but also redefined how organizations managed costs and efficiency.

The First Industrial Revolution in the late 18th century introduced mechanization powered by steam

engines. This transition from manual labour to machine-based production increased output and reduced unit costs, particularly in textile manufacturing, while driving urbanization and industrial growth.

The Second Industrial Revolution, beginning in the late 19th century, was characterized by electricity, mass production, and assembly lines. Standardization and economies of

From a cost management perspective, Industry 4.0 represents a paradigm shift. Cost control is no longer reactive or limited to accounting exercises; instead, it is predictive, technology-driven, and strategically aligned with organizational goals. The following sections explore how key Industry 4.0 technologies contribute to operational efficiency and sustainable cost management.

INTERNET OF THINGS (IOT)

The Internet of Things (IoT) connects physical assets—machines, sensors, equipment, vehicles, and logistics networks—through digital interfaces, enabling real-time data exchange and control. This continuous data flow plays a vital role in technology-driven cost management by improving operational efficiency, reducing wastage, and supporting informed decision-making.

IoT-based energy management systems monitor electricity, water, and gas consumption in real time. By automatically optimizing equipment usage and regulating HVAC systems, organizations can significantly lower utility costs while supporting sustainability initiatives. Predictive maintenance is another critical benefit of IoT adoption. Sensors track machine parameters such as vibration, temperature, and pressure to detect early signs of failure, allowing maintenance teams to address issues before breakdowns occur. This reduces unplanned downtime, emergency repair costs, and asset replacement expenses while extending equipment life.

In inventory management, RFID tags and smart sensors provide real-time stock visibility, minimizing overstocking, stockouts, pilferage, and storage costs. IoT data also highlights process bottlenecks, enabling automation and process

redesign to reduce waste and rework. Additionally, IoT wearables enhance workforce safety in hazardous environments, lowering accident-related costs, compensation claims, and insurance premiums. Fleet tracking and route optimization reduce fuel consumption, transportation delays, and logistics expenses, while real-time quality monitoring detects defects early, preventing costly recalls and reputational damage.

A practical example is Siemens, which uses IoT sensors in gas turbines and manufacturing plants to monitor vibration, temperature, and pressure. Early failure detection has resulted in lower maintenance costs, fewer unplanned shutdowns, and longer equipment life.

Despite its benefits, IoT adoption in Indian corporates faces several challenges, including high initial investment, cybersecurity risks, integration complexity, infrastructure limitations, skill shortages, regulatory compliance, scalability issues, and workforce resistance.

BIG DATA & ANALYTICS

Industry 4.0 has led to an explosion in data generation from machines, customers, supply chains, and digital platforms. Leveraging Big Data & Analytics enables organizations to transform this vast data into actionable insights, driving smarter, faster, and more cost-effective decision-making.

ADVANCED ANALYTICS UNCOVERS HIDDEN

Inefficiencies in energy consumption, material usage, and operational processes, allowing organizations to optimize resource utilization and reduce operational costs. Predictive analytics forecasts equipment failures, minimizing downtime and avoiding expensive breakdowns. Data-driven

insights into supplier performance, lead times, and logistics enhance supply chain efficiency by improving procurement decisions and reducing excess inventory.

Workforce analytics evaluates shift patterns, idle time, and overtime, helping organizations optimize staffing levels and control labor costs. Production analytics identifies bottlenecks and rework causes, improving throughput, quality, and cost efficiency. Additionally, route optimization analytics reduces fuel consumption and delivery delays, while fraud detection tools identify anomalies in procurement, billing, and claims, preventing revenue leakage.

A notable example is Amazon, which uses big data analytics to analyze demand patterns, customer behavior, and logistics routes. This enables precise inventory planning, faster deliveries, reduced warehousing costs, optimized transportation expenses, and lower stock-out losses.

However, Indian corporates face challenges such as high infrastructure costs, poor data quality, legacy system integration issues, talent shortages, cybersecurity risks, compliance requirements under the DPDP Act, weak data governance, scalability constraints, and low data literacy.

ARTIFICIAL INTELLIGENCE (AI) & MACHINE LEARNING (ML)

Artificial Intelligence and Machine Learning significantly enhance the capabilities of analytics by identifying patterns, automating decisions, and continuously improving outcomes. In cost management, AI and ML enable predictive and proactive operations rather than reactive control.

AI-driven predictive maintenance detects early failure patterns, reducing unplanned downtime and emergency repairs. Energy management systems dynamically optimize electricity

usage by adjusting lighting, HVAC, and production schedules. ML-based demand forecasting prevents overproduction, stock outs, and excessive inventory holding costs.

Administrative automation through AI-powered bots streamlines invoice processing, scheduling, and data entry, leading to substantial manpower savings. Workforce analytics optimizes staffing levels by analyzing productivity trends. AI-enabled vision systems strengthen quality control by detecting defects in real time, minimizing rework and warranty claims. AI-driven logistics optimization reduces fuel consumption and fleet maintenance costs, while anomaly detection systems prevent fraud and financial losses.

Unilever provides a strong example by using AI for demand forecasting and production planning, resulting in lower inventory costs, reduced waste, and improved service levels.

Despite these benefits, AI & ML adoption in India faces challenges such as high implementation costs, data quality issues, talent shortages, ethical concerns, cybersecurity risks, regulatory uncertainty, lack of explainability, scalability limitations, cultural resistance, and workforce reskilling challenges.

ROBOTICS & AUTOMATION

Robotics and automation are central to Industry 4.0, enabling faster, safer, and more cost-efficient operations. By replacing repetitive and hazardous manual tasks, robotics delivers sustainable cost savings.

Industrial robots operate continuously without fatigue, enabling 24/7 production and higher throughput without additional labor costs. Automated processes ensure precision and consistency, reducing cycle time, material wastage, and rework. Robotics minimizes human

error, extends machine life, and lowers maintenance expenses. Energy-efficient robotic systems further reduce power consumption.

In warehouses, automation and AGVs improve logistics efficiency, reduce manpower dependency, and optimize space utilization. Vision-enabled robots perform real-time quality inspections, lowering returns and warranty claims. Robotics also enhances workplace safety, reducing accident-related compensation and insurance costs.

Toyota exemplifies this approach through extensive use of robotics in welding, painting, and assembly, achieving lower defects, reduced labor costs, and higher productivity.

Despite its benefits, Robotics & Automation adoption in Indian corporates faces several challenges include high capital investment, integration complexity, skill shortages, workforce resistance, limited flexibility, maintenance costs, safety compliance, cybersecurity risks, scalability issues, and regulatory constraints.

CLOUD COMPUTING

Cloud computing has transformed IT cost structures by shifting from capital-intensive models to flexible, pay-per-use operating expenses. By eliminating on-premise infrastructure, organizations reduce hardware, facility, and maintenance costs.

Cloud scalability allows resources to be adjusted instantly, preventing over-investment. Maintenance, updates, and security are managed by providers, reducing IT manpower costs. Energy-efficient data centers lower electricity expenses. Cloud platforms enable remote work, reducing travel and office space costs. Affordable disaster recovery solutions minimize downtime and losses, while

faster deployment reduces time-to-market costs.

Netflix operates entirely on cloud platforms, benefiting from scalability during peak demand, a pay-as-you-use model, and reduced IT maintenance costs.

However, cloud adoption in India faces challenges related to security, compliance, connectivity, vendor lock-in, cost control, integration, skills, availability, data governance, and change management.

CYBERSECURITY

In a digital economy, cyber threats pose significant financial and operational risks. Cybersecurity plays a defensive yet strategic role in cost management by preventing losses and ensuring continuity.

Strong security frameworks prevent ransomware attacks and data breaches, protect intellectual property, ensure regulatory compliance, reduce fraud, boost productivity, lower cyber-insurance premiums, and enable reliable data recovery.

The Maersk cyberattack of 2017, which caused losses of USD 250–300 million, highlights the importance of cybersecurity investment. Post-incident, Maersk strengthened its defenses, improving resilience and reducing downtime risks.

Indian corporates face challenges such as high costs, skill shortages, evolving threats, compliance requirements, legacy system vulnerabilities, human error, weak incident response, data visibility issues, and reputational risks.

AUGMENTED REALITY (AR) & VIRTUAL REALITY (VR)

AR and VR create immersive digital experiences that reduce costs across training, design, maintenance, logistics, and customer engagement. VR enables safe, repeatable training,

while AR provides real-time operational guidance. Remote AR-assisted maintenance reduces travel and downtime. Virtual prototyping lowers material and redesign costs. AR-guided warehouses reduce errors and labor expenses. VR meetings cut travel costs, while VR safety training reduces accidents.

Boeing uses AR glasses in aircraft wiring, reducing errors, wiring time, and production cycles.

Adoption of AR & VR India facing many challenges including high hardware costs, infrastructure requirements, skill shortages, user acceptance issues, integration complexity, security risks, regulatory compliance, rapid obsolescence, maintenance costs, and uncertain ROI.

ROLE OF THE MANAGEMENT ACCOUNTANT IN TECHNOLOGY-DRIVEN TRANSFORMATION

In the era of Industry 4.0, the role of the Management Accountant has evolved from traditional cost reporting to strategic oversight of technology-driven transformation. As organizations adopt technologies such as IoT, Big Data & Analytics, AI, cloud computing, automation, and cybersecurity, Management Accountants play a critical role in evaluating the financial viability and long-term value of these investments. They are responsible for conducting cost-benefit analysis, ROI assessment, and total cost of ownership evaluation to ensure that technology adoption aligns with organizational objectives. By integrating real-time operational data with financial metrics, Management Accountants enable informed decision-making, performance monitoring, and

continuous cost optimization. They also oversee budgeting, capital allocation, and vendor evaluation for technology projects, while managing risks related to data security, regulatory compliance, and scalability. Additionally, Management Accountants act as a bridge between technology teams and senior management by translating complex technical outcomes into financial insights. Through KPI development, variance analysis, and value-based performance measurement, they ensure accountability and governance throughout the technology lifecycle. Ultimately, Management Accountants safeguard financial discipline while enabling organizations to leverage digital technologies for sustainable competitiveness and value creation.

CONCLUSION

The integration of Industry 4.0 technologies into cost management represents a fundamental shift from reactive cost cutting to proactive value creation. Technologies such as IoT, big data analytics, AI, robotics, cloud computing, cybersecurity, and AR/VR embed intelligence across organizational operations, enabling predictive decision-making, resource optimization, and sustainable cost structures.

However, the true value of these technologies can be realized only when their adoption is guided by strong financial oversight and strategic governance.

In this context, the Management Accountant plays a pivotal role in translating technological capabilities into measurable financial outcomes. By evaluating investment feasibility, monitoring returns, managing risks, and integrating real-time operational data with financial performance

metrics, Management Accountants ensure that technology initiatives align with organizational objectives. Their involvement strengthens accountability, supports informed capital allocation, and balances innovation with cost discipline.

Organizations that strategically adopt Industry under sound financial stewardship can reduce downtime, minimize waste, enhance safety, optimize inventory and logistics, and improve customer satisfaction, while supporting sustainability and resilience. In an increasingly competitive and uncertain global economy, technology-driven cost management is not optional but essential. Businesses that combine digital innovation with robust management accounting practices will not only protect margins but also secure long-term growth and competitive advantage in the markets of tomorrow ■

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Originally published in January 2026 edition of The Management Accountant, the journal of the Institute of Cost and Management Accountants of India.



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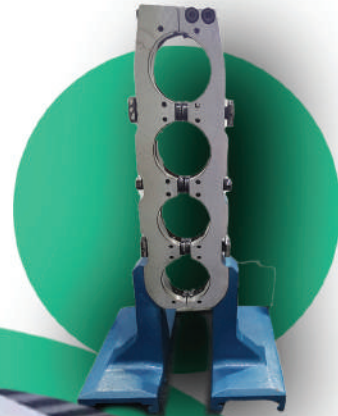
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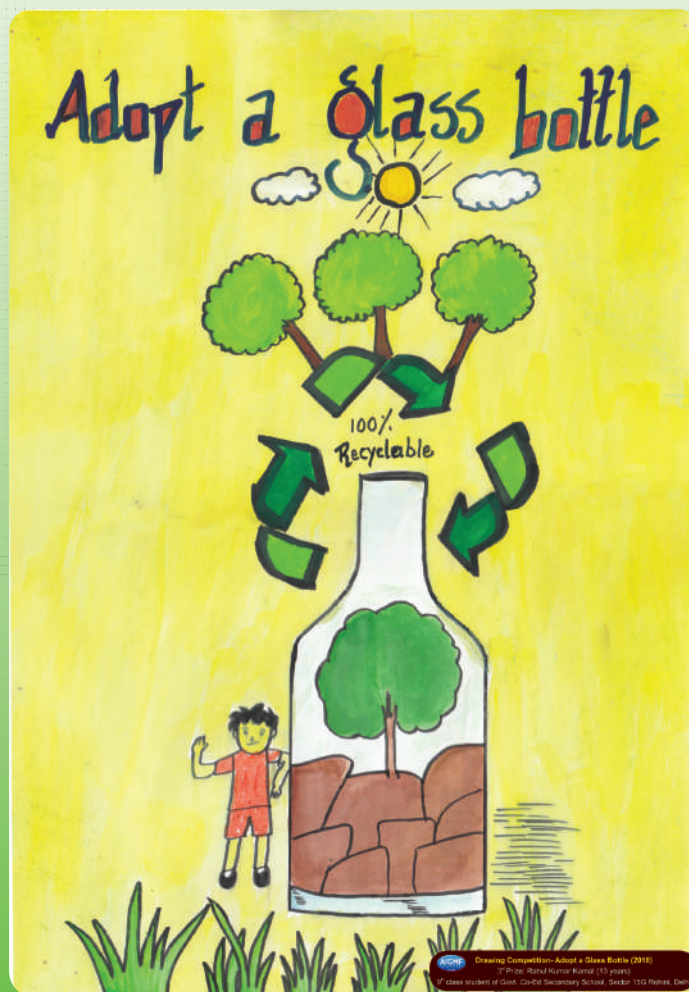
Excellence in Container Glass Manufacturing

An **AIGMF** Publication

www.aigmf.com

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Technical Articles

Price: INR 1000 (within India and including postage)
Overseas: US\$ 75 (including postage and bank charges)

Pay via bank transfer:

Account No.	: 0411156983
Name	: The All India Glass Manufacturers' Federation
A/c Type	: Savings Account
Bank	: Kotak Mahindra Bank
Branch	: G-11 Marina Arcade, Connaught Circus, New Delhi-110 001
IFSC Code	: KKBK0000214
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Container Glass Batching (chapter 2 of 15)

In this chapter from the book on "Excellence in Container Glass Manufacturing", we will learn the following:

1. Container glass raw materials and their specifications
2. Glass composition, glass oxides and their impact on glass quality and price
3. Raw materials sourcing, selection and raw materials cost considerations
4. Batching cost calculation
5. Glass composition, batch recipe and controls
6. Types of batching plants, selection and equipments
7. Quality controls in batching plant

Container glass batch making process consisting of following sub-processes:

1. Incoming RM inspection
2. RM unloading / handling
3. Cullet inspection and usage
4. Cullet processing
5. RM storage
6. Batching & transportation

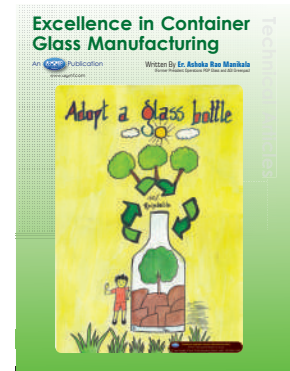
Batching Process is very important process in container glass manufacturing. As the saying— "garbage in - garbage out", the quality of glass produced directly depends upon the input quality of raw materials used. Hence at every stage of batching process, utmost focus on quality is to be maintained to get good quality of glass from melting furnace, for forming. Each raw material is having many variables like physical properties, chemical properties and compositions, and small changes in the raw materials quality can severely impact glass properties, energy required for glass melting and glass

quality etc. Hence it is very important to have very clear specifications for raw materials, good process control, good laboratory analysis and avoid material contaminations.

1.0 Container Glass raw materials and their specifications

Container glass means all Type of glass bottles and jars used for beverages e.g. juices, soft drinks, carbonated drinks, pharmaceutical, cosmetics, perfumes and foods. Glass containers are mostly intended to come into direct contact with the inside content. Therefore, they must comply with their respective specifications for identity and surface hydrolytic resistance. Container glass is generally classified as Type I, II and III glass. Also, there is Type IV glass which is having higher alkali in glass with less hydrolytic resistance. This is a general glass having less batch cost. Lead crystal and special aluminosilicate glasses are also used in container glass manufacturing. Special aluminosilicate glass is emerging as very high-performance pharmaceutical glass but cost is very high.

Ninety-five per cent of glass used for container glass is either soda-lime-silica glass or borosilicate glass (neutral). Soda-lime-silica glass has a moderate hydrolytic resistance due to the chemical composition of the glass



itself; it is classified as Type III. Suitable treatment of the inner surface of Type III soda-lime-silica glass containers will raise the hydrolytic resistance from moderate to a high level, changing the classification of the glass to Type II.

Borosilicate glass contains significant amounts of boric oxide, aluminum oxide, alkali and/or alkali earth oxides. Borosilicate glass has a high hydrolytic resistance and high thermal shock resistance due to chemical composition of the glass itself; it is classified as Type I. Now let us study in details, each Type of container glass and their applications.

1. TYPE I GLASS

Type I borosilicate glass is the gold standard in pharmaceutical packaging, primarily due to its exceptional material properties. Characterized by its low thermal expansion coefficient, this glass Type exhibits remarkable stability under temperature fluctuations. This stability is crucial in environments where drugs are exposed to varying temperatures, ensuring that the integrity of the glass remains intact.

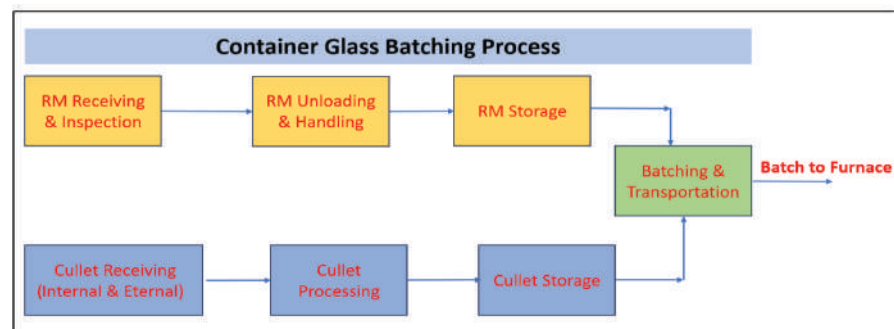


Figure 2.1

Also, its high resistance to chemical attack, makes it an ideal candidate for storing a wide array of pharmaceutical products. Whether the contents are acidic, neutral, or slightly basic, Type I borosilicate glass ensures minimal interaction, preserving the purity and efficacy of the medication. Its use in vials, ampoules, and containers for injectable drugs is widespread, as these applications demand the highest level of chemical inertness to prevent any potential drug-container interactions. The ability of Type I borosilicate glass to maintain the chemical composition of medications unaltered is invaluable for pharmaceutical companies.

Borosilicate glass is a Type of glass that contains silica and boron trioxide as glass formers and sodium oxide as a fluxing agent. It also contains a small amount of alumina and less alkaline solids. The glass formula is:



which usually contains SiO_2 (80.5%), B_2O_3 (13%), Al_2O_3 (0.3%), K_2O (3%) and Na_2O (0.5%)

2. TYPE II GLASS

Type II Glass offers an excellent balance of affordability and safety. As a treated form of soda-lime glass, it undergoes a surface treatment process known as de-alkalization. This process significantly reduces the glass's alkali content on inside surface of the glass, enhancing its chemical resistance compared to untreated soda-lime glass.

Although it doesn't reach the heights of chemical resistance seen in Type I Glass, Type II Glass still offers sufficient protection for less sensitive pharmaceutical preparations. It is an excellent choice for oral medication bottles and containers where the risk of chemical interaction is moderate. The cost-effectiveness of Type II Glass also makes it a popular option,

particularly in scenarios where the stringent requirements for Type I Glass are not necessary. This Type of glass is often used in situations where budget considerations are as crucial as the packaging's protective properties, providing a practical solution for a wide array of pharmaceutical applications. Type II glass also used for packing of high-end beverages, liquors, chemicals and water bottles. The process of making Type II Glass is explained in detail in a separate chapter.

3. TYPE III GLASS

Type III regular soda-lime glass is a widely utilized material in the pharmaceutical industry, particularly for non-critical applications. While less resistant to chemical attacks than Type I or II glasses, its composition is perfectly suited for packaging products where strong chemical resistance is not a primary concern. This makes it an ideal choice for non-aqueous products like tablets, capsules, and powders.

The affordability of Type III Glass is one of its most appealing attributes, offering a cost-effective solution for large-scale packaging needs. Its application is most common in products where the interaction between the medication and its container is less likely to compromise the medication's effectiveness.

Its chemical formula is $\text{Na}_2\text{O} \cdot \text{CaO} \cdot 6\text{SiO}_2$

Where soda serves as a flux to lower the temperature at which the silica melts, and the lime acts as a stabilizer for the silica.

4. TYPE IV GLASS

Type IV Glass is a category of general-purpose soda-lime glass used in the pharmaceutical industry. This Type of glass is not as chemically resistant

as Types I or II, and it's typically used for packaging products where the contents do not directly interact with the glass or are not highly sensitive to the container material. The primary advantage of Type IV Glass is its flexibility and cost-effectiveness, making it suitable for a wide range of non-parenteral products such as oral liquids, topical creams, and ointments. While Type IV Glass does not offer the same level of protection against leaching as borosilicate or treated soda-lime glasses, it is still a viable option for many pharmaceutical applications. Its use is generally preferred in scenarios where the risk of chemical interaction is minimal, and the primary requirement is a practical, economical packaging solution. Because of its versatility, Type IV Glass is the leading choice for less critical pharmaceutical packaging needs.

5. LEAD CRYSTAL GLASS

Lead crystal glassware and tableware is renowned for its exceptional clarity and brilliance, making it an ideal material for crafting high-end glassware and tableware. Lead glass, also known as crystal, is a Type of glass that has been prized for centuries for its exceptional clarity, brilliance, and luxurious appeal. This unique glass variety contains a significant amount of lead oxide, which enhances its optical properties, making it highly desirable for a wide range of decorative and functional applications. Lead glass has a rich history and has been revered for its beauty and versatility. Its distinct characteristics have made it a popular choice for creating exquisite glassware, chandeliers, jewellery, and decorative ornaments. The allure of lead glass lies in its ability to refract light with unparalleled brilliance, creating a dazzling display that captivates the eye and adds an air of sophistication to any setting.

Lead glass is also known as lead-oxide glass or lead crystal which contains at least 20% lead oxide. Its chemical composition is:



It contains lead oxide instead of calcium oxide as compared to soda-lime glass. The addition of PbO makes the glass brighter and more lustrous.

6. ALUMINOSILICATE GLASS

Aluminosilicate glass is emerging as a high-performance contender in pharmaceutical packaging. Characterised by its exceptional strength and durability, this Type of glass is particularly suited for medications that demand an extra layer of protection. Its robust nature makes it an ideal choice for prefilled syringes, cartridges, and other containers where the risk of breakage must be minimized. The increasing demand for more resilient packaging solutions in the pharmaceutical industry has put aluminosilicate glass in the spotlight, signaling a shift towards materials that can provide enhanced security for high-potency drugs.

The glass industries are striving to develop various glass Types to meet the packaging requirements for various applications. From the highly resistant Type I Glass to the economical Type IV Glass, each Type serves a specific purpose, ensuring that products are stored and delivered in the safest and most effective manner possible. The

evolution of glass technology for packaging requirements continues, promising even more advanced and secure solutions in the future.

1.1 Raw materials and batch composition

The decision of raw materials & batch composition requirements is taken based on product requirement, process requirement and cost as shown in Figure 2.2.

We will discuss on each requirement.

Product requirements: Based on the properties of glass required for the product to be packed, the glass composition is decided. For example, for high quality vials, Type I Glass is required and hence borosilicate glass is used. For vodka filling, Type II Glass

temperature, melting temperature, working temperature ranges for container glass forming, annealing temperature etc., are very important which are decided by the glass composition.

Cost / Price: The cost of raw materials, energy cost, melting cost etc., plays an important role in controlling the bottle cost. Glass composition determines the cost of batch, melting energy, annealing energy and forming costs. Hence optimizing the cost is a very important factor. This factor is considered while deciding the batch composition.

2.0 General Compositions of various Types of Glasses (Containers+other Glasses)

Table 2.1

Composition in mass%	SiO ₂	Na ₂ O	K ₂ O	CaO	MgO	Al ₂ O ₃	Fe ₂ O ₃	Diverse
Container Glass								
-Flint	72,6	13,7	0,5	11,0	0,1	1,6	<0,05	0,2 SO ₃ , 0,1 TiO ₂
-Green	72,0	15,1	-	8,4	2,1	1,1	0,4	0,02-0,06 SO ₃ 0,25 Cr ₂ O ₃
-Amber	72,7	13,8	1,0	10,0	-	1,9	0,2	0,05-0,08 SO ₃
Clear Float Glass	71	14	0,8	9	5	1-1,5	0,080	0,2-0,3 SO ₃
Tinted Float Glass	70	14	0,8	9	5	1-1,5	0,3-1,5	0,2-0,3 SO ₃
Display -LCD- glass	58-60	<0,1	<0,1	5-7	0-1	15		± 10 B ₂ O ₃ ± 10 % BaO+SrO
Lighting glass	72,4	17,4	-	5,3	3,7	0,8	-	
Tableware	75,6	13,5	4,1	3,7	2,6	0,4	0,02	
E-Glass'	55,2	0,5	0,5	17,7	4,3	14,8	0,3	0-10 B ₂ O ₃
Insulation wool	64	15,5	1,2	7	3	3,5	0,25	4,5 B ₂ O ₃ ; 0,15 SO ₃
Borosilicate (Pyrex)	80,2	4,5	0,3	0,1	-	2,6	0,07	12,3 B ₂ O ₃
Opal glass	66,9	13,3	2,2	4,8	0,4	6,9	0,08	Up to 6 Fluoride 1,6 BaO
Crystal glass	58,5	1,3	13,1	-	-	-	0,02	25,2 PbO
Lead crystal	54,9	0,2	12,3	-	-	-	0,02	32,0 PbO
Roman glass (first century AD)	70,0	16,5	1,0	7,0	0,6	5,0	-	-

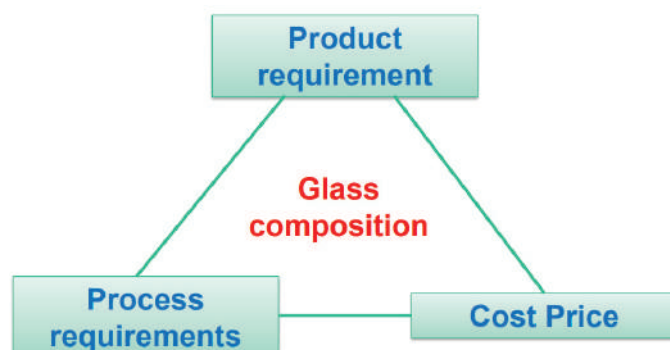


Figure 2.2

is used. For beer filling, Type III Glass is used.

Process requirement: For forming the glass, properties of glass are very important. Softening

The container glass Types are shown in Table 2.1

3.0 Container Glass raw materials

The raw materials used in glass are having oxides and based on the function of oxides in glass making, they are classified into following 3 major categories:

a) **Network forming oxides:** It also has other names like glass

former or glass forming oxides. Oxides, which form glasses when melted and fast cooled, are known as glass forming oxides or network forming oxides, because of their ability to build up a continuous three-dimensional random network. They have the ability to rearrange their bonds during crystallisation process. These oxides are SiO_2 , B_2O_3 , P_2O_5 and GeO_2

b) Network modifying oxide:

The role of a modifying oxide is that when such an oxide, for instance sodium oxide, is introduced into a silica glass to produce a sodium silicate glass system, the structure of glass will change. Furthermore, introducing different amount of Na_2O into a glass forming system result in significant modification in the end glass properties. These modifications are commonly observed on the viscosity of the glass, which influences the properties such as thermal expansion coefficient and/or chemical durability. Other alkali and alkali earth metal oxides, such as lithium, potassium or calcium oxides, can take part in the glass structure in a similar manner to fulfil the role of glass modifiers. However, multicomponent glass systems containing mixed alkalis, as a structural (network) modifying oxides, have far more complex changes in many properties. Network modifying oxides –

Na_2O , K_2O , Li_2O , CaO , BaO , MgO , SrO

c) Intermediate oxides–

An intermediate oxide does not form a glass on its own due to the lack of their glass forming characteristics.

However, such oxides are reported to take part in the glass network only in the presence of a glass network forming oxide. Examples of such oxides are aluminum oxide, titanium oxide, and magnesium oxide. Aluminosilicate, aluminoborate and aluminophosphate glasses are good examples where aluminum behaves as an intermediate oxide.

Other raw materials: Based on their purpose in glass making and use, the raw materials are further categorised as following:

- A) Cullet: Cullet is the rejected glass (internal or external), having very close properties as that of the glass obtained from melting the batch. It contains oxides close to the oxides in glass from batch. It acts as catalyst to improve melting as its melting temperature is far below that of batch made from other raw materials.
- B) Fining agents/redox active components – sulphates: Na_2SO_4 , CaSO_4 ; oxides: As_2O_3 , Sb_2O_3 , CeO_2 ; chlorides: NaCl , Nitrates: KNO_3 , NaNO_3 ; carbon
- C) Fluxing agents – CaF_2 , spodumene (lithium raw material), blast furnace slags/calumite
- D) Colouring agents – Fe_2O_3 , Cr_2O_3 , CoO , Mn_2O_3 , Se, $\text{Fe}_3^+/\text{S}_2^{2-}$, rare earth oxides, sulfides, selenides

Sources of Glass oxides and their properties

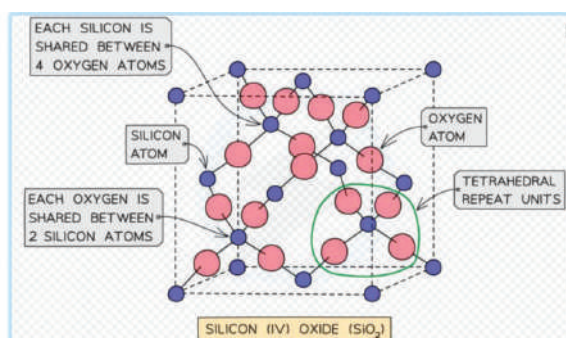
Silica as glass network former.

Silica at high temperatures, liquefies into a very viscous melt that generally impedes crystallization kinetically when it goes below its melting temperature. However, silica melts at 1713°C , and its viscosity at this point is too high to work with any reasonable amount of effort. Temperatures in excess of 2000°C must be attained to work pure silica glasses and these temperatures tend to render such pure silica glasses economically unviable for the majority of glass applications. Hence, to make it easily melt and form containers, modifiers such as soda is used. Natural silica sand or natural quartz stones are the main materials used as network formers for commercial container glass manufacturing.

Other network formers are oxides of boron, phosphorus (P_2O_5), arsenic and germanium. Boric oxide is used in manufacturing borosilicate glass (Type I Glass).

Soda (Na_2O) is a network modifier. Its addition reduces the melting temperature of the silica melt dramatically. Soda (Sodium Oxide) reacts with silica at much lower temperature than melting temperature of silica. In fact, the soda-silica mixture goes into liquid stage at temperature below 1000°C , depending upon amount of soda used.

If soda content is increased in soda-silicate glass, the glass is likely to be chemically attacked by water. Therefore, to produce a useful glass



The materials that form the basic structure of any Glass are called Network Formers. The most common former is silicon dioxide (SiO_2). There are no separate SiO_2 molecules instead they are all linked together to form a Giant network. The silicon and Oxygen atoms are shared between each other as shown in image. Another common network former is Oxide of Boron (B_2O_3). Oxides of Phosphorous, Arsenic and Germanium are also network formers in Glass but they are not used for large volume commercial Glasses.

Figure 2.3

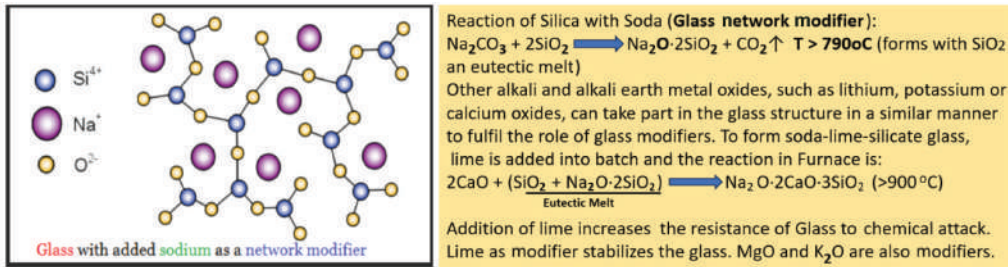


Figure 2.4

that can be melted easily and formed readily, further modifications to glass composition are necessary.

Other glass modifiers are calcium oxide, used for increasing the chemical resistance of glass; magnesium oxide (MgO), used for durability of glass. Other alternative modifiers are potassium oxide, lithium oxide and zinc oxide. Of these, potassium oxide and lithium oxide act similar to soda as fluxes and zinc oxide act in a similar way to CaO and MgO. An excess of calcium oxide to a silica melt will cause devitrification, however additions of small amounts of lime stabilize the

it with the properties it requires for its particular application. Hence intermediate oxides play the role of both former and modifier.

Methodology of glass composition determination

Because the raw materials for glasses are often in carbonate form (for stability reasons) or beneficiated as minerals (compounds containing several oxides), determining the glass composition from raw material batches requires a little mathematics. For the soda- lime silicate (SLS) glass, the raw materials often vary. Let us

now understand how much oxides are going to glass from batch and how much is getting into chimney (atmosphere). The effective oxides remain in the glass from the raw materials is known as yield.

Now let us understand the raw materials determination in glass

Silica sand and quartz is "pure" SiO_2 ; its ratio of oxide to total weight is ~100%. Quartz sand is produced from quartz stone, a mineral whose main component is silicon dioxide (SiO_2). Quartz itself is a hard and chemically stable mineral that is usually transparent or translucent and has good corrosion resistance. Silica sand usually refers to a sand-like substance whose main component is silicon dioxide, but it is not necessarily pure quartz. The silicon dioxide component in silica sand may include other silicon minerals besides quartz, such as feldspar, alumina. Therefore, there may be greater variability in the purity and mineral composition of silica

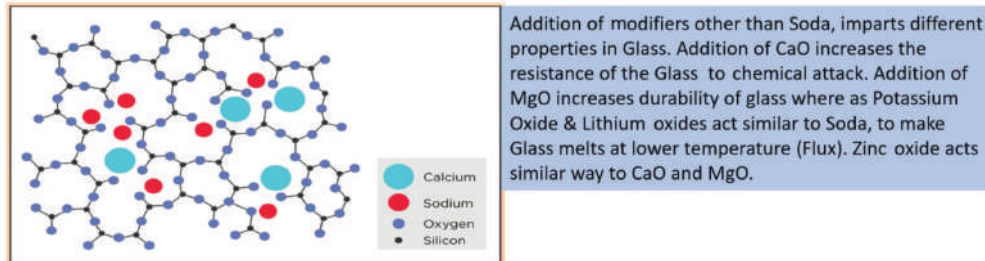


Figure 2.5

glass melt with respect to water, fixing the problem of water solubility introduced with the soda component.

Intermediate oxides: These are oxides which act partly as network former and partly as network modifier. Hence, they are known as intermediate oxides. Alumina (Al_2O_3), Lead oxide (PbO) are the intermediate oxides used in glass to make it more workable and provide

Requirements - Physical Properties of Raw Materials used in Glass Manufacturing

Table 2.2

Grain Size Conversion Charts and Recommended Sizes for Glass Raw Materials			
U.S. MESH	MICRONS	INCHES	MILLIMETERS
3	6730	0.2650	6.730
4	4760	0.1870	4.760
5	4000	0.1570	4.000
6	3360	0.1320	3.360
7	2830	0.1110	2.830
8	2380	0.0937	2.380
10	2000	0.0787	2.000
12	1680	0.0661	1.680
14	1410	0.0555	1.410
16	1190	0.0469	1.190
18	1000	0.0394	1.000
20	841	0.0331	0.841
25	707	0.0280	0.707
30	595	0.0232	0.595
35	500	0.0197	0.500
40	400	0.0165	0.400
45	354	0.0138	0.354
50	297	0.0117	0.297
60	250	0.0098	0.250
70	210	0.0083	0.210
80	177	0.0070	0.177
100	149	0.0059	0.149
120	125	0.0049	0.125
140	105	0.0041	0.105
170	88	0.0035	0.088
200	74	0.0029	0.074
230	63	0.0024	0.063
270	53	0.0021	0.053
325	44	0.0017	0.044
400	37	0.0015	0.037

Grain Size Distribution Silica Sand	
> 0.84 mm - 0%	
> 0.60 mm - 1% max	
< 0.125 mm - 1% max	
Grain Size Distribution Nepheline Syenite	
> 0.84 mm - 0%	
> 0.50 mm -3.5% max	
< 0.1 mm - 20% max	
Grain Size Distribution Lime & Dolomite	
> 3.15 mm - 0%	
> 2.0 mm - 10% max	
< 0.1 mm - 20% max	
Grain Size Distribution Soda Ash	
> 1.19 mm - 0%	
> 0.59 mm - 3% max	
< 0.074 mm -3% max	



Quartz is generally white in color with high % of SiO₂. It is processed by quartz stone crushing. Silica sand is naturally available in land close to sea. This sand may be washed by rain water for many years making it suitable for Glass manufacturing. This naturally available sand requires processing like washing, drying, sieving. The composition of silica sand may vary from mine to mine, location to location.

Figure 2.6

sand. Its true purity varies depending on the site from where it is mined.

High Quartz contains +99% SiO₂

The chemical composition of silica sand determines its quality and suitability for Glass applications. High-purity silica sand typically contains 96–99% silicon dioxide (SiO₂). However, minor impurities can influence its properties. Common impurities include:

Iron Oxides (Fe₂O₃): Affects color and transparency.

Aluminum Oxide (Al₂O₃): Impacts thermal resistance.

Calcium Oxide (CaO): Alters the sand's reactivity.

Magnesium Oxide (MgO): Affects structural stability.

Potassium Oxide (K₂O) and Sodium Oxide (Na₂O): Influence melting and fusion properties.

The other impurities which are found in natural sand are chromium (Cr₂O₃) titanium (TiO₂) and volatile compound (LOI).

Soda ash is sodium carbonate (Na₂CO₃); when heated, it transforms into Na₂O and CO₂. Its oxide to total weight ratio is 0.585. Only 58.5% Na₂O is going into glass and balance is going to chimney as CO₂. General composition of soda ash is shown in Figure 2.7.

Limestone is calcium carbonate (CaCO₃) and releases CO₂ on decomposition like soda ash as shown in Figure 2.8. There are 0.56 units of lime per unit of limestone.

Soda feldspar/albite: Feldspars and other feldspathic materials such as nepheline syenite are mostly used in the glass and ceramic industries. Feldspar consists essentially of aluminum silicates combined with varying percentages

of potassium, sodium, and calcium, and it is the most abundant mineral of the igneous rocks. The two Types of feldspar are soda feldspar (7% or higher Na₂O) and potash feldspar (8% or higher K₂O). Feldspar-silica mixtures can occur naturally,

such as in sand deposits, or can be obtained from flotation of mined and crushed rock.

The glass industry prefers to use orthoclase (potassium feldspar) mainly because it tends to make the melt transparent, while albite (sodium feldspar) tends to melt the clear glass. Anorthite (calcium feldspar), although it contains twice as much alumina as sodium and potassium feldspar and also contains lime, another important component of glass, is not preferred in glassmaking because it is more heat-resistant and has a high melting point. Feldspar acts as a melting agent, lowering the melting temperature of quartz and helping to control the viscosity of the glass, thereby reducing production costs.

Soda Feldspar (Na₂O-Al₂O₃-6SiO₂), also known as albite, is a mineral which contributes both soda and alumina to glass. It contains 11.8% Na₂O, 19.4% Al₂O₃ and 68.7% SiO₂ per unit of soda feldspar.

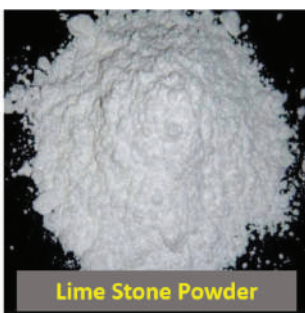
Figure 2.9 shows different Types of feldspar and their properties.

Without going into deeper understanding of other raw materials, let us look at the reaction/decomposition of RM (and their yield into glass)



Na₂CO₃ → Na₂O + CO₂ ↑ (Reaction in Glass Furnace at Temperature above 900 Deg C)
 100kg 58.5kg + 41.5kg ↑
 Purity: Sodium Carbonate (Na₂CO₃) – 99.5%, Na₂O – 58.5%
 Bulk Density: 951–1250 kg/m³

Figure 2.7



Decomposition of Calcium Carbonate (Lime Stone)
 CaCO₃ → CaO + CO₂ ↑ Molecular weight of CaCO₃ 100, CaO is 56 and CO₂ is 48
 Molecular weight is sum of individual atomic weights multiplied by the number of atoms of each elements in it. In this case, atomic weight of Ca, C and O are 40, 12 and 16 respectively. Hence Molecular weight of CaCO₃ is 40+12+(3x16) =100. Molecular weight of CaO is 40+16 =56 and that of CO₂ is 12+(2x16) = 44 . As CO₂ is Gas, it will leave the furnace as Gas, leaving CaO into Glass. Hence lime stone will give only 56% as CaO to the Glass.

Figure 2.8

- a) Potassium Carbonate: It releases potassium nitrate into glass.
($K_2CO_3 \implies K_2O + CO_2$)
- b) Dolomite: It is a combination of calcium and magnesium carbonate composition and is an extremely useful mineral in the glass industry because CaO and MgO act as network modifiers in the glass manufacturing process. Dolomite influence glass transition temperature, density, rigidity, durability, and dimension stability. Dolomite powder for glass industry requires high-grade dolomite with as little iron and silica as possible.
 $CaCO_3 \cdot MgCO_3 \implies CaO + MgO + 2CO_2$
- c) Sodium Sulphate
- d) Calcium Sulphate
- e) Sodium Borate
- f) Sodium Hydroxide (Caustic Soda)
- g) Sodium Nitrate
- h) Furnace Slag
- i) Black Soda
- j) Potassium Nitrate
- k) Potassium Carbonate

SiO₂ forms an excellent glass but has a high melting temperature (>2000°C).

- Fluxes are added to reduce the melting temperature to below 1600°C. Common fluxes: alkali oxides (usually Na₂O or K₂O), PbO.
- PbO is very good at dissolving impurities (e.g. refractory particles) but is toxic.
- Addition of alkali oxides causes degradation of many properties, especially chemical resistance. This degradation can be reduced by using property modifiers e.g. alkaline earth oxides, transition metal oxides, alumina. These oxides cause a small increase in processing temperatures, but improve glass properties.
- Colorants are added to control the colour of the glass. They are usually, oxides of 3d transition metals or 4f rare earths.
- Gold and silver can also produce colours by formation of colloids in glasses.
- Iron oxides (impurities in sands) are often unintentional colorants.
- Decolorants can be added to counteract the effect of other colorants.
- Fining agents are added to remove bubbles from the melt. They include As₂O₅, Sb₂O₃, NaCl,

CaF₂, NaF, Na₃AlF₆ and some sulphates. They are added in very small amounts (< 1 wt %)

Batch composition and yield calculation

Now, one could have understood how much each raw material will give oxides into glass. With this knowledge, it will be now easy to calculate the glass oxides and yield. It should be noted that moisture content in each raw material should not be considered in deciding batch composition calculation and yield calculation as water is not going to give any oxides into glass, instead it will evaporate in furnace or while transporting the batch. Proper control of moisture is very important as this will increase the raw material cost, energy cost and RM transport cost.

Table 2.3 shows an example of batch recipe for one glass manufacturing plant. We learn how to calculate the glass composition and yield.

Table 2.3

Raw Material	Weight Kgs.
Silica sand	1000
Soda ash	300
Lime stone	240
Feldspar	100
Sodium Sulphate	12
Dolomite	90
Cullet	900


Now let us understand how to calculate the glass composition and yield.

First, one should have complete chemical composition analysis of each raw materials and keep in excel format.


Next enter the batch recipe details in Excel and then calculate the theoretical oxides going inside as shown in Table 2.4. The glass composition can be easily

Container Glass raw materials-Summary


- Most commercial glasses use SiO₂ as the network former.



Soda Feldspar (Albite)



Potash Feldspar (Orthoclase)



Nepheline Syenite

Nepheline syenite (silicate, naturally occurring blend of albite, microcline and nepheline) is a feldspatic mineral mined in Canada and Norway. Nepheline syenite is used within the glass batch to promote faster melting at lower temperatures whilst at the same time decreasing viscosity. Its addition therefore helps to reduce overall energy consumption. Nepheline syenite increases the chemical resistance and stability of the finished glass.

Feldspar	Formula	Theoretical Chemical Composition				
		K ₂ O	Na ₂ O	CaO	Al ₂ O ₃	SiO ₂
Orthoclase- Potash	K ₂ O.Al ₂ O ₃ .6SiO ₂	16.9	-	-	18.4	64.7
Albite- Soda	Na ₂ O. Al ₂ O ₃ .6SiO ₂		11.8		19.4	
Anorthite- Calcium	CaO. Al ₂ O ₃ .2SiO ₂			20.1	36.62	
Nepheline Syenite	Combination of Minerals	6.5	4.2	2.2	21.5	61.3

Figure 2.9

found by making an Excel file and incorporating formulas, which will give the composition once the raw material's oxide value and weight of each RM as per batch recipes entered. As the cullet is generally having close composition as that of virgin glass from batch, yield is not calculated with cullet as 100% cullet used is converted into glass in furnace.

4.0 Batch cost calculation

There are two ways of calculating the cost. One is cost per ton of batch or cost per ton of glass (Table 2.5).

Cost per ton of glass is straight forward to calculate. Decide the recipe and then calculate the cost of each RM by multiplying weight and rate. Add the cost of all the raw materials. By dividing the cost of all raw materials with total batch weight, cost/ton of batch will be calculated. In the example below, calculated the batch cost/ton of batch and also batch cost/ton of glass in Indian Rupees. Same thing can be calculated by changing price in your local currency.

Batch Optimisation: In the above example, we have considered only the virgin batch cost of 5 raw materials and cullet cost is not added. The cost can be worked-out considering the cullet cost and that of all other materials used like colouring agents. By changing the raw materials without changing the desired glass oxides, one can optimise the batch recipe for achieving lowest cost per ton of glass. It is always advisable to workout

Table 2.4

Glass Batch Calculation									
Raw Material Composition as % (Oxides into Glass)									
RM	SiO ₂	Na ₂ O	CaO	K ₂ O	Al ₂ O ₃	MgO	Fe ₂ O ₃		
Sand	98.8	0.22	0.01		0.77	0.02	0.04		
Soda		58.5					0.002		
Lime stone	0.94		56.5		0.31	0.12	0.18		
Feldspar	66.5	9.4			1	17.8	0.3		
Dolomite	1.2		30.41			21.8	0.25		
Sod.Sulphate	0	43.6	0	0	0	0	0.07		
Batch Calculation: Oxides going into Glass (Kgs): (Weight x % of Oxide in RM/100)									
RM	Weight Kgs	SiO ₂	Na ₂ O	CaO	K ₂ O	Al ₂ O ₃	MgO	Fe ₂ O ₃	Total Glass Oxide Kgs
Sand	1000.00	988.00	2.20	0.10	0.00	7.70	0.20	0.40	998.60
Soda	325.00	0.00	190.13	0.00	0.00	0.00	0.00	0.01	190.13
Lime Stone	220.00	2.07	0.00	124.30	0.00	0.68	0.26	0.40	127.71
Feldspar	100.00	66.50	9.40	0.00	1.00	17.80	0.00	0.30	95.00
Dolomite	94.00	1.13	0.00	28.59	0.00	0.00	20.49	0.24	50.44
Sod. Sulphate	12.00	0.00	5.23	0.00	0.00	0.00	0.00	0.01	5.24
									0.00
Total	1751.00	1057.70	206.96	152.99	1.00	26.18	20.96	1.35	1467.12
Glass Comp		72.09	14.11	10.43	0.07	1.78	1.43	0.09	
									83.79 Yield

batch cost per ton of glass and not batch cost per ton of batch. Please note that the yield value of each raw materials will be different and hence the cost per ton of batch is not giving the exact impact of recipe on glass cost.

5.0 Batching plant operation

Now let us delve into batch plant operation.

1. **Incoming RM Inspection:** As explained earlier, most of the raw materials used in container glass manufacturing are minerals and there will be many variations in physical & chemical properties of each lot of RM received. This is mainly because the minerals while mining will have lot of variations in properties with

respect to depth, site and climate conditions. Also, there can be contamination issues in RM while processing RM, packing and transportation. Hence every glass industry should have very clear specifications for each raw materials mentioning acceptable limits for physical and chemical parameters. As small changes in properties of RM will have impact on cost, melting and glass quality, good inspection of all RMs is necessary. Every lot to be checked physically and also checked for composition in laboratory before accepting for use.

2. **RM Unloading / Handling:** Unloading and handling of raw materials is also important activity

Table 2.5

Batch Cost Determination - Cost per Ton of Batch				Batch Cost Determination - Cost per Ton of Glass				
RM	Weight as per Recipe Kgs	Rate/ Kg INR	Total Cost INR	RM	Weight as per Recipe Kgs	Rate/ Kg INR	Total Cost INR	Total Glass Oxide Kgs
Sand	1000.00	3	3000	Sand	1000.00	3	3000	998.6
Soda	325.00	45	14625	Soda	325.00	45	14625	190.1
Lime stone	220.00	5	1100	Lime stone	220.00	5	1100	127.7
Feldspar	100.00	4	400	Feldspar	100.00	4	400	95.0
Dolomite	94.00	6	564	Dolomite	94.00	6	564	50.4
Sod.Sulphate	12.00	35	420	Sod.Sulphate	12.00	35	420	5.2
Total	1751.00		20109	Total			20109	1467.1
Batch Wt.in Ton	1.75			Glass Wt.in Ton				1.4671
Batch Cost INR / Kg			11.48	Batch Cost/ Kg of Glass				13.71
Batch Cost INR / Ton			11484	Batch Cost/ Ton of Glass				13707

as it will have direct impact on cost and quality. If unloading is taking very long, then the truck or container to be detained for longer period and the vendor will definitely charge or consider the cost of RM. Also, if not unloaded properly, contamination issues, loss of material, environmental issues may crop up. Hence good procedure for unloading and handling is required. As the inhalation of dust from raw materials can lead to some diseases to unloading/ handling crew, every precaution to unload safely without dust creation should be taken. Also, automation for unloading of RMs to be incorporated for safety, quick unloading and for avoiding mix-up. Housekeeping in batching plant is very essential and proper cleaning of handling equipments after every change in raw materials is necessary to avoid mix-up and contamination.

5.1 CULLET PROCESSING & USAGE

For general public, “cullet” is typically an unfamiliar word but in glass industry, it is used commonly on daily basis. It is believed that the first use of this word started in the year 1817, perhaps from French word cueillette, meaning act of gathering (Latin word collecta).

Cullet refers to crushed or broken glass that is used in the production of new glass products. It is typically composed of glass that has been rejected or discarded, often due to damage or breakage, and is generally of the same composition as the mineral mixture used in glassmaking. The inclusion of cullet in the glass batch is beneficial because it melts early in the furnace, helping to bring the mineral particles together and

accelerating the reactions necessary for glass formation.

Cullet has been an integral part of glassmaking for many years due to its role in improving the efficiency of the melting process. The use of cullet in glass production is also a form of recycling, as it involves reusing waste glass to create new glass products. This practice helps reduce the need for raw materials and can lower energy consumption in the glassmaking process. The use of recycled glass (cullet) in the manufacturing process has major advantages. Cullet reduces the consumption of natural raw materials such as sand or synthetic materials such as sodium carbonate. By replacing raw materials, it reduces CO₂ emissions on two levels: by lowering the energy required for melting and by decreasing the use of raw materials whose melting emits carbon dioxide.

Today, cullet is the main raw material for glassmakers. Its incorporation rate in the furnaces has increased considerably in recent years. This rate could technically reach up to 95% for certain colors. Today it is mainly the availability of cullet that limits this integration. There are many difficulties in collection of cullet due to various reasons. Collection of cullet requires a lot of effort and dedication.

Despite the benefits, recycling glass and using cullet can be challenging. One of the main difficulties is separating glass from other waste materials and sorting it by color, as different colors of glass must be processed separately to maintain the quality of the final product. Nevertheless, cullet remains a crucial component in glass manufacturing, with usage rates varying significantly by country, ranging from 35 to 95 per cent in new glass production. Figure 2.10 shows the typical cullet received from market.

CULLET PREPARATION

Within the intricate realm of glass production, the process of preparing cullet for use in glass manufacturing takes center stage as a critical phase that weaves together sustainability, quality, and innovation. This crucial step acts as the gateway to transforming discarded glass into useful cullet to form new glass products, championing both environmental consciousness and manufacturing excellence.

Collecting and preparing Cullet: The journey of cullet begins with the collection of recycled glass, often sourced from used glass bottles and the remnants of previous glass production. This raw material, once collected, undergoes a meticulous preparation process. Initially, the



The cullet received from market contains caps, labels, mud and impurities along with different colored glasses. This cullet can be used after proper processing & sorting. The process includes crushing, washing, sorting as explained in this article. It is difficult to do the sorting manually and hence many Glass manufacturers use automatic cullet sorting systems to have a good quality of cullet.

Figure 2.10

collected glass is sorted, ensuring that it meets the specific criteria required for the desired glass product. The sorted glass then undergoes rigorous cleaning to eliminate any impurities or foreign substances that could compromise the integrity of the final glass product. This thorough cleaning process not only guarantees the quality of the glass but also aligns with sustainability goals by maximizing the usability of recycled materials.

The importance of sorting and cleaning: The sorting and cleaning of cullet plays an important role in ensuring that the resulting glass maintains the highest standards of quality. The precision of this process directly impacts the properties of the glass, from its transparency and color consistency to its durability. By meticulously sorting the cullet, manufacturers can select pieces that match the specific requirements of their intended glass product, enhancing uniformity and performance. Moreover, the intensive cleaning of cullet eliminates contaminants, creating a clean canvas for the glass-making process. This focus on quality not only satisfies customer expectations but also upholds the industry's commitment to sustainable practices, as higher-quality cullet optimizes resource usage.

Challenges and considerations in handling cullet: While the benefits of using cullet in glass production are undeniable, this practice does come with unique challenges. One significant challenge revolves around the removal of contaminants from the collected glass. These contaminants can range from non-glass materials to residues from previous contents in glass bottles. Effectively identifying and eliminating these contaminants requires sophisticated technology and meticulous attention to

detail. Additionally, ensuring the consistency of cullet quality can be a consideration. Variations in cullet characteristics, such as size and composition, can impact the final glass product. Addressing these challenges involves a combination of advanced sorting and cleaning techniques, as well as a commitment to continuous improvement. As we delve into the intricacies of cullet preparation, it becomes evident that this process is a cornerstone of sustainable glass manufacturing. It is a testament to the industry's dedication to innovation and eco-conscious practices. By meticulously collecting, sorting, and cleaning cullet, manufacturers not only enhance the quality of their glass products but also contribute to the preservation of natural resources and the reduction of waste. It is a harmonious blend of craftsmanship and environmental responsibility, paving the way for a brighter, greener, and more resource-efficient future. Hence cullet processing is an important activity in glass manufacturing and understanding it well will help industries to get good quality of their glass products, save energy & reduce natural raw materials usage.

Recycling is gaining very high importance now a days. What was already the norm in advanced countries a long time ago, is now on the agenda in all countries around the world. However, there are still big differences in the quality of the collection systems. In some countries the raw material glass is collected and sorted according to color; sometimes, however, it is collected completely mixed. The proportion of foreign substances (metals, ceramics, waste in general, etc.) also differs from country to country.

Stages in Cullet processing:

1. Receiving & storage of cullet

2. Cullet sorting

3. Processed cullet storage

4. Processed cullet usage

1. Receiving & storage of Cullet

It is a very important activity in container glass manufacturing facility. Proper inspection of cullet while receiving & storage in designated locations according to Type, grade, size, source etc., will largely help to process the cullet for final use. If all the incoming cullet is stored together, then sorting load will be extremely high & maintaining quality of glass will be a herculean task.

Cullet is classified into two categories based on source namely internal and external cullet. These two categories should be processed and stored separately. Based on glass properties, external cullet can be classified as flint, amber, green, mixed, sheet glass etc., and they have to be again stored separately before & after processing for better control of glass quality. One dedicated staff may be given full responsibility of cullet receiving, processing & storage as it is an important activity. With good sorting quality, cullet up to 95% can be used in batch for glass melting.

Inspection of cullet while receiving & unloading is extremely important. While unloading the external cullet, check the quality at different stages of unloading as there is every chance of contamination at different areas of truck (top, middle, bottom or at front & backside of truck). Any suspected quality of cullet (especially for metals, stones, ceramics, porcelain, micro-oven glasses) should be stored separately and then sorted properly to avoid such contaminants going to glass furnace. Regular training & advise to vendors to supply cullet as per the specification will largely reduce the load on sorting process.

2. Cullet sorting

Earlier cullet sorting used to be a laborious & tedious process but, thanks to innovative technologies, which is helping glass industries to sort the cullet with high quality & speed. Manual sorting is exceedingly difficult and slow process. As the glass industries are expanding and increasing their capacities, manual sorting of cullet is becoming difficult and hence they are moving to automatic cullet sorting.

a) **Manual sorting:** Figure 2.11 shows the flowchart of general manual sorting system adopted.

In manual sorting, controlling the sorting quality is difficult due to various constraints with labor, speed of sorting, thickness of cullet on belt conveyor etc. Along the conveyor, powerful magnets can be installed to remove ferrous material and eddy current separator can be independently installed to remove non-ferrous items like aluminum caps. Sorters need to be positioned along the manual sorting belt conveyors and there are chances of some accidents if adequate safety precautions are not taken. All the conveyors should have emergency pull chord system to immediately stop the belt conveyor in case of emergency and the sorters should have good seating & walking arrangements along the belt conveyors to avoid any accidents (to avoid fall).

b) **Automatic Cullet sorting system**

As the glass quality requirement is becoming stringent day by day, cullet sorting quality should be extremely high because it

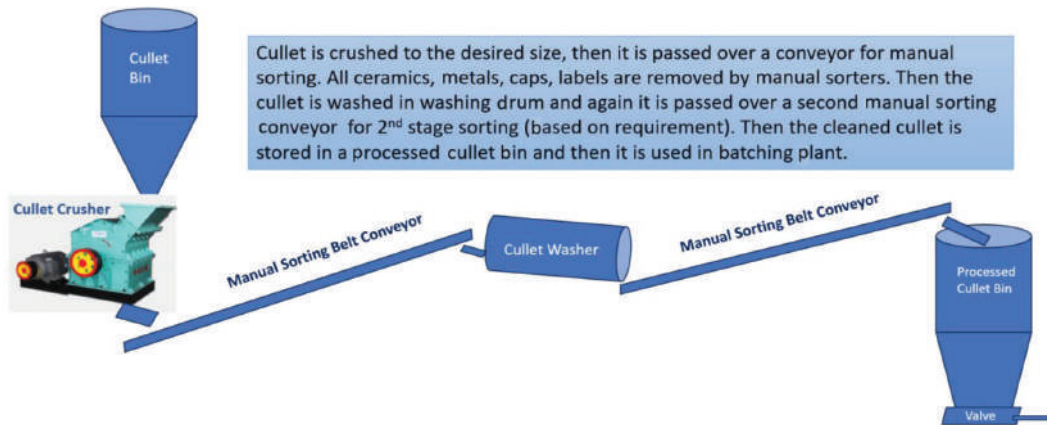


Figure 2.11

has direct bearing on melted glass. It can be achieved only by auto cullet sorting system. Auto cullet sorting system consists of screening the cullet for coarse and fines, crushing bigger size cullet, drying of cullet, organic matter removal, metal separation, color and CSP sorting (sorting flint, amber and green separately) as shown in process map in Figure 2.12. There are many reputed suppliers of cullet sorting system like M/s BINDER+CO AG Austria, M/s REDWAVE Austria, M/s ZIPPE GmbH Germany etc., who can design & supply as per plant requirement.

Necessity of sorting / processing of Cullet

Cullet is sorted and processed for following reasons:

1. Cullet is one of the major ingredients for producing glass. Without cullet (minimum of 10%), glass melting will be exceedingly difficult, and it will lead to many melting problems.

Cullet acts as a catalyst for melting. Hence minimum amount of cullet in batch is necessary for melting Glass.

2. Proper sizing of cullet for use in batch is very important. It is recommended to use 6mm to 15mm size of cullet for satisfactory results in terms of melting, energy saving and glass quality.
3. Un-sorted or poorly sorted cullet may lead to many problems. Following are a few of them:
 - a) Damage to furnace & furnace equipments:
 - If there are lot of contaminants like ferrous materials & aluminum caps,

Process Map of Container Glass Cullet Auto Sorting

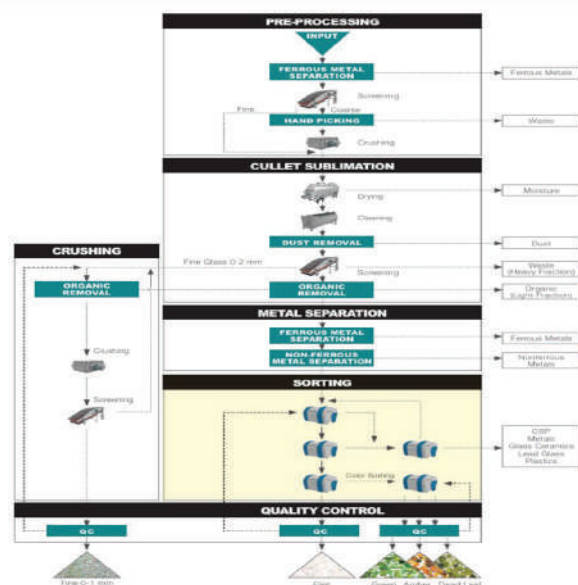


Figure 2.12

the same can settle at the bottom of the melter and create downward drilling of bottom tiles. This will make the refractory to corrode quickly and glass can leak from melter bottom.

- The ferrous and non-ferrous metals can form a metal layer at the bottom of the melter and as the time passes, it can have a metal layer of many millimeters of thickness. If there are bottom boosting electrodes, then it can create sparking of electrodes and electrodes may be damaged very quickly making the electrodes ineffective or lead to glass leak from electrode areas at the bottom. This kind of leakage will be very difficult to control and there can be a major accident due to glass leakage.
- Due to metal contaminants present in cullet, the furnace life will be seriously impacted due to rapid corrosion of melter bottom tiles.

b) Poor glass quality:

- If cullet is not sorted properly & has lot of impurities, the glass color can vary frequently resulting in customer complaints. This is extremely critical for cosmetic glass production.
- Final glass may have lot of stones, glass knots and forming defects. This can lead to higher rejections, lower production efficiency and increased customer complaints.
- Frequent yellow lines in glass because of reaction of glass with contaminants (ferrous and non-ferrous metals).

- Bubbles, seeds may increase suddenly due to reaction of contaminants with glass.

c) Increased melting energy:

- Increase in iron level in glass will lower the heat transfer rate in melter and forehearth. Hence melting energy or SFC (specific fuel consumption) for melting and forehearth energy consumption will increase.
- More bubbles and seeds in glass due to high contaminants in cullet may necessitate increase of melter temperature which will lead to increase in energy consumption.

3. Processed Cullet storage

It is very important that the processed cullet is stored properly in batching plant. It is recommended to have separate cullet bins / silos for internal and external cullet with independent weighing and feeding units for better control of glass quality. Also, for different types of cullet (flint, amber, green), separate silos / bins are to be used. As the cullet is highly abrasive material, storage bins / silos to be designed by experts to minimize wear & tear and avoid contamination of cullet from storage silos.

During transportation of cullet from processing to storage and then storage to melting, enough powerful magnets need to be fixed on conveyor belts and cullet chutes to remove any left-over ferrous contaminants.

4. Processed Cullet usage: During the batching, cullet is generally not mixed in mixer as cullet is highly abrasive and can damage the mixer blades quickly. Hence cullet is spread over the batch uniformly by proper cullet feeding system. During conveying and feeding of

cullet powerful hanging magnets may be used to catch the ferrous contaminants present in cullet. It is recommended to daily collect the cullet sample from cullet feeding system and check the quality for sorting & contamination. Accordingly corrective actions to be taken in sorting. There are systems to pre-heat cullet using furnace waste heat to save energy. M/s ZIPPE GmbH Germany and few others can design and supply these systems. However, in India, this system is not installed due to low return on investment.

Advantages of using Cullet

When it comes to the ecological footprint of glass manufacturing, the adoption of cullet serves as a game-changer, yielding an impressive array of environmental benefits that outshine the conventional reliance on virgin raw materials. Let us embark on a journey through the eco-conscious realm of cullet, unearthing its profound contributions to reducing raw material extraction, conserving energy, and mitigating carbon emissions.

Reduction in raw material extraction:

One of the most glaring advantages of incorporating cullet into the glass-making process is the substantial reduction in the need for primary raw materials such as sand, soda ash, and limestone. These materials are traditionally mined, a process that extracts a significant toll on the environment. By substituting a portion of these virgin materials with recycled glass, we are diminishing the pressure on fragile ecosystems, preserving pristine sand dunes, and minimizing the ecological disturbances caused by mining operations. This reduction in raw material extraction is a triumph for the environment, as it directly curbs habitat disruption and soil degradation while easing the strain on natural resources.

Energy savings during the melting process:

The allure of cullet extends beyond material conservation, delving into the realm of energy efficiency. When recycled glass is introduced into the melting furnace, its lower melting point imparts a profound energy-saving effect. The furnace does not need to reach the same temperatures as it would when processing solely virgin materials, resulting in reduced energy consumption. This translates into fewer fossil fuels burned, fewer emissions spewed into the atmosphere, and a tangible step towards a greener future. It is a virtuous cycle where every shard of cullet becomes a catalyst for energy conservation, aligning industry practices with sustainable aspirations. It is established in glass industry that every 10% increase in cullet usage will result into 3% reduction in specific fuel consumption. Also, by increasing the cullet usage, glass draw can be increased by 2 to 3% for every 10% increase in cullet.

Decreased carbon emissions due to reduced energy consumption:

The connection between energy use and carbon emissions is a fundamental pillar of environmental responsibility. As the energy demands decrease, so do the carbon emissions. By leveraging cullet in glass manufacturing, we are ushering in a paradigm where reduced energy requirements equate to a significant reduction in carbon footprints. The virtuous synergy of cullet's lower melting point and the resultant energy savings culminate in a measurable decrease in greenhouse gas emissions. This not only contributes to cleaner air but also aligns with international efforts to

combat climate change, positioning cullet as a frontline ally in the battle for a sustainable planet. It is estimated that every ton of glass cullet saves about 300 kg of CO₂, thanks to reduced fuel consumption and the absence of carbonate raw material decomposition in the purified material.

5.2 COLOURING AGENTS

Glass colours can be obtained either from furnace or individual forehearth (Colouring forehearth). The colour from furnace will be for mass production in all lines whereas colour from colour forehearth will be for a particular line. Colour forehearth is described separately in glass conditioning chapter.

Furnace Glass colours from batch composition:

From furnace we can produce basically 3 types of glass-flint, amber or green (dark, light). Commercial green container glass is coloured by additions of approximately 0.25 wt% chromium oxide (Cr₂O₃) and 0.35 wt% iron oxide (Fe₂O₃) and amber (brown) is essentially coloured by 0.5wt% iron oxide in a reduced

state. Both chromium and iron oxide are relatively strong colouring oxides in container glass. Therefore, flint (clear) container glass must only have trace additions of chromium and iron to avoid visible colour; a slight green/yellow colour is generally masked by adding a decolouriser. However, the addition of decolouriser can result in loss of light transmission and result in a grey appearance in the flint glass. Commercial flint container glass generally has no more than 0.5wt% of green glass added as cullet.

Figures 2.13. a & b show images of impact of addition of metal oxides into flint Glass (in colour FH) or into RM batch

6.0 Batching systems: Batching plants require to provide consistent batch without weight variations with proper sequence of operation. It has 2 sections namely silo seeding & storage of raw materials and batching. The first section is for receiving the raw materials and storing; and the second section is making glass batch as per recipe.

Silo feeding: Once the raw material

Glass Colours can be obtained in 3 ways. A) By addition of rare earth metal ions B) By colloidal particles formed in the glass C) By particles which are coloured themselves.



The colour effect is affected by base Glass composition or by the level of oxidation of Glass. Also by mixing different oxides, different Glass colors

Figure 2.13.a

Colour Metal Oxides



Glass colours can be obtained by adding oxides of metals in furnace or in colouring forehearth. Basically flint, Amber and Green (Dark, Light) colours for mass production are produced by adding colourants into the furnace batch and the entire Glass coming out of furnace to all the forming machines will have same colour. Other colours like Black, Red, Antiquity Blue etc. are produced by adding colourants in coloured forehearth whereby only these lines can produce the required colours. The picture shows the oxides of metals to get the desired colour.

Colorant	Color
Iron oxides	greens, browns
Manganese oxides	deep amber, amethyst, decolorizer
Cobalt oxide	deep blue
Gold chloride	ruby red
Selenium compounds	reds
Carbon oxides	amber/brown
Mix of manganese, cobalt, iron	black
Antimony oxides	white
Uranium oxides	yellow green (glows!)
Sulfur compounds	amber/brown
Copper compounds	light blue, red
Tin compounds	white
Lead with antimony	yellow

and should be closely monitored by the operators. The sequence of operations are generally done as follows:

1. Weighing of all the RMs as per recipe with weight corrections for moisture & losses, if any.

is inspected and accepted for use, it has to be stored for further usage in batching plant. The process of unloading and storing in respective RM silos is known as silo feeding. There are generally 3 unloading bays- 1st for silica sand / quartz, 2nd for all other RM like soda ash, feldspar, dolomite and lime stone, 3rd for cullet. Fine chemicals are manually loaded in many companies using hoists or lifts as the daily quantity requirement is very less. Earlier days, bucket elevators were used for unloading of most of the raw materials but now pneumatic conveying is introduced for many RMs provided the moisture in it is very less. Pneumatic conveying is advantageous to prevent dust in batching plant and avoid manual labour for unloading. It is very convenient and faster.

to requirements. This will help in controlling the glass quality. For main raw materials except soda ash and fine chemicals, it is always advisable to use 3 stage magnetic separators to remove free iron and fine dust. This will help to reduce iron in glass as well as improve melting & save melting energy. While feeding RMs into silos, wherever possible, install hanging magnets or pipe magnets to catch iron (magnetic) contaminants. Contaminants can come from external source (with RM) or from internal sources. Hence it is important to catch these contaminants where ever possible till it goes inside the furnace.

Batching system: In batching, weighing of RMs as per the recipe and then releasing & mixing sequence is very important. It is done automatically

2. Once all the weighing is completed release RMs to running empty mixer in following order- release sand/ quartz first and when it is almost done, release soda ash. Once soda ash is completely released, then release other RMs like lime stone, dolomite, feldspar and fine chemicals (done directly into mixer manually or in auto as releasing it on conveyor with other RMs may have some spillage of it, resulting in loss of fine chemicals which is very less in quantity). It is important that silica / quartz grains get soda ash coating to enable it to melt in furnace quickly and effective, as explained in melting reaction

In silo feeding, there are bucket elevators, vibro-feeders, belt conveyors, diverters, shuttle conveyors etc., as shown in Figure 2.14. There can be few silos for silica and quartz storage for storage of the same from different quality / sources so that they can be used according

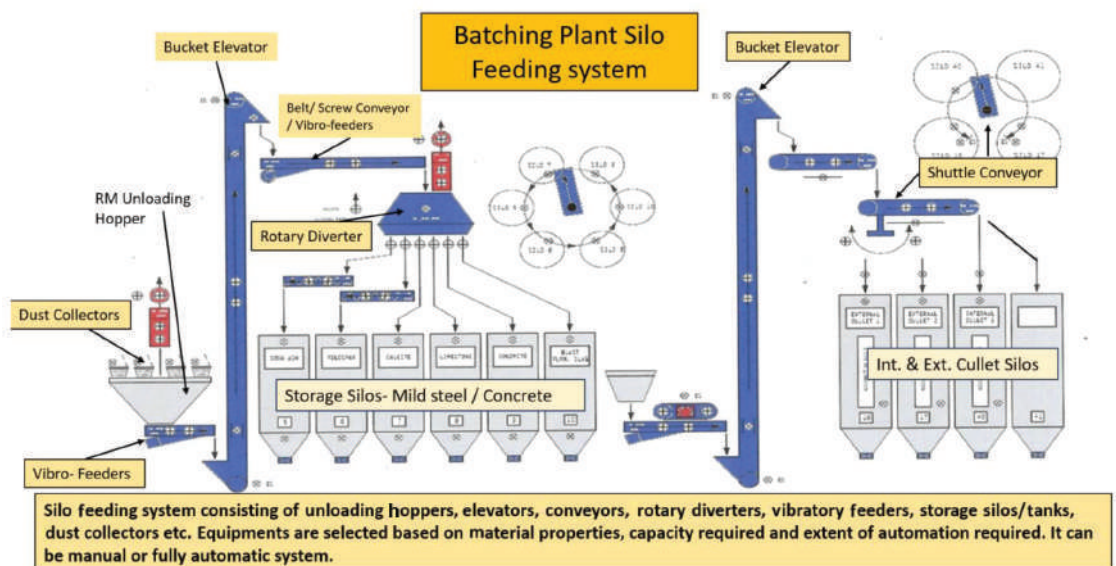


Figure 2.14

process. Simultaneously cullet weighing should be working separately and ready for release into batch after the mixer. (Cullet is not mixed in mixer as it can damage the mixer and hence cullet is dropped on batch after the mixer).

3. Mixing generally takes 5 minutes to mix the entire RMs. For initial 3 minutes, dry mixing and after this 2 minutes, wet mixing by adding water to maintain 2 to 3% total moisture in batch (considering moisture in RMs+ addition of water to get 2 to 3% moisture in batch). During mixing, the weighing of all the RMs will start as per the recipe and weight for next mixing cycle.
4. Once batch is mixed completely, it is released on to the surge hopper and then to batch conveyor. On this batch in conveyor, the cullet should be dropped such that it is completely released by the time the entire mixed batch is moved. The cullet should be spread over the batch such that it is uniformly mixed with batch while moving forward into hoppers, conveyors and day bin of furnace.
5. Once the batch from mixer is released completely, the mixer gate is closed and it then sends signal to system to release RMs again in sequence as above. So, the batch mixing is continued as per requirement in auto mode.
6. Generally, the mixing operation stops in auto mode, when the day bin level near furnace doghouse is reached full. Again, when the day bin

level drops to low level, the batching plant starts automatically. The operation of batch house in majority of companies work on auto mode with level sensors installed in dog house day bin. If there are two doghouse for one furnace, diverters are installed to divert batch to required silos, depending on silo levels.

7. In many manufacturing facilities, single batching plant supplies batch to many furnaces in auto mode. The recipe can be different or same for different furnaces. However, care should be taken to ensure that the batch shouldn't get mixed or contaminated when different recipe is used for different furnaces (especially when the same batching plant is used for different glass colors- flint, amber & green). When different recipe is used, separate mixer and batch conveying systems are used for each furnace to avoid mix-up or contamination of batch.

The auto batching diagram is shown in Figure 2.15.

The batching plant can be as big as 2000 TPD capacity depending upon the requirement of the plant

considering future expansion plans. M/s ZIPPE and M/s EME are the leading designers and suppliers of batching plants in the world and also there are other suppliers like M/s Eliar Turkey and M/s Glass Service s.r.l. Italy.

Important considerations in batching plant design & operation:

The accurate and reliable weighing, dosing and movement of raw materials used in glass production is critical to final glass quality. Like, how food recipe and preparation is important for human beings, the batch recipe and preparation is important to get good and consistent glass quality from furnace. Following are some of the procedures and of pre-requisites for good batching operation:

Design

- a) Weighing accuracy should be good and should have high repeatability/ reproductivity.
- b) For major RMs, the weighing tolerance can be +/- 100 gms. But for fine chemicals it can be +/- 1gm.
- c) The weighing system should have good auto-correction. Ex.: If in first batch 100 gms. of extra material is fed, then in

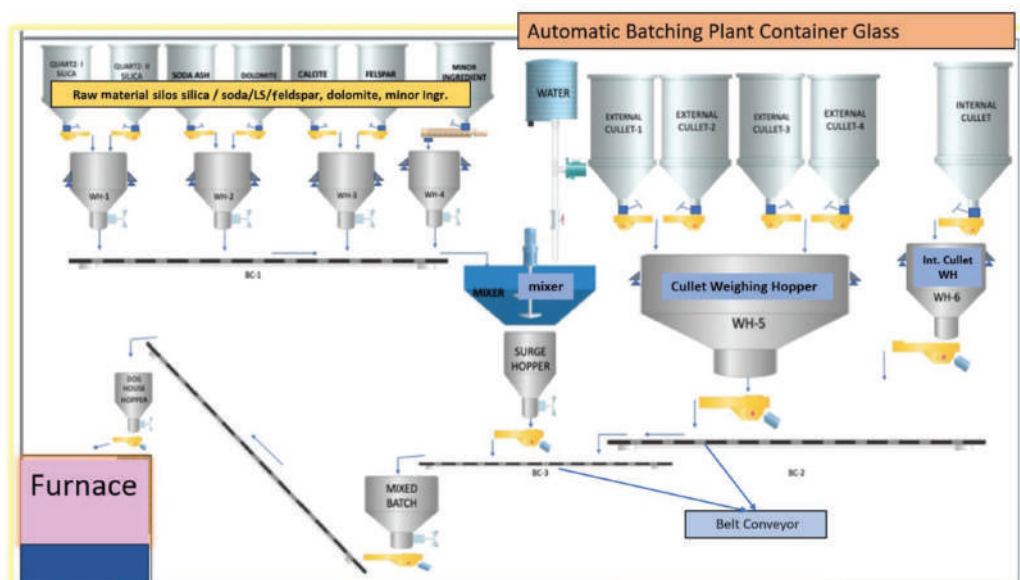


Figure 2.15

2nd batch, 100 gms. should be automatically reduced. This is for all RMs. In weighing hopper, after gate closing, if any material is left, it should be automatically corrected in new batch.

- d) All the equipments should operate very reliably especially gate opening and closing, diverters functioning, online moisture measurement etc.
- e) Weighing controls should be very effective. They should work on auto control feeds with weighing such that during start of weighing, the feeding to weigh hopper is at higher rate and when it is going to reach close to the set parameter, the feed rate should be slow so that the accurate weighing is achieved.
- f) Mixer performance should be excellent. Homogeneity of batch is very important to control to get desired glass quality and hence mixer should be very reliable and give required homogeneity of batch.
- g) Batch transport design is important to avoid spillage and batch segregation.
- h) All the weighing parameters to

be captured by SCADA or good control systems so that all the batch details can be monitored and data can be retrieved, as & when required.

- i) Design of silos, equipments should be of high standard to reduce contamination, wear and tear, breakdowns and glass quality problems (batch segregation, contamination, poor homogeneity), as wear and tear is high due to abrasive nature of RMs, provision of rings at 1 meter spacing is recommended, as shown in Figure 2.16.

Operation of Batching Plant: Good operational controls are necessary to get good quality batch from batching plant. Following are the important operation disciplines required in batching plant.

- a) Raw materials should be properly checked before unloading and storage. Good & clear SOPs for RM inspection, unloading and storage should be in place and practiced religiously.
- b) When common equipments like hoppers, elevators and conveyors are used for loading & unloading

of different raw materials, ensure good cleaning procedure, before using it for other materials. This is essential for avoiding mix-up of materials. Also have good interlock & automatic systems for silo feeding of raw materials to avoid mix-up. It is very common error in batching plants where operators many times make mistake in unloading resulting in mix-up, leading to loss of productivity, time and quality.

- c) Regular calibration of weighing system is required. In every shift, calibration of each weighing hopper once, is recommended.
- d) Batching sequence should be followed as per SOPs. Silica sand mixing with soda first should be ensured.
- e) Cleaning of mixers, silos, hoppers, equipments, magnets to be done regularly to avoid contamination and breakdowns.
- f) Timely maintenance of all equipments is very essential. Mixer and elevators should be given top importance as any breakdown in these equipments may disrupt production due to more time required for repair. Condition monitoring of critical equipments is recommended.

g) All the dust collectors should work effectively and there should not be dust in plant. Batching plant equipments can frequently fail if dust is too much.

h) Environment should be clean and no rain water should enter the building. There should be

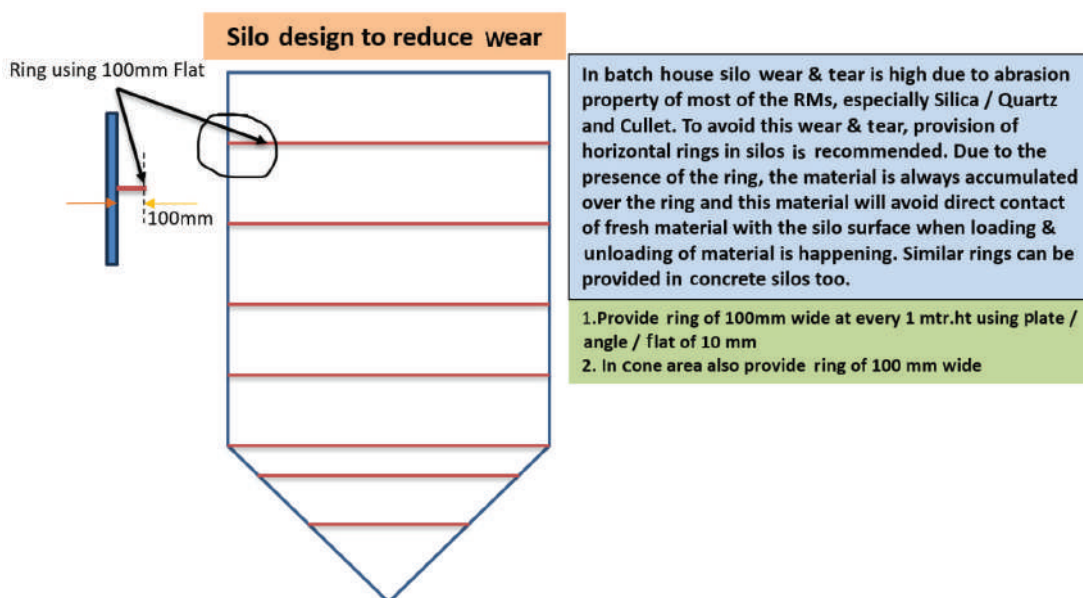


Figure 2.16

good ventilation system and good covering of batching plant to avoid entry of wind & rain. Top class housekeeping is required for smooth operation of the batching plant.

7.0 Quality controls in batch house

As batch house is responsible for quality of glass in terms of achieving desired physical & chemical properties of glass for producing good container bottles, it is very important that quality is maintained in every batching processes. Glass properties like density, glass colour, seeds & blisters, annealing temperature etc., are having direct relationship with glass recipe. Following controls are required in batching operation to get good quality of glass.

1. All incoming materials need to be checked thoroughly for physical and chemical properties and materials meeting the specifications only to be accepted for use in batch, as there are many variables in raw materials, deviations in any of the properties can impact glass quality. Few examples are-
 - a) Silica sand chemical analysis
2. Cullet sorting should be very good and contaminations should be below the limits. In few

is okay and meeting the specification, however the grain size is above specification. In this case, glass melting will be impacted, stones can appear in glass and bottle quality can be a major problem in all production lines.

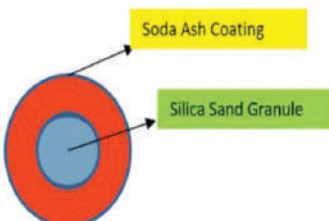
- b) Lime stone chemical analysis is okay but it has very high fine material. If this is used in batch, lot of dust can fly everywhere, batch segregation may happen and dust can go to regenerator & chimney. Glass composition also can be impacted due to loss of material in every stage of batching operation due to high fine dust in lime stone.
- c) Cullet physically looks okay but has high porcelain or microwave waste glass. These impurities are difficult to sort and if it is accepted to use, can result in glass knot, bubbles, blisters issues in glass.

organisations, cullet up to 95% is used. Hence cullet quality has direct bearing on quality of glass coming out of furnace. Enough eddy current separators, magnets need to be used to catch contaminants effectively.

3. During unloading care should be taken to avoid mix-up and contamination. Proper unloading procedure, cleaning procedure need to be strictly followed to eliminate these issues. If any mix-up or contamination incident occurs, it will take a few days to clear the glass and the entire production may have to be scrapped. Also, such scrapped glass (internal cullet) if used back in batch house, can create issue in glass again as the specification of the recycled cullet may be totally different and make it difficult to control the glass composition.
4. While making batch, operation should be watched carefully. Any malfunction in equipments, gate opening, sequence of RM releasing into mixer, errors in weighing and improper mixing can lead to melting & glass issues. To rectify the problem, if not noticed quickly, will take

Batching Ideas

1. It is very important to get good mixing so that batch homogeneity is excellent which will lead to energy saving in melting, good & consistent Glass quality.
2. Soda ash coating on silica sand granules will accelerate melting leading to lower seed count, lower SFC.
3. Proper distribution of cullet with batch is important to get good quality of Glass.
4. 6 to 12 mm cullet size helps in good melting.
5. Optimum moisture in batch is very important for melting / furnace operation. 2-3% moisture recommended.
6. Batch transportation is to be designed properly. Iron particles removal, batch segregation aspects to be evaluated.



Batch mixing sequence is very important to get very good Glass quality, improved melting and reduce SFC & seed count. The sand / quartz to be released first followed by soda and both should be mixed first for few seconds to get good soda ash coating on sand / quartz granules. The coating of soda on silica will accelerate dissolution of silica into glass and this will be achieved at lower temperature compared to uncoated granules without soda or coated with other materials. Once the dissolution of silica improves with soda coating at lower temperature. The melting becomes easy, melting energy requirement reduces, seed count improves.

Figure 2.17

few days to clear the glass in the furnace. Proper checklist should be prepared and monitored to avoid such issues. One example of such cases is that in one of the installations, the jack bolt above the load cell got loose in sand weigh hopper and bolt was touching the bottom frame of load cell mounting while sand filling for batching. This resulted in wrong weighing as one of the load cells had obstruction but the control system was showing the recipe weight correctly in panel. Since it was not noticed immediately, after 24 hours, the glass density became abnormal due to high silica in glass and entire production was scrapped till the problem got rectified.

5. Batching plant operators and furnace operators should have proper communication and provide quick feedback to each other to make small changes in operations, in case some abnormalities are observed. The feedback related to moisture in

batch, batch segregation, cullet segregation, seeds, bubbles, glass colour, melting issues may be immediately communicated to batch house team for finding if there are any abnormalities.

6. Batching plant & laboratory should have quick & proper communication channels. Any issue in batching will reflect in glass properties and hence to maintain consistent quality, getting the report from chemical lab & analysing to make corrections is an important task by batching team.

7. Batching operators should get regular bottle sample from production floor and look at glass quality like stone, bubbles, blisters, glass knots etc., and act quickly to rectify the problems, if it is related to batch or batching process. Also, should have good communication with quality/QA departments regarding defects related to glass (cordy glass, seeds, blisters, colour).

8. Control on internal cullet quality is important as there can be many possibilities of local contamination from various areas of operation. Sometimes along with rejected cullet, foreign materials are mixed if GMP is not followed and there are instances like moulds, iron pieces and packing materials getting mixed with internal cullet due to negligence by IS Machine operators, sorters and other maintenance people. Also, the internal cullet crushing quality need to be checked regularly. Install sufficient magnets in internal cullet conveyors, to catch any ferrous materials mixed accidentally, with cullet.

9. Figure 2.17 shows some important points to be noted in batching plant.

We have now understood importance of batching process in detail. Here we have a small root cause analysis chart (Figure 2.18) to act quickly, if similar glass problem occurs in your factory ■

Batching plant problems, root cause and remedy chart (related to batch only)

Sl. No.	Problem	Root Cause	Remedy
1	Increased stone in glass	1. Contamination in cullet Intl. or Ext. 2. Grain size high- silica, quartz and dolomite	1. Check cullet sorting 2. Check grain size of RMs 3. Check intl. cullet quality
2	Glass density decreased suddenly	1. Sand feeding high 2. Change in RMs quality 3. Weighing abnormality	1. Check sand scale 2. Check glass oxides by lab analysis 3. Check all weighing scales
3	Glass density increased suddenly	1. Soda feeding high 2. Weighing abnormality 3. Change in RMs quality	1. Check soda scale 2. Check all weighing scales 3. Check Glass oxides by lab analysis
4	Yellow lines in Glass	1. Contamination in cullet 2. Contamination in RMs	1. Check free iron in cullet 2. Check contamination in RMs
5	Increase in seeds and blisters	1. High contamination 2. Mixing abnormalities 3. Weighing abnormalities	1. Check RMs and batch 2. Check mixing 3. Check weighing scales
6	Increase in iron content in batch	1. Iron content high in RMs 2. Increase in iron contamination in cullet 3. Magnets not catching iron 4. Equipment parts missing and entered furnace (Especially from dog house silo or batch charger)	1. Check RMs quality & functioning of magnetic separators 2. Check cullet 3. Check magnets 4. Check equipments
7	Cordy Glass & bottles breaking in thermal shock	1. Abnormal batch change 2. Mixing issue 3. Segregation	1. Check changes made / weighing accuracy 2. Check homogeneity / mixer 3. Check batch transport / silo for segregation

Figure 2.18

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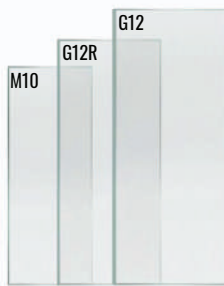
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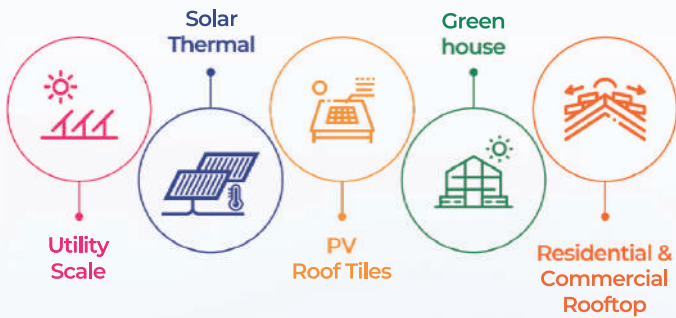


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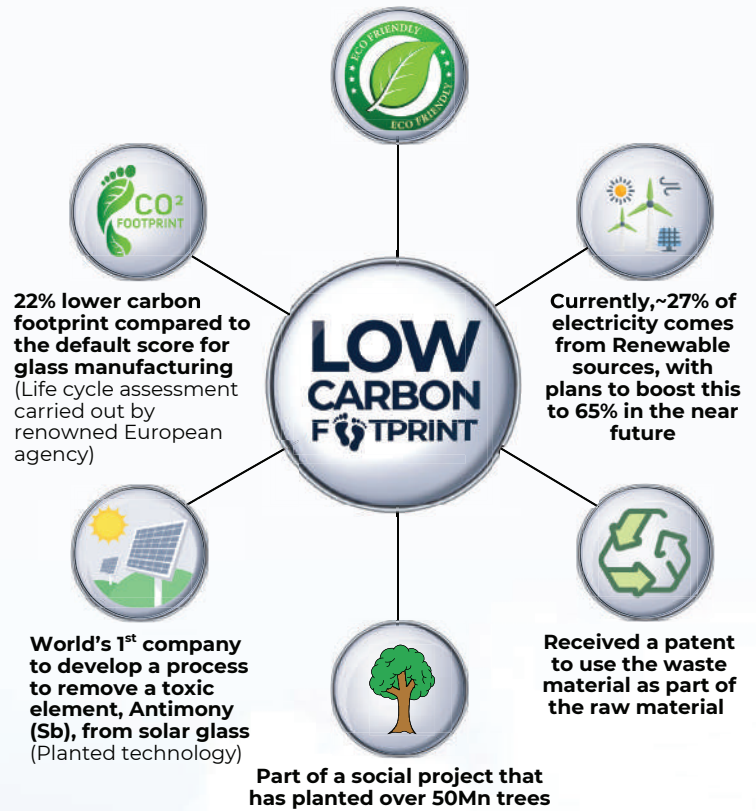
Glass Thickness 2.0 mm | 2.5 mm | 2.8 mm | 3.2 mm
4.0 mm | 5.0 mm | 6.0 mm

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Reflections on Glass

Kanch is pleased to reprint the following write up about Prof. Manoj Choudhary.

Prof. Choudhary is the Former-President of the International Commission on Glass (ICG) and has worked closely with the Indian glass community. In 2024, The All India Glass Manufacturers' Federation felicitated Prof. Choudhary with C.K. Somany Award for Excellence. Prof. Choudhary has delivered Dr. Atma Ram, M. G. Bhagat and C. K. Somany Lectures in INDIA.

"The article below was originally published in MIT Alumni News, published by MIT Technology Review, and is reprinted with permission".

Manoj Choudhary, ScD '80, *can't believe that most people look through glass without a second thought. To him, it's humanity's most important material. "No material combines utility and beauty like glass," he says.*

"Can you imagine our forefathers before the windows came along—what kind of dark, dank buildings they lived in?" he asks. "Now we are surrounded with glass that lets the light come in and protects us from the snow, sleet, and rain."

From eyeglasses to wine glasses, microscopes to telescopes, products made with glass allow us to see and enjoy the world around us at every scale. Choudhary says *it's durable, impermeable, transparent, and deceptively strong.* And it is to this material that he devoted his career after finishing his schooling.

Choudhary grew up largely in Kolkata, INDIA. He majored in Chemical Engineering at the nearby Indian Institute of Technology at Kharagpur, igniting a passion for using fundamental science to do something tangible in the world.

He never planned to come to the

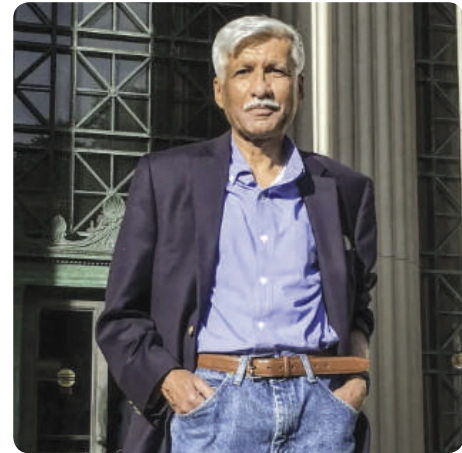
United States. But then Choudhary's academic department received a request from the University of Buffalo asking for its best students; he was recommended and went to New York for his master's.

"Once I was in the US and had gained confidence in my knowledge of Chemical Engineering, I wanted to branch out and explore applying my knowledge to other fields," he recalls. "And there are very few places on this planet that can match MIT—frankly, in any discipline, but in my case the materials science and engineering department."

Choudhary arrived at MIT in 1976 to pursue his doctorate, working with leaders in fluid dynamics of materials processing, metallurgical thermodynamics, and welding engineering to mathematically model flow and heat transfer in a steel refinement process. *"Nowhere else would I have had the opportunity to come in contact with such a constellation of luminaries," he says.*

Upon graduating, he joined Owens Corning, a company with a long history of glass innovation. *"I had an intuition that what I had learned at MIT in materials processing and metallurgy I could apply to glass," he says.* One of Choudhary's first tasks was to find ways of using electricity rather than fossil-fuel combustion in the melting process for manufacturing glass fibers used in composites for such things as wind turbine blades and printed circuits. The approach would become central to decarbonizing glassmaking. *"It made a tremendous impact on reducing emissions, increasing throughput and enhancing quality," he says.*

Choudhary also established and led the use of computational fluid dynamics modeling at the company to understand flow and heat transfer in glass melting furnaces. *"When you speak in mathematics, people get*



extremely nervous in manufacturing plants," he says. They ask, "How can equations explain something as complicated as glass melting?"

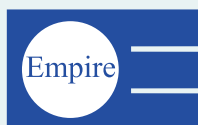
But the work paid off. At a glass manufacturing plant in Amarillo, Texas, his mathematical models helped increase production efficiency by 20%.

Convinced of the benefits of employing computational fluid dynamics to improve manufacturing processes even further, Owens Corning became one of the first glass companies to make a massive investment in the approach. Perhaps most rewarding for Choudhary was that the success of this effort earned him the respect of his colleagues.

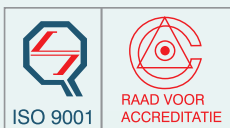
From 2015 to 2018, he served as President of the International Commission on Glass. And in 2024, he won the L. David Pye Glass Hall of Fame Award from the American Ceramic Society in recognition of a lifetime of "dedication, vision, and accomplishments in advancing the fields of glass science, glass engineering, and glass art."

Choudhary retired from Owens Corning in 2018. He's now an adjunct Professor of materials science and engineering at Ohio State University, where he enjoys mentoring young people. *"Mentorship is one of the things that I've benefited from greatly throughout my life, including at MIT," he says. "So I'm trying to pay my debt in some small way" ■*

by Ari Daniel, PhD '08 MIT



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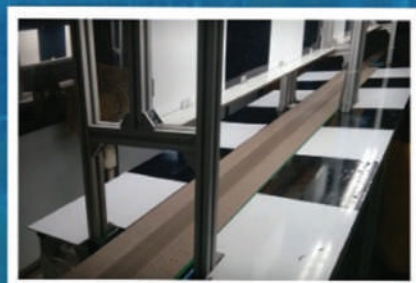
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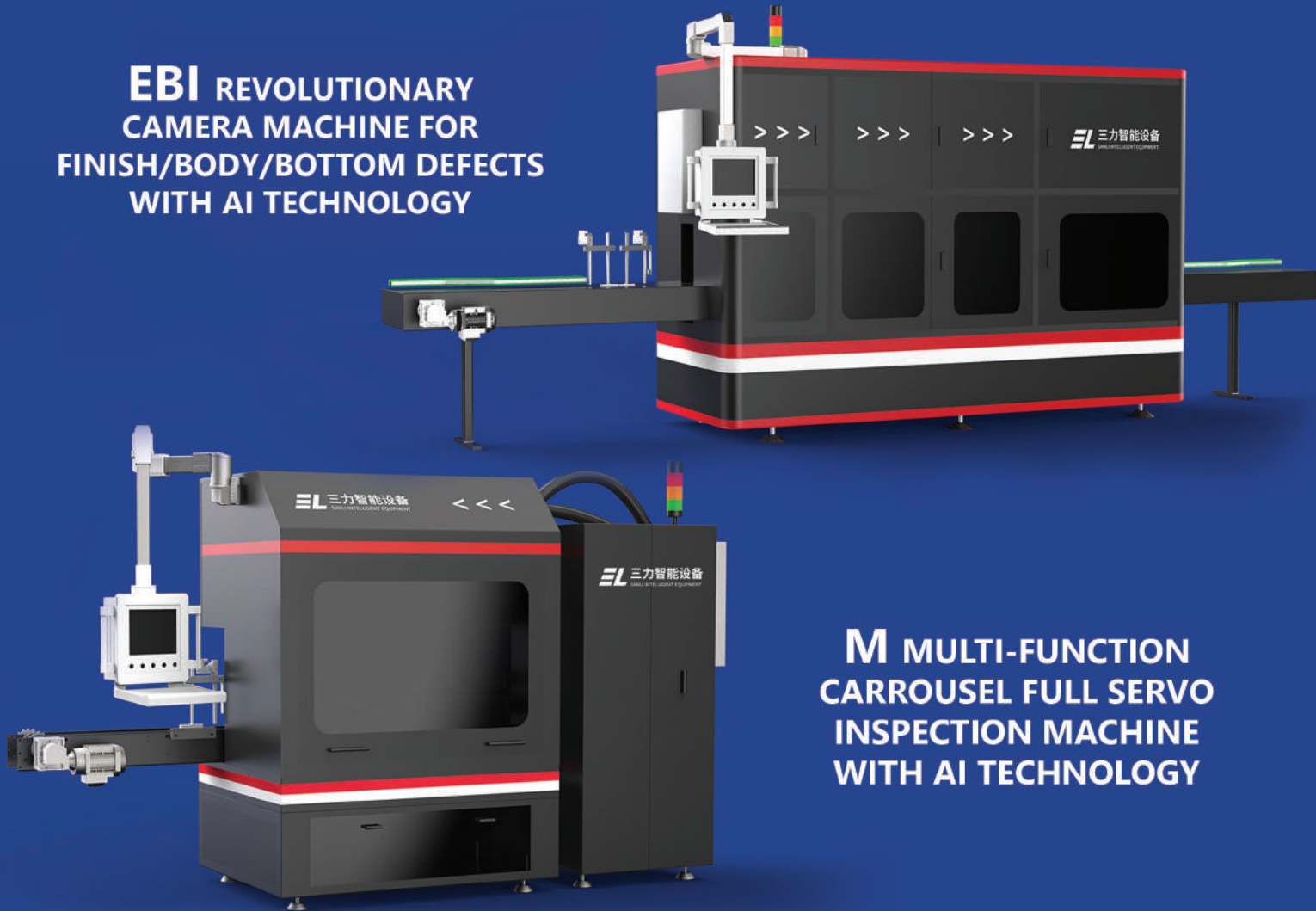
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Glass Science at KMV: Empowering Women

Dr. Atima Sharma Dwivedi, the Director of Kanya Maha Vidyalaya, is a distinguished academician with over 40 years of teaching and administrative experience.

She holds a Ph.D. in Contemporary American Literature and has been recognized for her leadership in expanding gender equality in higher education.

Dr. Dwivedi has been instrumental in various initiatives, including the introduction of progressive programs in line with the New Education Policy.

Her dedication to education and her innovative approach have made her a role model for other institutions.



kmvjalandhar@yahoo.com

Kanya Maha Vidyalaya (KMV), founded in 1886, has always stood as a beacon of hope and progress for women's education in India. Established with a vision to uplift women through knowledge, values, and freedom of thought, KMV continues to stay true to its motto "Empowerment through Education." Over the decades, the institution has grown into a modern, autonomous, and research driven college where discipline blends with creativity, and tradition walks hand in hand with innovation. With its rich history, strong academic leadership, and a student-centric ethos, KMV has nurtured generations of young women into confident, capable leaders ready to contribute meaningfully to society. Its unwavering focus on skill development, entrepreneurship, and scientific curiosity makes it a national model for holistic women's education.

Among its many achievements Glass Science at KMV has emerged as one of the most distinct and pioneering academic endeavours in North India. What began as an academic interest has now grown into a vibrant interdisciplinary space that introduces young women to the fascinating world of glass structure, solar glass, optical materials, THz technologies and sustainability under the leadership of Dr. Gopi Sharma and Dr. Neetu Verma. The department has built strong academic and industrial collaborations with nationally and internationally renowned institutions

including ENEA (Italy), Coe College (USA), TIFR Mumbai, BARC Mumbai, Sri Venkateswara University Tirupati, and NIT Jalandhar. These linkages bring global exposure right into the classroom, strengthening both learning and research capabilities.

Faculty and students have contributed research in areas such as optical materials and novel glass compositions, while actively exploring patents for innovative formulations. What makes this journey special is the hands-on experience students receive on melting glass, understanding annealing, observing structural transitions, and learning characterization techniques. For many students, this is their first encounter with real scientific discovery, and it sparks a sense of wonder that often shapes their career aspirations.

Teaching glass science at KMV is designed to be deeply engaging and experiential. Instead of treating glass as just another topic in the syllabus, teachers transform classrooms into interactive spaces where concepts become tangible. Students witness glass formation through practical demonstrations, explore the physics of non-crystalline materials, work with thermal properties, and even get an early introduction to glass ceramics. The curriculum is strengthened through project based learning, industrial case studies, and international standards that expose students to real world scientific

challenges. Through small research projects, presentations, and scientific writing exercises, students begin to see themselves not just as learners, but as budding engineering researchers.

The department also relies heavily on ICT tools, multimedia content, and its active social media presence to keep students connected and inspired. Visits to laboratories, research centers, and industries give them opportunities to see science in action moving learning beyond the classroom and into the world of innovation.

A major driving force behind these efforts is KMV's commitment to empowering women for meaningful careers in India's rapidly growing glass, materials, and solar industries. Placements in these sectors provide not just financial independence, but also a voice, an identity, and the strength to break long standing stereotypes about women in technical fields. When young women step into manufacturing floors, research labs, and industrial setups, they aren't just building their own futures, they are rewriting what society believes women can achieve.

But the path isn't always easy. Many students feel anxious about relocation, adjusting to industrial environments, or staying in hostels far from home. Family concerns, long work shifts, and male dominated workplaces can create hesitation. These challenges are real, and KMV

acknowledges them with sensitivity. Through mentoring, counselling, exposure visits, and strong industry collaborations, the institution slowly bridges these gaps and helps students grow the confidence needed to take bold professional steps.

The impact of this approach is already visible. Students and faculty recently visited Gold Plus Glass manufacturing unit upon the invitation of Ms. Sheetal Khanna (GM), where they watched float glass being made from scratch huge furnaces glowing, molten glass flowing, coatings applied with precision, and quality control techniques ensuring perfection. Earlier visits to Borosil, one of India's most respected glass manufacturers upon the invitation of the Kheruka family, further strengthened industrial insights. Last year, KMV students secured prestigious internships at the Borosil Research Centre, where they worked on real research problems in

advanced materials and sustainability. These experiences transformed their understanding of science, boosted their confidence, and marked a proud milestone for the institution.

One of the greatest honors for the department is being academically adopted by Dr. Arun K. Varshneya, one of the world's most influential glass scientists affectionately nicknamed, "the Glass Guru" for his textbook, "Fundamentals of inorganic Glasses". His contributions have shaped glass science globally, and his mentorship has opened doors of possibility for KMV students. Through the "Darshana and Arun Varshneya Excellence in Glass Science Stipends," he encourages and supports young women who aspire to enter this specialized field. His guidance helps KMV refine its curriculum, pursue deeper research, and build a platform where women can dream of becoming materials scientists, innovators, and leaders.

Dr. Varshneya's involvement has humanized science for students it makes them feel seen, encouraged, and capable. It motivates them to dream beyond the limits of their surroundings and believe that they, too, can contribute to global scientific advances.

In essence, Glass Science at KMV is far more than an academic program. It is a journey of empowerment, discovery, mentorship, and transformation. It offers young women a chance to explore a field that is both scientifically rich and industrially relevant while building confidence, ambition, and a sense of purpose. With its strong collaborations, visionary mentorship, research oriented environment, and commitment to women's advancement, KMV is not just teaching glass science, it is shaping the next generation of women scientists, innovators, and change makers ■



GLASS FORMATION, STRUCTURE AND PROPERTIES

MONTPELLIER (France), 6th – 10th JULY 2026

The workshop examines fundamentals in glass science, structure-property relationships, experimental techniques, simulations and selected tools to probe structure. The specific subjects and applications covered are: thermodynamics and kinetics, structure modelling, optical behaviour, mass transport, NMR, strength, sol gel coatings, chemical analysis and AI. The lecturers are leading experts in their fields.

A significant feature of the workshop is student-centred learning. Formal lectures are supplemented by a) tutorials involving student-staff discussions and b) team exercises.

On day 1, all participants describe their own interest in glass to develop their presentation skills. This also informs the class of the breadth of glass research worldwide and the range of measurement tools in use. Based on their interests, students are grouped into teams who must present on the last day of the school their solution to an allocated glass-based problem and answer questions from the audience. These projects help participants think on their feet, helps forge lasting connections, develops understanding by applying what they have learned to specific issues, and is 'competitive'!

Organization: Prof. J. M. Parker, University of Sheffield, UK
Prof. R. Conradt, uniglassAC GmbH Co., Germany

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- Normal fee: 1100€
- Reduced fee: 410€ for students and academics.

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- Lodging: 500€ in single room 300€ in twin room

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- **Application forms, programmes and more detailed instructions concerning travel will be circulated to those who register and will also be posted on the ICG web site. (www.icglass.org)**

To pre-register your interest and receive mailings

Contact: verres2026@mycema.fr

Final Registration: Deadline 01/06/2026

Participants will be limited to 50

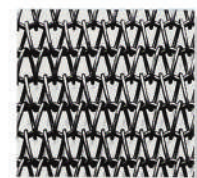
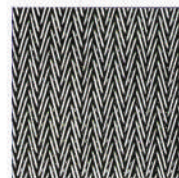
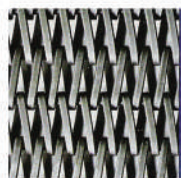
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Mr. M.D. Farooq, the founder of Umda Engineering, brings to the table more than 35 years of expertise in the manufacturing industry. Starting from humble beginnings, today more than 350 of Mr. Farooq's Lehr machines are successfully installed around the world.

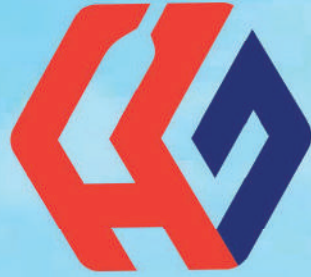
Mr. Farooq is best recognised as one of the co-founders of TNF Engineering, a company known across the industry as not only the leading manufacturers of Metallic Wire Conveyor and Lehr belts but also of Glass Plant Equipment. This mantle of superior performance and expertise has now been passed on to Umda Engineering.

Belts

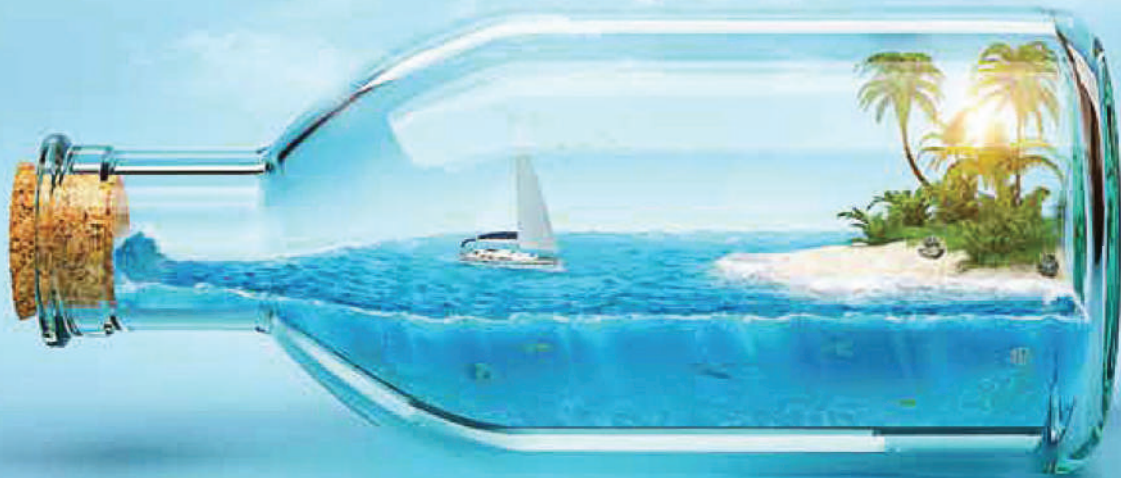


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Creating Spaces Protected by Glass

Toughened glass: requirements on physical security, climate resilience and cyber security are rising

Europe has to become more independent, resilient and secure – this could be the credo of a current press review. The need for security is rising noticeably and now KRITIS, the new umbrella act to improve the physical security of critical infrastructure, was adopted on January 29. The Act requires uniform minimum standards, risk analyses and attack monitoring. Many of the rules relate to the physical resilience of installations and buildings, which also impacts the glass industry and is expected to further fuel the rising demand for toughened glazing. glasstec asked ift Rosenheim and Kuraray as a producer of high-performance interlayers for toughened glass structures about the trends in requirements for toughened glass.

In view of growing threats posed by geopolitical tensions, cyber attacks and natural disasters the reliable protection of critical infrastructures seems as important as ever. These infrastructures include facilities, systems and organisations highly critical to maintaining the fabric of society and whose failure would substantially impact everyday life such as energy supply, information technology and telecommunications, transport and traffic, health, water, food, waste disposal, finance and insurance, state and administration, media and culture. Germany's federal Länder decide which facilities in Germany are governed by the KRITIS Umbrella Act on the basis

of quantitative and qualitative criteria. If a facility is critical for serving a total of 500,000 people, for example, it is rated as critical infrastructure. Mutual dependencies also have to be considered – energy, water and operational transport routes, for instance, are also instrumental to all other critical sectors.

VANDALISM AND PHYSICAL ATTACKS

According to estimates by ift Rosenheim, vandalism – though increasingly also sabotage – poses a high risk to public buildings, transport infrastructure or administrative buildings. In acts of vandalism perpetrator behaviour is completely different that seen in acts of burglary, as Dipl.-Ing. Jürgen Benitz-Wildenburg, Head of PR and Technical Communication at ift Rosenheim, explains: *“Here, perpetrators act openly, mostly on impulse, using improvised tools ranging from paving stones and street signs to manhole covers as their ramming implements. This means endangered building elements and glazing have to resist direct violent attacks as well as concealed manipulation by burglars. Burglar-resistant components are therefore only suitable to a limited extent.”* This is why ift Rosenheim has elaborated the ift Guideline EI-06/I “Vandalismus hemmende Bauelemente und



The ift Guideline EI-06/I “Vandalism-Resistant Building Elements and Facilities” defines typical perpetrator behaviour, tools, reproducible sequences as well as possible hazard classes for glazing. This is determined by manually testing resistance against vandalism – using a pile driver in this photo.

Photo: ift Rosenheim

Einrichtungen” (Vandalism-Resistant Building Elements and Facilities) with a circle of experts; this guideline defines the typical procedure, tools, reproducible sequences of events as well as possible classifications. These are determined by deploying an array of implements to manually test a functioning installed element (with fixtures, frame, door leaf, lock, glazing etc.) to gauge its resistance to vandalism – where resistance time also counts. Also important is the added “LS (Liquid Safe)” protection requirement, where the test team attempts to create an opening in the test specimen, which is large enough to insert a bottle (Molotov cocktail). The aim is to protect buildings and people better against deliberate destruction and violence in public areas as well as highly frequented and vulnerable locations.



The ift Guideline EI-06/1 “Vandalism-Resistant Building Elements and Facilities” defines typical perpetrator behaviour, tools, reproducible sequences as well as possible hazard classes for glazing. This is determined by manually testing resistance against vandalism – this photo shows additional LS (Liquid Safe) testing whereby the test team attempt to create a penetrable hole in the test specimen large enough to introduce a bottle (Molotov cocktail). Photo: ift Rosenheim

The market is also displaying a trend towards higher protection classes, as Mr. Jochen Regenauer, Head of Strategic Projects & Business Development EMEA at Kuraray Europe, observes: “Security is an area experiencing global growth and one witnessing a massive increase over the last few years. In Germany, for public spaces originally subject to medium requirements, protection class P4A for glazing is already the rule today. Often in demand here are glass structures with increased resistance to projectiles, break-in/forced entry, baseball clubs and massive use of force. In the US Kuraray is already operating on the market with a tested solution involving SentryGlas, thereby complying with the ASTM F1233 standard. Beyond this, bullet-proof glazing complying with protection classes BR4-NS to BR6-NS is also increasingly in demand – for public buildings such as train stations, bank buildings and glazed entrance concourses, even in IGU applications for store fronts or foyers.”

RISING REQUIREMENTS THROUGH EXTREME WEATHER CONDITIONS

The KRITIS Act focuses not only on security risks but also on risks

from ever more frequent extreme weather conditions such as heavy rains and floodings that no longer just affect buildings near rivers. Mr. Benitz-Wildenburg explains: “During heavy and prolonged rainfall normal windows and doors are often no longer sufficient to protect against water ingress. Here suitable structures including sealed connections to the building fabric are needed, which in turn require correspondingly sized laminated toughened glass units.” ift Rosenheim therefore tests these components



Dipl.-Ing. Jürgen Benitz-Wildenburg, Head of PR and Technical Communication at ift Rosenheim. Photo: ift Rosenheim

according to the ift Guideline FE-07 “Hochwasserbeständige Fenster und Türen” (Flood-Resistant Windows and Doors). The test results and classifications form the basis for planning and tenders for flood-barrier building elements.”

Mr. Regenauer sees similar developments: “A lot has already been done in flood protection in the last few years; but since it is a local authority responsibility, measures still have room for improvement due to budgetary restraints. The KRITIS Umbrella Act will definitely inject impetus here.” More frequent storms, hurricanes and typhoons – depending on the geographical situation – are also generating growing demand



Flood-protection walls and balustrades with SentryGlas interlayers made by Kuraray are categorised as highly load bearing laminated toughened glass (LTG) for structural applications. Unlike classic polyvinyl butyral laminates they boast a significantly higher residual load bearing capacity, stiffness and durability – which is key for flood loads but also for components preventing falls from a height. Photo: ©FENEX, LLC



Jochen Regenauer, Head of Strategic Projects & Business Development EMEA, Kuraray Europe.

Photo: Kuraray Europe GmbH

for relevant protective glazing, as Regenauer reports: “Storm-proof glazing is now necessary for a large part of the American East Coast because hurricanes hit more and more often and earlier in the year. The same applies to parts of Asia with more frequent typhoons – these are similar to hurricanes but come with more water. Kuraray supplies various solutions for this – highly secure glass structure with SentryGlas interlayers to further increase energy absorption and penetration resistance in the glazing.” Ift Rosenheim also offers corresponding testing for this purpose according to American standards at its Rosenheim site.

BUILDING SKIN AS PART OF CYBER SECURITY

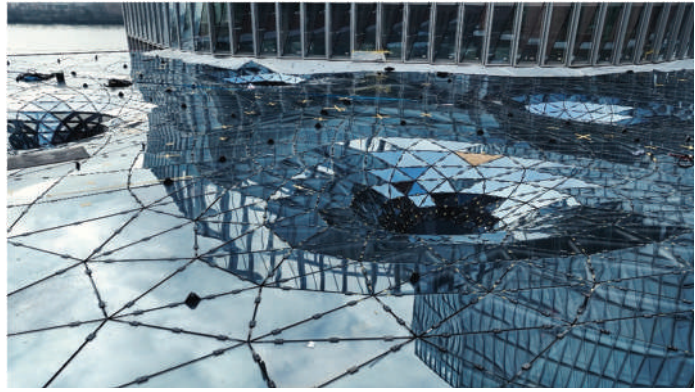
The KRITIS Umbrella Act is strongly oriented towards the requirements of NIS2, the EU Directive that already defines minimum standards for cyber and information security. Through the KRITIS Umbrella Act this Directive is transposed into German law and complemented for all relevant areas of infrastructure at the same time. This means, the understanding of security is broadened from purely digital defence to physical protection measures. One growing risk in terrorism or espionage is electromagnetic attacks, for example, where radio or radiation signals are used to tap or hack into networks.

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departments, authorities or data centres where radio signal can neither enter nor exit. These signals include Wi-Fi signals or electromagnetic radiation from screens and keyboards (war-driving or remote tapping). This type of glass is also used in labs and hospitals where sensitive medical equipment needs protecting from radio interference or in security areas such as conference rooms where confidentiality is key. These solutions complement classic IT security measures and follow the Defence-in-Depth principle where physical and digital protection levels are combined.

DEMAND FOR EXCLUSIVE APPLICATIONS IS RISING

There is growing demand for toughened glass in many other areas especially in exclusive applications, says Mr. Regenauer: “Toughened glass for the armoured vehicle market is a hot ticket especially in South Africa and South America – designed predominantly to protect against kidnapping. In the narrow streets of the city of London (London’s financial district) blast resistance is called for and comparatively thin LTG is used since it can react more flexibly to quick, massive pressure. Most lounges and VIP areas are equipped with bullet-proof glass and balustrades achieve a particularly high residual load



Complex glass roof structure at Westfield Hamburg Überseequartier: the complex geometry of the glass-steel structure executed with high-performance Kuraray interlayers ensures maximum security, transparency and architectural precision.

Photo: ©Darren Arpe / Roschmann Group

bearing capacity thanks to SentryGlas interlayers. There is also rising demand for glass sky pools for hotels and private villas that have to constantly withstand very high water pressure. And, last but not least, more and more vessels and yachts are being registered with glass structure specs needing to withstand the high dynamic impact loads from waves. These applications mostly involve structural SentryGlas interlayers for reducing the glazing thickness, or LTG with up to eightfold lamination often containing chemically toughened sheets for flawless looks ■”

glasstec 2026 in Düsseldorf from October 20-23, 2026 will once again be the pivotal and leading pace-setting trade fair for exchanging ideas on the future of the glass industry featuring Artificial Intelligence & Digital Technologies, Decarbonisation and Circularity as Hot Topics. But it will also show that glass products for building skins are no longer planned solely with an eye on energy-efficiency and design quality but also increasingly with security in mind. At glasstec 2026 the trade fair company and ift Rosenheim as a cooperation partner will organise the first special show “secure – innovative – sustainable”, which will place resilient and security-critical glass solutions for protected rooms and critical infrastructures centre stage.

For more information go to: www.glasstec-online.com

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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 by New United Process, A-26, Ph-II, Naraina Industrial Area, New Delhi-110028

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