78th Conference on Glass Problems
including 11th Advances in Fusion and Processing of Glass Symposium

November 6 - 9, 2017
Greater Columbus Convention Center
Columbus, Ohio USA

GPC is the largest glass manufacturing event in North America, attracting global manufacturers and suppliers to exchange innovations and solutions.
More installed systems than all other suppliers combined
Nearly a decade in glass: container, flat glass, tableware

The proven solution for air-fuel and oxy-fuel gas furnace emissions:
PM, NOx, SOx, HCl, HF, metals, mercury, hex chrome, dioxins/furans, VOCs, CO

Talk with Technical Sales Director Kevin Moss, Booth 305, or call 989-321-2991
Welcome to the 78th Conference on Glass Problems (GPC), which is devoted to glass manufacturing, a vibrant and dynamic industry. It is an enterprise that ranges over almost all aspects of civilization. From products in daily use by virtually all humanity, to applications that dramatically expand the frontiers of industry and science. In similar fashion, the scope of this conference is expansive, providing information of value to a wide range of industry interests.

The Glass Manufacturing Industry Council (GMIC), the leading trade association bridging glass segments, in partnership with Alfred University, the leading American glass teaching and research institution, co-organize the conference, with programming direction provided by an industry advisory board.

This year, we are pleased to double the scope of the conference program with the addition of the 11th Advances in Fusion and Processing of Glass symposium (AFPG), organized in collaboration with The American Ceramic Society’s Glass and Optical Materials Division.

GPC technical sessions address manufacturing issues, citing real world data from manufacturers and solutions providers. AFPG expands programming into materials science and current research. Additional value-rich resources are available, such as our popular short courses, and full-day technical symposium, Reducing Construction, Rebuild, and Hot Repair Times for Glass Manufacturing Furnaces. For continuing reference after the conference, proceedings manuscripts are made available.

Often, what is talked about in conference hallways can be just as valuable as what is learned in lecture halls. Here, you will find one of the most extensive platforms for glass manufacturing industry networking and exhibiting in North America, where leading solutions providers mingle with all segments of glass manufacturers at our social events, booth exhibits, hospitality salons, and booths.

We are grateful for the sponsors who support the conference, for the time and effort of the conference organizers, and for you, the glass manufacturing industry professionals. Thank you for enriching the 78th Conference on Glass Problems with your participation. We trust you will find it a valuable and rewarding experience.

THANK YOU SPONSORS!
WHO IS GMIC

The Glass Manufacturing Industry Council (GMIC) is a trade association of the glass industry that includes among its members, representatives of all four sectors: container, fiber, flat, and specialty glass companies, as well as leading suppliers to the industry, research institutes, and industry experts. Our goal is to promote the interest, growth, and sustainability of the glass industry. GMIC does for individual companies what they cannot easily do on their own—provide technical education, coordinate technical initiatives, advocate with law makers, and promote the usage and image of glass products as a vital part of society around the globe.

If you are a glass industry manufacturer, supplier, or research organization, and you are not presently a member, we encourage you to join GMIC now to ensure the vitality of the industry through your support of the industry’s trade association. Membership dues are based on company size and category. Contact GMIC’s Executive Director, Robert Weisenburger Lipetz, for full information.

GMIC EXECUTIVE COMMITTEE

Rob Hofman, Roman Manufacturing; President; Brian Naveken, TECO, Immediate Past President; Andrew Zamurs, Rio Tinto Minerals; Vice President; Martin Goller, Corning, Incorporated, Treasurer; Robert Weisenburger Lipetz; GMIC; Secretary

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Donna M. Banks, Executive Assistant

CONTACT GMIC

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GMIC MISSION

Facilitate, organize and promote the interests economic growth and sustainability of the glass industry through education and cooperation in the areas of technology, and the environment.

ALFRED UNIVERSITY

The Kazuo Inamori School of Engineering at Alfred University (AU) is a leader in glass and ceramic education. Established in 1900 as the New York State School of Clayworking, the School has a long-standing history of providing industry a workforce well-educated in the manufacturing of glass and ceramic materials. Today, the School offers BS and MS degrees in five disciplines: Biomaterials Engineering, Ceramic Engineering, Glass Engineering Science, General Materials Science and Engineering and Mechanical Engineering, as well as doctoral degrees in the materials disciplines.

The School also serves industry by advancing the forefront of ceramics and glass research. In addition to maintaining an active portfolio of federally funded research, the faculty routinely collaborate with industry or projects ranging from fundamental research through product/process development. Interactions with industry are conducted through the Center for Advanced Ceramic Technology (CACT) and the Center for High Temperature Characterization (CHTC). The CACT facilitates collaboration between industry and academia with the goal of creating economic impact for the CACT’s industrial partners. The CHCT is a user facility that provides research unparalleled access to equipment designed for characterizing materials in the situ at high temperatures.

More information about the Kazuo Inamori School of Engineering: www.engineering.alfred.edu

Alastair Cormack, Interim Dean, Engineering Alfred University, cormack@alfred.edu

S.K. Sundaram, Inamori Professor of Materials Science and Engineering Alfred University, sundaram@alfred.edu

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PUBLICATION OF THE 78TH GPC PROCEEDINGS

Following the 78th Conference on Glass Problems attendees will be emailed instructions with a link on how to download the 78th GPC proceedings.
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### SCHEDULE AT A GLANCE

#### Monday, November 6, 2017
- 11:00 a.m. – 5:00 p.m.: Registration
- 12:00 – 5:00 p.m.: Student Plant Tour
- 12:00 – 5:00 p.m.: Fundamentals of Batch and Furnace Operations
- 1:00 – 4:30 p.m.: Glass Defects
- 12:00 – 5:00 p.m.: Energy Savings at Glass Furnaces
- 5:00 – 5:30 p.m.: Student Meeting
- 5:00 – 11:00 p.m.: Hospitality Suites at Hilton

#### Tuesday, November 7, 2017
- 7:30 a.m. – 5:30 p.m.: Registration
- 8:00 – 8:45 a.m.: Exhibiting
- 9:00 – 10:30 a.m.: Operations Session
- 10:30 – 11:00 a.m.: Exhibiting
- 11:00 a.m. – 12:30 p.m.: Controls Session
- 12:30 – 2:00 p.m.: Lunch & Exhibiting
- 2:00 – 4:30 p.m.: Energy Session

#### Wednesday, November 8, 2017
- 7:30 a.m. – 4:00 p.m.: Registration
- 8:00 – 9:00 a.m.: Exhibiting
- 9:00 – 10:00 a.m.: Meeting Session
- 10:00 – 10:30 a.m.: Exhibiting
- 10:30 a.m. – 12:00 p.m.: Modeling and Forming Session
- 12:00 – 1:30 p.m.: Lunch & Exhibiting
- 1:30 – 3:30 p.m.: Refractories Session
- 4:00 – 5:00 p.m.: GMIC Member Meeting

#### Thursday, November 9, 2017
- 7:30 a.m. – 12:00 p.m.: Registration
- 8:00 a.m. – 4:00 p.m.: Reducing Construction, Rebuild & Hot Repair Times for Glass Manufacturing Furnaces – Hilton

### PROGRAM SCHEDULE

#### SUNDAY, NOVEMBER 5, 2017
- 6 p.m.: GPC ADVISORY BOARD DINNER

#### MONDAY, NOVEMBER 6, 2017
- 12 noon – 4:30 p.m.: STUDENT PLANT TOUR – OWENS CORNING

### SHORT COURSES

**COLUMBUS HILTON DOWNTOWN HOTEL**

**Monday, November 6, 2017 | 12 Noon – 5 p.m.**

**FUNDAMENTALS OF BATCH AND FURNACE OPERATIONS – Edna Boies Hopkins Room**
- Instructor: C. Philip Ross, President, Glass Industry Consulting International (GICI)
- The course is an introduction to the principles of commercial glass production employed in Batch & Furnace operations by US Glass producers. Raw Materials, Glass Technology and Properties, Melting Furnaces, and Environmental Issues will all be touched upon. Suggested attendees could be vendors or newer individuals to glass manufacturing seeking an introduction to the issues faced in glass production.

**EXPLORING THE CHANGING SAFETY LANDSCAPE OF SILICA, HEXAVALENT CHROMIUM, AND CONFINED SPACE IN THE GLASS INDUSTRY – Elijah Pierce A Room**
- Instructor: Dragan Savic, Vice President of Glass Technology and Safety Staff Augmentation, SCT
- SCT Vice President Dragan Savic, a leader in the safety industry, will delve into the changes in OSHA standards and guidelines for crystalline silica, hexavalent chromium, and confined space, all of which are/can be critical hazards for those working in the glass industry.

**Monday, November 6, 2017 | 1 – 5 p.m.**

**FUNDAMENTALS OF GLASS MELTING CONTROL SYSTEMS – Elijah Pierce B Room**
- Instructor: Dale Gaerke, Senior Member, The International Society of Automation (ISA), Retired Director of R&D Controls and Electrical Engineering for Owens-Illinois, Inc.
- The course is an introduction and general overview of the control system features and adjustments typically employed in regenerative glass melters by US glass producers. Focus will be on control system settings for regenerative gas fired melters with time for in depth open discussion and questions. This can also include discussion of oil fired and oxy/gas fired melter issues. Suggested attendees are newer individuals to glass melting control systems and their operational adjustments.

**5 – 5:30 p.m.: STUDENT MEETING | Elijah Pierce A Room**

**5 – 11 p.m.: HOSPITALITY SUITES | Lower Level**

**78TH GPC SESSIONS | Battelle Hall A**

**11TH AFPG SESSIONS | Battelle Hall B**

**GREATER COLUMBUS CONVENTION CENTER**

**TUESDAY, NOVEMBER 7, 2017**
- 8 – 8:45 a.m.: EXHIBITING
- 8:45 – 9 a.m.: OPENING REMARKS: PLENARY
  - Robert Weisenburger Lipetz, Conference Director, Glass Manufacturing Industries Council
  - S. K. Sundaram, PhD, Program Director, Alfred University
- 9 – 9:30 a.m.: KEY NOTE ADDRESS: PLENARY
  - David Pye, PhD, Professor of Glass Science (Emeritus), Past President, The American Ceramic Society (Emeritus), Alfred University
  - A Special Moment in Time: Arrival of the Glass Age
### 9:30 – 10:30 a.m. TECHNICAL SESSION: PLENARY
Session Chairs: Robert Weisenburger Lipetz, Conference Director, Glass Manufacturing Industries Council and S. K. Sundaram, PhD, Inamori Professor of Materials Science and Engineering Alfred University

- **9:30 – 10 a.m.** Tom Cleary, Research Manager – Reliability Sciences, Corning Inc. - *Driving Innovation: Bringing Thin, Lightweight Glass to the Automotive Industry*
- **10 – 10:30 a.m.** Paul Woskov, Senior Research Engineer, Plasma Science and Fusion Center, Massachusetts Institute of Technology – *Gyrotron Based Melting*

### 10:30 – 11 a.m. BREAK & EXHIBITING

### 11 a.m. – 12:30 p.m. TECHNICAL SESSION: PLENARY
Session Chairs: Glenn Neff, Vice President, Glass Service USA, Inc. and Michelle Korwin-Edson, Senior Scientist, Owens Corning

- **11 – 11:30 a.m.** Mark Zupan, PhD, President, Alfred University – *Glass Education, History, and Alfred University*
- **11:30 a.m. – 12 p.m.** Reinhard Conradt, RWTH Aachen University, Germany (retired), now uniglassAC GmbH – *The Relation between Furnace Efficiency and the Physics and Chemistry of the Melting Process*
- **12 – 12:30 p.m.** Erik Muijsenberg, PhD, Vice President, Glass Service – *How the Industrial Revolution 4.0 will Impact the Glass Industry*

### 2 – 4:30 p.m. TECHNICAL SESSION: GPC MODELING, SENSORS, AND FURNACE DESIGN
Session Chairs: Adam Polcyn, Senior Research Manager, Vitro Architectural Glass; James Uhlik, Director of Technical Services, Toledo Engineering Co., Inc.

- **2 – 2:30 p.m.** Oscar Verheijen, PhD, Senior Consultant, CelSian Glass & Solar BV – *Optimization of Regenerator Design*
- **2:30 – 3 p.m.** Ing. Martina Jezikova, Laboratory Engineer, Glass Service, Inc. – *Glass Defects Identification Using a Mass Spectrometer SEM-EDX Microanalysis and HTO Analysis*
- **3 – 3:30 p.m.** Wolf Kuhn, Senior Process & Development Expert, Fives Stein – *A New Radiometric Measurement Device for the Temperature Ribbon Zones in Tin Bath and Lehrs*
- **3:30 – 4 p.m.** Dipl., Ing. Christoph Jatzwauk, Chief Operating Officer, HORN Glass Industries AG – *Furnace Design for Extended Furnace Life*
- **4 – 4:30 p.m.** Mark Bennett, Glass Sector Manager, AMETEK Land – *Use of Continuous Infrared Temperature Image to Optimize Furnace Operations*

### 7:30 – 11 p.m. Hospitality Suites at Hilton | Lower Level

### WEDNESDAY, NOVEMBER 8, 2017

### 8 – 9 a.m. EXHIBITING

### 9 – 10 a.m. TECHNICAL SESSION: MELTING
Session Chairs: Laura Lowe, Sales Representative, HarbisonWalker International; Larry McCloskey, Consultant, Anchor Hocking and Andrew Zamurs, Industry & Marketing Analyst, Rio Tinto Minerals

- **9 – 9:30 a.m.** Daniel Swiler, PhD, Senior Research Scientist, Owens-Illinois, Inc. – *Acceptance Test of Fused Cast AZS Sidewall Blocks Using Ground Penetrating Radar*
- **9:30 – 10 a.m.** Yakup Bayram, PhD, CEO & Chief Technology Officer, Panera Tech Inc. – *New Industry Standard in Furnace Inspection*

### 9 – 10 a.m. TECHNICAL SESSION: AFPG – FIBER GLASSES
Session Chair: Hong Li, PhD, Sr. Scientist, Nippon Electric Glass

- **9 – 9:30 a.m.** Hong Li, PhD, Sr. Staff Scientist, Nippon Electric Glass – *Research and Development of New Energy Saving Environmental Friendly Fiber Glass Technology*
- **9:30 – 10 a.m.** Qun Zu, Senior Engineer, Nanjing Fiberglass R&D Institute Sinoma Science & Technology Co., Inc. – *Composition Effects on Properties of High Strength and High Modulus Fiber Glasses*

### 10 – 10:30 a.m. EXHIBITING
10:30 a.m. – 12 Noon  TECHNICAL SESSION: GPC – COMBUSTION

Session Chairs: Glenn Neff, Vice President Glass Service USA, Inc. and Uyi Iyoha, PhD, Business Development Manager, Praxair, Inc

10:30 a.m. – 11 a.m. Marco van Valburg, Strategic Program Director, Libbey, Inc.; Stefan Laux, PhD, Director R&D Applications Equipment, Praxair, Inc. – Design and Implementation of OPTIMELT™ Heat Recovery for an Oxy – Fuel Furnace at Libbey Leerdam

11 – 11:30 a.m. William Horan, PE, Lead Engineer, Commercial Technology, Air Products and Chemicals, Inc. – Maintaining Full Production in Furnaces with Failing Regeneration Using Oxy-Fuel Combustion

11:30 a.m. – 12 Noon Sarah Juma, PhD, R&D Engineer Combustion, Air Liquide – Heat-Oxy-Combustion Bi-Fuel Burner – Heavy Fuel Oil Trials

10:30 a.m. – 12 Noon  TECHNICAL SESSION: AFPG – GLASS STRENGTHENING

Session Chair: Hong Li, PhD, Sr. Scientist, PPG Industries, Inc.

10:30 – 11 a.m. Arun Varshneya, President, Saxon Glass Technologies, Inc. – Warp Reduction in Thin Chemically Strengthened Float Glasses

11 – 11:30 a.m. William LaCourse, Kruson Distinguished Professor of Glass Science, Alfred University – Design of SLS Glass Compositions for Accelerated Chemical Strengthening

11:30 a.m. – 12 Noon Brian Coburn, Research Scientist, Owens-Illinois, Inc. – GC/FID/TCD to Analyze Entrapped Gas in Foamy Glass

12 – 1:30 p.m. LUNCH

12 – 1:30 p.m. EXHIBITING

1:30 – 4 p.m.  TECHNICAL SESSION: GPC – ENVIRONMENTAL & SAFETY

Session Chairs: Phil Tucker, Senior Research Engineer, Johns Manville and Elmer Sperry, Technical Leader Batch & Furnace Design, Libbey, Inc.

1:30 – 2 p.m. Weijian Chen, Batch and Furnace Engineer, Libbey Glass – Glass Furnace Catalytic Ceramic Filter, Installation and Operational Experience

2 – 2:30 p.m. Gerald Hunt, Flue Gas Treatment Specialist, Lhoist North America – Operational Considerations and Lessons Learned for Dry Sorbent Injection Systems

2:30 – 3 p.m. Greg Bedford, Application Technology Manager, Unimin Corporation – Glassil DustShield: A Materials Engineering Solution to Meet OSHA’s New Respirable Silica Regulations

3 – 3:30 p.m. Greg Carmichael, VP of Sales, NA, RoboVent – Deadly Dust: Reducing the Risks of Silica Dust in Glass Working Operations


1:30 – 4 p.m.  TECHNICAL SESSION: AFPG – MELTING AND CHARACTERIZATION

Session Chair: Irene Peterson, PhD, Senior Research Associate, Corning Inc.

1:30 – 2 p.m. William Carty, Professor of Ceramic Engineering and Ceramic Engineering/Glass Engineering Science Program Chair – Obstacles to Commercialization: A Case Study in Select Batchin

2 – 2:30 p.m. Irene Peterson, PhD, Senior Research Associate, Corning Inc. – In-situ Measurement of Reactions in a Glass-Forming Batch by Neutron Diffraction

2:30 – 3 p.m. Takeshi Saito, Researcher, Taiyo Nippon Sanso Co. – Novel Oxygen-Enriched Combustion Burner Using Self-Induced Oscillating Phenomenon

3 – 3:30 p.m. Alexander Priven, Research Associate, Corning KOREA – Pseudo Equilibrium Approach to Prediction of Batch Melting Kinetics

3:30 – 4 p.m. Pierre Florian, CEMHTI – CNRS Univ. Orléans – Aluminum Local Environment and Dynamics in Aluminosilicate Melts: a High-Temperature NMR Approach

4 – 5 p.m. GMIC MEMBER MEETING

5 – 9:30 p.m. EXHIBITING BREAKDOWN

THURSDAY, NOVEMBER 9, 2017

COLUMBUS HILTON DOWNTOWN HOTEL

8 a.m. – 4 p.m. GMIC SYMPOSIUM – Reducing Construction, Rebuild, & Hot Repair Times for Glass Manufacturing Furnaces
Hilton Columbus Downtown, November 9, 2017 – Emerson Burkhart Room

Description: The Reducing Construction, Rebuild, and Hot Repair Times for Glass Manufacturing Furnaces symposium is focused on the latest technologies in the market to support significantly reducing the time to construct and rebuild furnaces. It provides a forum for the audience to gain technical knowledge and exchange experiences with each other in support of streamlined project execution.

Audience: Glass manufacturers, Glass equipment suppliers, Design Engineers, Engineering Service providers, refractory suppliers, and construction firms.

Objectives: The participants should come away from the symposium with knowledge of developments in construction and rebuilding technologies for glass manufacturing furnaces.

PROGRAM COMMITTEE
- Co-Chairman: Brian J. Naveken – Furnace Design Engineer, Toledo Engineering Company
- Co-Chairman: Steven Weiser – Total Systems Cost Community Leader, O-I
- Glenn Aspholm – Project Manager, Johns Manville
- Brian Baker – Director, Furnace Engineering, Knauf Insulation
- Frank Miller – Project Manager, Toledo Engineering Company
- Ernie Moylan – Furnace Specialist Supervisor, Cardinal FG
- Ryan Nelson – Vice President Sales & Business development, Lilja Corporation
- Mark Recker – Project Manager – North American Manufacturing, Owens-Illinois
- Robert Weisenburger Lipetz, MBA, Executive Director, Glass Manufacturing Industry Council

SCHEDULE:
7:55 – 8 a.m. Welcome – Robert Weisenburger Lipetz, Glass Manufacturing Industry Council
8 – 10 a.m. PROGRAM I – PROJECT MANAGEMENT PLANNING
8:05 – 8:25 a.m. Cost and Time Effectiveness of Choosing a Project Management Turn-Key Contractor – Doug Burgoon, TECO
8:25 – 8:30 a.m. Q&A
8:30 – 8:55 a.m. Non-Negotiable Project Management Fundamentals for Major Capital Projects – Nestor Duran, O-I
8:55 – 9:00 a.m. Q&A
9 – 9:25 a.m. Advantages and Cost Avoidance using a Design Build Project Management Approach – Brian J. Naveken, Toledo Engineering Company
9:25 – 9:30 a.m. Q&A
9:30 – 10 a.m. BREAK
10 – 11:30 a.m. PROGRAM II – SYSTEMS PLANNING
10:00 – 10:25 a.m. Ways to Reduce the Installation Time for Mechanical and Electrical Systems – Fred Aker, SORG
10:25 – 10:30 a.m. Q&A
10:30 – 10:55 a.m. Effective Process Controls Installation – Keith Bagarus, RoviSys
10:55 – 11:00 a.m. Q&A
11:00 – 11:25 a.m. Coordinating Schedules to Check-out Systems – Dan Base, EAE Tech
11:25 – 11:30 a.m. Q&A
11:30 a.m. – 12:30 p.m. LUNCH
12:30 – 1:30 p.m. PROGRAM III – HOT FURNACE BEST PRACTICES
12:30 – 12:55 p.m. Innovate Hot Repairs: Drivers and Technology – Bob Chambers, Fosbel
12:55 – 1 p.m. Q&A
1:00 – 1:25 p.m. Rapid Steam Cooldown and Optimizing Furnace Drain Time – Demetrius Rankin, Hotwork
1:25 – 1:30 p.m. Q&A
1:30 – 3:30 p.m. PROGRAM IV – DESIGN FOR CONSTRUCTION
1:30 – 1:55 p.m. Shortening the Rebuild: When and Where Castables are Appropriate – Bryn Snow and Laura Lowe, HarbisonWalker International
1:55 – 2 p.m. Q&A
2 – 2:25 p.m. Hot Repairs and Reduced Rebuild Times – Incorporation Lift Bolts – Greg Canute, SSRCO
2:25 – 2:30 p.m. Q&A
2:30 – 3 p.m. BREAK
3:25 – 3:30 p.m. Q&A
3:30 – 4:30 p.m. PROGRAM V – ENVIRONMENT, HEALTH & SAFETY
3:30 – 4:25 p.m. Safety Concerns Silica Dust, Refractory Removal, Hex Chrome, Heavy Metals, Permitting, Safety on Hot Repairs – Dragan Savik, Safety Controls Technology Corporation
4:25 – 4:30 p.m. Q&A
4:30 – 4:35 p.m. CONCLUDING REMARKS – Steven Weiser, O-I, Inc.
4:35 p.m. SYMPOSIUM ENDS
Hospitality Booth & Salon Hosts
Takes place at the Hilton Columbus Downtown

Monday, November 6 | 5 – 11 p.m.
Tuesday, November 7 | 7:30 – 11 p.m.

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FlammaTec (FT), founded by STG and Glass Service in 2008, supplies advanced burner technology for glass furnaces. Over 2,500 burners have been installed on float, container, tableware and special glass furnaces. When replacing conventional burners, FT’s advanced LoNOx burners improve heat transfer, efficiency and emissions:

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Fuse Tech’s core business is Ceramic Welding and Refractory Repair on both cold and hot furnaces. We also have equipment to photograph inside the furnace for use in damage and operation evaluation. Through the use of high pressure water lasers, Fuse Tech is able to remove debris from port sills as well as the tops of checker packs and flues and tunnels. Hot Tech will help you with your Refractory and Operational Problems. Specializing in drilling, rebuilds, hot repairs, cold repairs, diamond chain sawing, burner block replacements and overcoats. Fuse Tech/Hot Tech also is a source for Consulting on furnace operation and refractory problems.

Glass Service
HB 200
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Phone: +1-772 287 6061  
www.gsl.cz
Glass Service (GS) is a leading global consultant for glass melting/conditioning, furnace control, operation, troubleshooting, and furnace design. Mathematical modeling GFM software (design optimization) and Expert System ESIII (automated furnace and forehearth control) provide cost savings and ease of operation. GS labs analyze 2,000+ defects yearly, and offer melt testing utilizing basic and applied research.

HarbisonWalker International
HB 11
1305 Cherrington Parkway, Suite 100, Moon Township, Pennsylvania 15108
Phone: +1-412-375-6600  
www.thinkHWI.com
HarbisonWalker International (HWI) provides the largest manufacturing capacity to the glass industry in North America. Over 85 years of research and development in the glass market have enabled us to pioneer innovative glass solutions. Every day around the world, our people and products stand up to the challenges and pressures of every job. Our world-class refractory products perform to the highest degree. And by bringing intensity, reliability and passion to work every day, we’re able to provide superior value to our customers and their businesses.

H.C. Starck, Inc.
HB 305
460 Jay Street, Coldwater, Michigan 49036
Phone: +1-517-279-9511  
www.hcstarck.com/glass_melting_electrodes
H.C. Starck’s premium Mo and MoZr electrodes are the gold standard for efficient glass and electric boosted melting. We offer GME oxidation resistant coatings and fabricate flow orifices, stirrers, mandrels, and much more for glass and quartz melting, and sputtering targets for thin film coatings. H.C. Starck’s modeling simulation services include custom designed solutions to analyze thermal and mechanical stress, and deformation crystallographic texture for improved glass melting performance.

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www.hft.com
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HB 205, HB 207
229 Rickenbacker Circle, Livermore, California 94551
Phone: +1-925-455-2300  
www.lilja.com
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Magneco/Metrel, Inc.
HB 307
233 W. Interstate Road, Addison, Illinois 60101
Phone: +1-630-543-6660
www.magneco-metrel.com
MMI has developed a family of refractory monolithic products referred to as “Metpump” for Glass Furnace Applications. MMI’s unique cement-free colloidal silica (sol-gel) bonded monolithic refractory products offer an alternative to the electrofused cast blocks for the glass furnace. Metpump Products can be used in five different applications: 1) Major Repairs of the melter and regenerator 2) Full or Partial Crown Construction or Repair 3) Partial Construction of the furnace 4) Minor Repairs of the melter and regenerator 5) Full Construction of the furnace.

Praxair, Inc.
HB 204, HB 206
10 Riverview Dr., Danbury, Connecticut 06810
Phone: 1-800-PRAXAIR
www.praxair.com/glass
Praxair has extensive oxy-fuel combustion experience in the glass industry. With our full range of industrial gases and technologies, Praxair may enable substantial fuel savings, increased productivity and product quality, reduced NOx emissions and alkali volatilization, and prolonged furnace campaigns. Offerings, such as Praxair’s OPTIMELT™ Thermochemical Regenerator system, can help recover waste energy by pre-heating fuel and endothermically reacting the fuel with the carbon dioxide and steam in recycled flue gas. This converts fuel into hot syngas, allowing you to use 20% to 30% less fuel to melt glass, compared to oxy-fuel and air-fuel glass furnaces. Additionally, Praxair also supplies atmospheric, process and specialty gases, high performance coatings, and related services to various industries worldwide.

RHI US Ltd.
Bellows A
3956 Virginia Avenue, Cincinnati, Ohio 45227
Phone: +1-513-527-6178
www.rhi-ag.com
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RoviSys
HB 301, HB 303, Booth # 102
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Phone: +1-502-379-7605
www.sefpro.com
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Bellows E
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www.teco.com
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8750 Resource Park Drive, Sylvania, Ohio 43560
Phone: +1-419-843-4820
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Phone: +1-866-721-3322
www.ceramics.org
The American Ceramic Society is the leading professional membership organization for ceramic and glass materials scientists, engineers, researchers, manufacturers, plant personnel, educators, and students. The Society serves more than 11,000 members worldwide.

American Glass Research
Booth # 8
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American Glass Research, an independent, research, consulting and analytical laboratory, offers expertise in Testing, Breakage Diagnosis, Design Analysis, Training, Glass Composition, Heavy Metal Analysis, Product Liability and Auditing for glass container industry.

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AREA IMPIANTI CORP
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Phone: +1-781-428-0638
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Booth # 5
Friden, Newhaven, Nr Buxton, Derbyshire, SK17 0DX
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www.ortonceramic.com
The Edward Orton Jr. Ceramic Foundation manufactures pyrometric products and thermoanalytical instruments. In addition, the Foundation operates an independent material testing laboratory specializing in refractory, glass, whiteware, and advanced ceramic materials.

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Phone: +1-703-724-7300
www.eurotherm.com/glassproblems/
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**Fives Stein Limited**  
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www.Glass.fivesgroup.com  
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With over 100 years of experience in a wide range of glass processes and applications all over the world, we can provide a complete range of services. We provide full support and training for your teams, on our equipment, to assist with your full-scale glass production needs.  
We are part of the Fives, an industrial engineering group, who design and supply machines, process equipment and production lines for the world’s largest industrial groups. The group has over 8,300 employees worldwide and an annual turnover in excess of $2 billion.

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**GEA Group**  
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www.gea.com  
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*Booth # Registration Area*  
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Phone: +1-614-523-3033  
www.gmic.org  
GMIC is a trade association of the glass industry that includes among its members, representatives of all four sectors: Flat, Container, Fiber and Specialty Glass Companies as well as leading suppliers to the industry, research institutes and industry experts. Our goal is to promote the interests and growth of the glass industry.

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www.glassworkshounsell.co.uk  
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Global Combustion Systems specialize in the design, manufacture service and commissioning of gas, oxygen and fuel oil combustion control systems which are used in the glass melting process worldwide. Systems include, Underport, Throughport and Side-of-Port Burner systems used on regenerative furnaces. Hot Air and Oxygen burners for Unit fired furnaces. Each system is engineered for the specific requirements of the customer, meeting environmental, production quality and efficiency requirements.  
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**EXHIBITORS**

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McGill AirClean has over 50 years experience engineering, manufacturing, and installing air pollution control equipment. In the glass industry alone, we have over 250 installations worldwide controlling many different pollutants such as particulates, heavy metals, acid gases (SOx, HCI, HF, and Boron), VOCs, and NOx. Our products and services include dry and wet electrostatic precipitators, fabric filter systems (including catalytic filters), spray dry and dry injection acid gas scrubbers, regenerative thermal oxidizers, DeNOx reactors (SCR), mobile testing services, and parts and service.

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Mixer Systems is an American manufacturer of four types of mechanical batch mixers for the glass & refractory and ceramic industries. Located near Milwaukee, Wisconsin USA., we have supplied over 3500 projects in 42 different countries worldwide since 1945. The planetary mixer works like an egg beater and provides excellent mixing action for colored batches or hard to mix applications where top to bottom mixing action is critical to the end product. The horizontal shaft mixer is a paddle or spiral blade mixer that is lower cost, lower maintenance than the pan mixers. The turbin mixer is a low profile, pan mixer that features angled mixing paddles and it moves in a circle for constant, intensive mixing action. The twin shaft mixer has twin, horizontal shafts with six mixing paddles per shaft. This is a very intensive mixer with mixing times as little as 60 seconds and discharge times of 5-10 seconds.

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Motim Fused Cast Refractories Ltd.is recognized as a world leader producing fused cast AZS and alumina refractories, refractory castables. Our products are used in the glass manufacturing furnaces. More than 95% of our turnover is from export sales. Our traditional markets are Western and Central Europe, but we are present with our products on all continents of the World. Represented in the USA by Argent Enterprises Inc. | Phone: +1-724-499-5800 | aeinc@windstream.net
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www.plansee.com  
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Phone: +1-216-502-1507  
www.sct.us.com  
Safety Controls Technology, Inc. (SCT) provides safety and health services for glass demolition and rebuild sectors including clients that have requirements to comply with local, state or federal regulations. SCT is a Woman-Owned Business Enterprise (FBE, DBE, SBA, EDGE) delivering comprehensive Occupational and Environmental Engineering consulting services to both the public and private sectors.

**SAFINA Materials, Inc., A Plaurum Company**  
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100 Hilbig Rd, Ste B, Conroe, Texas 77301  
Phone: (805) 937-2210  
www.safinamaterials.com  
SAFINA Materials, part of the Plaurum Group companies, is a precious metal products manufacturer with a 150 year history. Products applicable to the glass industry include platinum and Pt alloy crucibles, funnels, cups and more. Typical metals include platinum-rhodium, and we also offer grain stabilized metals. We also supply platinum-rhodium thermocouple wire for temperature sensing and platinum coated ceramic parts.

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**Booth # 7**  
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Phone: + 0331 82 31 95  
www.sigmaref.it  
With two manufacturing facilities, S.I.G.MA. GROUP is specialized in the production of refractory materials for the glass industry since 1990 and operates today on the five continents selling abroad more than 85% of its production. Thanks to continuous investments, SIGMA GROUP has improved already widely used products like the specially grooved tube, the bonded high alumina for channel blocks and a high grade mullite as well as engineered a new structural design for the regenerator chambers.

**SORG USA**  
**Booth # 401**  
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Phone: +1-724-366-6513  
www.sorg.de  
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Special Shapes Refractory Company, Inc.
Booth # 302
1100 Industrial Blvd., Bessemer, Alabama 35022
Phone: +1-205-424-5653
www.ssrcro.com
Special Shapes Refractory Company (SSRCO) is a family owned business that manufactures specialized, engineered pre-cast refractory shapes utilizing SSRCO developed refractory mixes for use in the Glass Industry. We offer grinding and finishing services, quick turn-around times for emergency repairs, and with our co-op partners, we can provide refractory solutions that assist our customers for either “hot or cold” repairs. As we move into our 30th year, SSRCO is still continuing to work on refractory developments, both in refractory material and shape designs, that will continue to help our customers compete in the Global Market.

Specialty Rondot, Inc.
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Phone: +1-201-434-3600
www.specialtyrondot.com
Specialty Rondot is the industry leader in providing the most up to date and advanced forming equipment to the container glass industry. Our high quality equipment and precision instruments implement the most advanced technology available today. Specialty Rondot, a Groupe Rondot company, specializes in servicing the container glass industry through the supply of unique products and customized engineering solutions. The product range is comprised of products manufactured by Groupe Rondot companies such as Graphoidal, Rondot and Sonicam as well as complimentary products from external Principals such as Sheppee International, Pennine Industrial Equipment and Heat-Up. Experienced sales engineers are available to visit customers and discuss regular requirements as well as potential efficiency and quality improvements within the container glass manufacturing process. CAD design services are offered for bespoke customer solutions or modifications to standard equipment.

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www.tiama.com
TIAMA AMERICAS based in Maumee, Ohio (USA), is the American subsidiary of the global leader of inspection solutions: the Tiama Group. Tiama is a global provider of real-time process and quality controls for the glass packaging industry.
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www.teco.com
Toledo Engineering Co., Inc. (TECO) is a group of companies serving the worldwide primary glass industry since 1927. TECO has in-depth knowledge of the entire glass manufacturing operation, designing and building all types of glass melting furnaces (regenerative, recuperative, oxy-fuel and electric melters). TECO has experience in melting all glass types, including soda lime, borosilicate, alumina silicate, sodium silicate, etc., giving TECO the ability to optimize your capital and operating costs. TECO is uniquely qualified to discuss your glass manufacturing application.

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Phone: +1-614-523-3033
www.gmic.org/ugsc/
Most glass companies cannot independently support a fundamental research agenda to understand and improve the usable strength of glass. However by working together with pooled funding and shared risk, the opportunity to improve the usable strength of glass is achievable. The UGSC supports fundamental, pre-competitive research on increasing the usable strength of glass across all sectors; provides an opportunity for researchers to develop expertise in industrial applications; develops tools and measurement techniques for the advancement of glass science; and publishes valuable pre-competitive glass research in the public domain.

Zircar Zirconia, Inc.
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Zircar Zirconia, Inc. employs the original ZIRCAR process to manufacture yttria stabilized zirconia fibers, textiles, and rigid, vacuum formed boards and cylinders for applications up to 2,100°C. Additional fiber chemistries include pure alumina, ceria, yttria and zirconia produced with this unique method. Product applications include insulation, separators, setters and gaskets in glass processing, furnace construction, and quartz working. We manufacture standard 1,600°C and 1,700°C, molybde disilicide heated, 110V, lab furnaces and custom designed furnace hot zones.

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ZIRCAR Ceramics’ high temperature ceramic fiber products bring significant utility to challenging glass making problems. Products feature low thermal conductivity, 1825°C refractoriness, corrosive environment stability & low particulate generation. Products include stocked standard boards, blankets, papers, cements & coatings. Our Engineered Products Dept., 6 CNC milling centers & 40+ years’ experience designing & building custom engineered insulation & furnace chambers help make better glass.

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THANK YOU FOR TAKING THE TIME TO PROVIDE YOUR FEEDBACK
We appreciate your feedback.
Sincerely,
Robert Weisenburger Lipetz, MBA
Conference Director
Richard Conradt, PhD, Chair of Glass and Ceramic Composites | Aachen University  
**The Relation between Furnace Efficiency and the Physics and Chemistry of the Melting Process**  
Glass melting may be optimized significantly via its intrinsic chemical steps. Raw materials may be chosen with respect to their impact on energy demand, batches may be designed with respect to high conversion rates, and glass compositions may be adjusted with respect to low liquidus. Positive effects have been clearly verified by lab experiments. Yet, the question remains on how such measures translate to the industrial scale. The present contribution outlines an answer. It rests on the complementary analysis of the performance of glass furnaces, typically recorded over periods of ½-2 years. The data required are: power input by fuel and boosting; pull rate; melt exit temperature; batch composition; cullet content. This is easily available information for any glass factory on a shift-by-shift basis. What will be shown is that the response to any change of the intrinsic chemical process (glass composition, choice of raw materials, design of the batch) is a highly sensitive discriminator of the performance of a given furnace. Case studies will be presented that demonstrate how the above procedure has been used to predict correctly, on the industrial scale, the effects of a reduced energy demand of melting, an enhanced turnover rate, a lowered temperature of conversion, or a lower liquidus temperature of the glass.

Erik Muijsenberg, PhD, Vice President | Glass Service  
**How the Industrial Revolution 4.0 will Impact the Glass Industry**  
Mathematical modeling of glass furnaces started around 1965. Such simulation models can reliably predict a glass melting furnace behavior and then help to improve its design, productivity and energy efficiency. The paper will show some the added value from new models with whom we can predict actual glass quality at a given furnace efficiency.  

What kind of melting efficiency can I expect from this new furnace? Mathematical models are a very good tool to help to select the best option, but they are not (yet) able to say exactly how many bubbles per kilogram of glass you will get. This is not only limited by the accuracy of the models, but also due to the fact that we cannot know now, how many bubbles per square meter per time unit will be nucleated. The good news is that if we assume a certain bubble source and a certain amount of nucleated bubbles, then “Yes,” the model can help us to select the best furnace. This can be done by first calculating the temperature and velocity in the glass melt. Then the redox and gas distribution dissolved in the melt as well. For the model, we need to start the bubbles from an origin within the furnace and trace them. During the path of these bubbles travelling through the furnace, the gases can diffuse into and out of the bubble. In this presentation, we want to show recent developments and examples.  

Glass quality and furnace efficiency are calculated together for the optimal furnace operation.

L. David Pye, PhD, Professor Emeritus | NY State College of Ceramics at Alfred University; Manoj Choudhary, President | International Commission on Glass | Owens Corning Science & Technology  
**A Special Moment in Time: Arrival of the Glass Age**  
The presentation will emphasize that we are at a special moment in time for the global community of glass scientists, technologists, educators, manufacturers, and artists to declare with certainty and pride the arrival of the Glass Age. Glass has played a major role in advancing civilization and mankind throughout the recorded history and is one of the most transformative materials of all times. In this talk, we will begin with a review of the impact glass has made in diverse fields including arts/aesthetics, architecture, astronomy, communications, energy generation and conservation, medicine, transportation, and, especially important in other branches of science. Following this review, we will focus on the present day impact of glass including its role in ushering the communications revolution. Next, we will describe what to expect in the future for the role of glass and show that the unique properties of glass make it an indispensable material to handle the major challenges and opportunities in areas such as healthcare, cleaner air and water, safety and security, and more efficient communications. We will conclude the talk by positing we have an unprecedented opportunity to herald the Glass Age and outlining steps that the international glass community should take to make it a reality.
Paul Woskov, Senior Research Engineer | Massachusetts Institute of Technology

Gyrotron Based Melting

Gyrotron sources of intense millimeter-waves in the frequency range of 30 – 300 GHz can remotely heat materials to high temperatures that include melting glass. This electromagnetic frequency range is ideally suited for applications in industrial environments because the wavelengths are long enough to propagate through paths and into materials that would impede shorter wavelength infrared radiation, but short enough for efficient absorption and spatial localization not possible with longer wavelength microwaves. A 28 GHz gyrotron with up to a 5 kW launched from a 32.5 mm or 20 mm internal diameter waveguide has been used at MIT for melting experiments with granite, basalt, and two nuclear waste vitrification glass matrixes. Typically an area about 50 mm in diameter on the surfaces can be melted within 1 or 2 minutes on the crystalline rock materials and less than 1 minute on the nuclear waste glasses. The temperature can be raised to the radiative heat loss limit in the 2,500-3,000°C range as detected by a 137 GHz radiometer view collinear with the heating beam and an observed millimeter-wave melt emissivity of about 0.7. Phase transitions and flow from the heating beam can be observed in the radiometer signal. The increased capabilities for non-contact rates of heating, high temperatures, localization, and increased real-time diagnostic access open up new possibilities for researching and processing glass materials.

Mark Zupan, PhD, President | Alfred University

Glass Education, History and Alfred University

On July 1, 2016, Mark Zupan became the 14th president of Alfred University. Established in 1836, Alfred University has one of the leading glass science, engineering, and art programs in the world. Alfred alumni have been involved in solving several problems in glass industries and making discoveries. The history and reasons for the expertise as well the impact that Alfred University has had on the glass industries and world through its alumni, faculty, and staff will be the subject of President Zupan’s remarks.
From June 23rd 2018, the Occupational Safety and Health Administration’s (OSHA) new respirable crystalline silica (RCS) regulations will go into effect for many industries, including the glass industry. The new regulations will lower the permissible exposure limit for RCS to 0.05 mg/m³ with an action level of 0.025 mg/m³. In anticipation of the stricter regulations, DustShield technology has been developed to provide the required engineering controls with the glass sand to meet the new OSHA regulations under normal operating conditions. In addition to reducing airborne dust by up to 99% as compared to untreated silica sand, the DustShield technology has several advantages over alternative mechanical dust suppression technologies. The major advantage is that the dust suppression engineering control is effective from the time of application of the DustShield technology until the end use. This ensures regulatory compliance risk is minimized throughout the supply chain. Mechanical and isolation dust suppression methods are limited to the areas where the equipment is installed, and require space, maintenance, and capital investment. This presentation has a two-fold objective: 1. Review the methodology and results that confirm the effectiveness of the DustShield technology for dust suppression 2. Review the melting evaluation work and results confirming the compatibility of the DustShield technology for glass manufacturing.

Mark Bennett, Glass Sector Manager | AMETEK Land

Use of Continuous Infrared Temperature Image to Optimize Furnace Operations

Temperature measurement at critical locations in the production process is essential for efficient control and optimization of glass manufacture and processing. An innovative thermal imaging solution for glass furnace applications using a Near Infrared Borescope provides a true-temperature radiometric image, so live temperature values can be obtained from >324,000 pixels and continuous coverage 24/7. The solution allows long term data trending for product quality and fuel optimization and enables thermal optical profiles to be measured continuously and specifically during furnace reversal.

Example case study shows how a leading container glass manufacturer has used this infrared temperature measurement solution to highlight issues within a glass melt tank, enable the end-users to make necessary repairs and then optimize firing to achieve new record pull rates on an asset nearing the end of its campaign.

Alarms and temperature isotherms also provide the manufacturer with long-term asset protection against over-heating and condensation zones. On the firing side, clear correlations have been identified between measured flame temperatures and corresponding NOx, allowing these findings to be used potentially as part of emission and de-NOx cost reduction programmes.

Greg Carmichael, VP of Sales, NA, RoboVent

Deadly Dust: Reducing the Risks of Silica Dust in Glass Working Operations

Temperature measurement at critical locations in the production glass and tile manufacturing produce dust containing respirable crystalline silica. Silica dust has been linked to health problems including lung cancer, chronic bronchitis and other respiratory diseases, and silicosis. For these reasons, the Occupational Safety and Health Administration (OSHA) issued new regulations governing the control of silica dust in the workplace in early 2016. These regulations directly impact glass and tile workers—but many manufacturers are not yet prepared to meet the new standards.

In this session, we will review the new regulations and discuss mitigation strategies, including housekeeping issues, personal protective equipment, and ventilation and filtration options.

Greg Bedford, Applications Technology Manager | Unimin Corporation; John Jackson, Applications Technology Manager | Unimin Corporation

Glassil DustShield: A Materials Engineering Solution to Meet OSHA’s New Respirable Silica Regulations

From June 23rd 2018, the Occupational Safety and Health Administration’s (OSHA) new respirable crystalline silica (RCS) regulations will go into effect for many industries, including the glass industry. The new regulations will lower the permissible exposure limit for RCS to 0.05 mg/m³ with an action level of 0.025 mg/m³. In anticipation of the stricter regulations, DustShield technology has been developed to provide the required engineering controls with the glass sand to meet the new OSHA regulations under normal operating conditions. In addition to reducing airborne dust by up to 99% as compared to untreated silica sand, the DustShield technology has several advantages over alternative mechanical dust suppression technologies. The major advantage is that the dust suppression engineering control is effective from the time of application of the DustShield technology until the end use. This ensures regulatory compliance risk is minimized throughout the supply chain. Mechanical and isolation dust suppression methods are limited to the areas where the equipment is installed, and require space, maintenance, and capital investment. This presentation has a two-fold objective: 1. Review the methodology and results that confirm the effectiveness of the DustShield technology for dust suppression 2. Review the melting evaluation work and results confirming the compatibility of the DustShield technology for glass manufacturing.
**Weijan Chen**, Batch and Furnace Engineer | Libbey Glass; **Martin Schroter**, Senior Manager of Business Development | Dürr Systems Inc.

*Glass Furnace Catalytic Ceramic Filter Installation and Operational Experience*

Melting glass has consumed energy and generated air emissions for hundreds of years. For the glass fabrication industry to responsibly meet ever restrictive emission requirements, installation of an exhaust treatment system at affordable cost is one of the obvious options. Libbey recently installed a Catalytic Ceramic Filter System on its glass furnace near Beijing, China (capital city with rapidly changing and increasingly restricted air emission requirements) to fulfil the local NOx, SOx and particulate requirements. The rapid evolution of the environment standards and regulations in the Beijing area will be discussed. Considerations for choosing a Ceramic Catalytic Filter system and the physical arrangement of the equipment will be presented. The control methodologies to address the variability of furnace exhaust flow, exhaust temperature and emission concentration for this small regenerative glass furnace will be examined. How to properly control adding the treatment agents (Lime and Urea) on a regenerative furnace with “Reversal” will be reviewed. Results of SOx, NOx data compared to local emission requirement and the cost of running the treatment system will also be discussed.

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*Maintaining Full Production in Furnaces with Failing Regenerators using Oxy-Fuel Combustion*

It is well known that the progressive failure of regenerator checker packs frequently occurring in aging glass furnaces causes a gradual restriction of combustion air and flue gas flow passages. This fouling process, which if left unabated, can ultimately lead to a significant reduction in pull rate while also lowering energy efficiency during glass melting. Moreover, even when compartmentalized checkers are employed and hot repairs can be carried out, these are very time consuming and labor intensive processes that may require extended furnace downtime or at best extended periods of reduced pull, sometimes up to several weeks or more. Recognizing the need that thereby emerges for a substantial amount of high-temperature, on-the-fly fire-power, often on an emergency basis, Air Products has developed the Cleanfire® ThruPort Oxy-Fuel Burner to debottleneck production for furnaces that are constrained by crippled regenerators. To illustrate their use and effectiveness, this paper presents and describes two recently-executed projects using the ThruPort burners on regenerative air-fired float glass furnaces. One furnace, equipped with compartmentalized checkers, used three ThruPort burners during a one-month period over which checker repairs were made. The second furnace, which did not employ compartmentalized checkers, used two ThruPort burners to maintain full production for the final seven months of the furnace campaign. Details presented herein include burner design, installation and operation, oxygen supply, and melter performance.
Furnace Design for Extended Furnace Life

Furnace designer’s view on what possibilities and potentials there are in order to considerably influence the life of a melting furnace based on an example of a 175m² (approx. 1884sf) furnace for up to 700tpd (770 US tpd). HORN has implemented two end-fired furnaces in India. In the run-up to the implementation a lot of items were discussed regarding the possibilities of operating such a big furnace as end-fired furnace, of extending the life of such a furnace, of facilitating the maintenance and servicing for the staff and of generally getting a better overall view of the processes in the melting end. So, some solutions have been found and implemented for these furnaces which are, from the technical point of view, rather atypical for end-fired furnaces in the container glass sector. These solutions will be shown and explained as part of this presentation. In addition some measures will be depicted and explained which, apart from saving energy, are important for direct stabilization of the melting process and are expected to lead to reduction of flux line corrosion and corrosion in general.

Dipl., Ing. Christoph Jatzwauk, Chief Operating Officer | HORN Glass Industries AG

Operational Considerations and Lessons Learned for Dry Sorbent Injection Systems

Dry sorbent injection has become a widely accepted acid gas (SO₂, HCl, HF, SO₃) emission control solution for a multitude of industries including the glass industry. While the technology offers a relatively simple and low capital cost solution it also has certain operational and design considerations which should be properly considered to minimize future headaches for the end user. Lhoist North America will describe a range of issues that have been experienced over the past decade of operating experience and provide some considerations and lessons learned that may be valuable for the glass industry. These lessons learned may provide value to the end users as it may provide insight into current DSI operational users in the glass industry or alert new/future DSI end users in the glass industry of issues to look out for to ensure their DSI system has maximum reliability and optimized system performance. Such issues may include DSI design considerations, addressing conveying line design as well as scaling/plugging, sorbent dispersion as well as operating cost optimization potential with enhanced hydrated lime products. Presentation will include photos and case studies from actual DSI installations which address the problem, lesson learned and solution. The objective of this presentation is to provide a guide for common DSI issues to reduce the learning curve for DSI system users in the glass industry based on a decade of actual operating experience to ensure the DSI technology remains a cost effective and trusted technical solution for acid gas control.

Dipl., Ing. Christoph Jatzwauk, Chief Operating Officer | HORN Glass Industries AG

Glass Defects Identification Using a Mass Spectrometer, SEM-EDX Microanalysis and HTO Analysis

Glass defects, whether in the form of stones and cords, or other solid inclusions, or gaseous bubbles are a big issue for glass manufacturers. Even with increasing technical improvements in the glass melting processes, these glass defects still occur and are a big impact to good glass quality, which can sometimes lead to significant losses in production.

For solid inclusions, determination of the chemical and phase composition of the defect and the information on its microstructure is necessary for the identification of their origin. Classification of some typical defects is proposed based on their chemical composition and microstructure determined using SEM-EDX microanalysis. For gaseous defects the composition of the gases, the size and internal pressures, or the presence of deposits assists in determining the potential source of the problem. A Mass Spectrometer is utilized. Additional laboratory services, such as a High Temperature Observation Furnace can assist in comparing different melting processes.

Sarah Juma, PhD, R&D Engineer Combustion | Air Liquide; Taekyu Kang, PhD, R&D Engineer & Project Manager Combustion | Air Liquide; Xavier Paubel, PhD, Worldwide Altec Combustion Manager | Air Liquide; Luc Jarry, Worldwide Marketing Director, Air Liquide

Heat-Oxy-Combustion Bi-Fuel Burner - Heavy Fuel Oil Trials

Heat Oxy-Combustion (HeatOx) is one of the innovative technologies that aim to enhance combustion efficiency and reduce the environmental impact for glass-melting processes. It reduces CO₂ through fuel savings, while significantly reducing NOx and dust emissions. The main principle of HeatOx is to use the sensible energy in the flue gas to preheat the combustion reactants, mainly oxygen and natural gas (NG), providing a 10% or higher energy consumption reduction compared to conventional oxyfuel combustion without preheating. HeatOx is proven technology, but as a new technology, it is being rapidly improved in terms of efficiency gain and competitive equipment cost.

In this context, Air Liquide has developed a bi-fuel HeatOx burner for the countries where fuel price is volatile. This burner combines the advantages of HeatOx technology—oxygen preheating—and fuel flexibility to optimize operational costs by switching back and forth between NG and Heavy oil fuel (HFO). This burner, based on Air Liquide patented ALGLASS FC technology and patented Trident oil injector, generates a flat flame for both NG and HFO configurations, thereby ensuring a good coverage over glass bath.

This paper presents 1,000 kW burner test results with HFO, which showed its capability to be operated over 500 kW to 1,500 kW range with oxygen temperatures from 15°C to 600°C or higher without any coking inside the lance or at the burner nozzle. HFO temperature was maintained below the cracking point (~140°C), at any given oxygen temperature. Flame shape and NOx emissions will also be reported.
New Approach to Safety Estimation of Heat Soak Tested Thermally Toughened Safety Glass

Actually, in Europe, the EN 14179-1 describing the Heat Soak Test (HST) for Thermally Toughened Building Glass is revised. This revision comprises the holding temperature decrease from 290°C to 260°C because previous R&D had shown a principal incompleteness of the NiS a to b transformation at too high temperature. On the other hand, a discussion on the holding time started because, following Arrhenius’ law, temperature decrease should be compensated by longer time. At this occasion, in order to help to clarify the situation, we publish new data from seldom breakages on buildings, collected over the past 30 years, and compare the results with a dataset from breakages in Heat Soak Test. Applying mathematical curve fitting, we prove that both size and position of the nickel sulphide inclusions in the glass section are significantly different. The main reason for this is the difference in the coefficients of thermal expansion of nickel sulphide and glass. We presume that more than one third of the breakages obtained in HST are “useless” for safety on building. We observe that the nickel sulphide inclusion’s sizes in HST are in average smaller, and also the positions’ curve allows the conclusion that the HST eliminates more panes than necessary for sufficient safety of the soaked building glass. Our datasets make clear that actually (i.e. based on estimations made during the last 15 years) the HST safety is under-estimated and needs to be re-calculated. Based on these findings we assume that every potentially dangerous nickel sulphide inclusion is already eliminated during the heat-up phase of both the old and the new HST. Because the new conditions allow the complete phase transformation of every nickel sulphide inclusion, independently of its composition, we conclude that the new conditions make the HS-tested glass safer than before, even with unchanged holding time of two hours.

A New Radiometric Measurement Device for the Temperature of Ribbon Zones in Tin Bath and Lehrs

The conventional thermocouple rods used to adjust the ribbon temperature in annealing lehrs is significantly disturbed by the cooling system. This leads to reading errors of up to 80°C compared to the real temperature of the glass ribbon.

A novel radiation measurement device has been developed that is based on the capture of the hemispherical ribbon radiation by a device with an absorption surface. This radiometric device is installed at distances of about 100 – 300 mm from the glass ribbon. The temperature of the absorption surface is detected by simple rugged sensors like TCs or NTCs. A detailed analysis of the radiation field allowed attributing a sensitivity width bands on the running glass ribbon to each radiation sensor. The sensitivity bandwidth depends on the distance of the sensor from the glass surface. This way, the implementation of the sensors is adapted to the width of the cooling zones of the lehr. Moreover, the impact of the coolers on the measured temperature is largely reduced. Tests with different configurations revealed the reliability and precision of the new method. The measurement precision of the new method is of the same order of magnitude as pyrometers. An annealing lehr has been equipped with the new ribbon temperature sensors and even tiny fluctuations of the ribbon temperature are measured correctly. The intrinsic precision of the sensors is better that 5°C and the measured ribbon temperatures compared to pyrometer values lay within 10°C.

The new measurement method allows cheap reliable mapping of ribbon temperatures in annealing lehrs. Moreover, the new radiometric measurement sensor can also be applied in the tin bath opening the gate for ribbon temperature mapping in this environment inaccessible for scanners.

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Design and Implementation of OPTIMELT™ Heat Recovery for an Oxy-Fuel Furnace at Libbey Leerdam

Praxair’s OPTIMELT™ regenerative Thermo-Chemical Regenerator (TCR) system has been for three years in commercial operation on a 50 tpd container glass furnace in Mexico. The technology is currently being implemented on an oxy-fuel fired tableware melter at Libbey’s Leerdam plant in the Netherlands. The TCR stores waste heat from the hot oxy-fuel flue gas in regenerator beds and uses this energy to reform a mixture of natural gas and recirculated flue gas to hot syngas which is combusted with oxygen in the furnace. Compared to an oxy-fuel furnace without heat recovery, the reduction of the flue gas temperature from approximately 1,400°C at the furnace exit to about 650°C after the TCR results in a recovery of about 60% of the sensible heat in the flue gas and a total fuel...
consumption and CO\textsubscript{2} emission reduction by typically 20%.
This paper will briefly update the operational experience, refractory performance and maintenance requirements of the TCR system on the 50 t/d commercial container glass furnace. The technology implementation at Libbey Leerdam will be introduced by reviewing the engineering design, scale-up, and integration with the oxy-fuel furnace. First results of the operation may be available in time for the presentation.

**Oscar Verheijen**, PhD, Senior Consultant | CelSian Glass & Solar B.V.; **Götz Heilemann**, Director Service Department | RHI GLAS GmbH

**Optimization of Regenerator Design**
Improving energy efficiency and cost reduction in glass production are of key importance to maintain glass as cost-competitive product with environmental sound footprint. Regenerators of glass furnaces have a major impact both on energy efficiency in glass production and investment costs for new glass furnaces. The aim with designing of regenerators is to maximize heat recovery from the hot flue gases (and to preheat combustion air) while minimizing its volume (to avoid purchasing expensive regenerator bricks) and ageing. In addition, the type of regenerator bricks applied as function of height in the regenerator (or better: as function of temperature in the regenerator), needs to be chosen such that it can chemically resist the attack/corrosion by the expected flue gas components at the prevailing temperature.
Optimal design of regenerators (in view of heat recovery, costs and lifetime) requires three-dimensional simulation to determine the turbulent flows in the complete regenerator, the local temperatures of the gases and regenerator bricks and the convective and radiative heat exchange between gases and checkers for both flue gas and air phase. The design of regenerators currently applied in glass industry has not changed significantly over the last decades. The state-of-the-art simulation tools combined with advanced industrial measurements techniques enable the improvement of regenerator design in view of energy consumption and regenerator integrity. This paper reports on the tools used in optimizing regenerator performance and provides results of regenerator performance simulations comprising 3D-temperature fields, the distribution of flue gas (and air) over the top (and bottom) cross-sectional checker layers, and the longitudinal and lateral flows further through the regenerator. In addition, critical areas for chemical fouling—either by sodium sulphate condensation or by attack of (especially the binder phases of) refractory material—are discussed.
William Cart<sup>y</sup>, PhD, New York State College of Ceramics at Alfred University | Christopher Sinton, PhD, Chief Operating Officer | CSL Materials, LLC; Hyo Jin Lee, Vice President Research | CSL Materials, LLC

**Obstacles to Commercialization: A Case Study in Selective Batching**

Selective Batching is a technology that substantially reduces the reaction time for glass batch components producing a batch-free glass in a fraction of the time normally observed for conventional batching processes. Initial studies, conducted using crucibles melts, ranging from 25 grams to 2.5 kilograms, demonstrated the feasibility of the approach. These results were, not surprisingly, insufficient to justify a commercial melting trial, based initially on the long-standing premise that laboratory scale experiments often are not reasonable predictors of performance in a commercial tank. To rectify this problem, two pilot-scale trials were conducted in a continuous tank with a pull rate of 1-2 kg/hour. Both trials demonstrated that the technology worked remarkably well. The move to a commercial tank, however, was hindered by limitations in modeling the technology (ironically via crucible melt data), the proposed granulation approach, and the drop in natural gas prices.


**GC/FID/TCD to Analyze Entrapped Gas in Foamy Glass**

Checking the composition of gasses entrapped in glass is a common tool to diagnose glass melting and conditioning problems. The gaseous species present in blisters can point to the location and the cause of formation. Several commercial labs analyze these samples, and they provide very specific compositional and pressure information about the contents of a single blister or seed.

O-I was interested in analyzing multiple seeds and blisters from a glass stream prior to forming containers. This gas analysis could aid in understanding the formation mechanism of groups of bubbles in glass-making processes. This may also assist in improving our understanding of foaming episodes and the effect of new compositions.

This paper will discuss the development of a low operational cost, low temperature custom sampling system to interact with a commercially available GC/TCD/FID.

A.J. Faber, Senior Scientist | CelSian Glass & Solar B.V.; Mouritz Swenson, PhD, Glass Scientist | CelSian Glass & Solar B.V.

**Experiments and Modelling to Understand the Crystallization Behavior of Glass Ceramics**

The application of new glass ceramic materials in diverse products like sealants and dental implants is increasing. These applications generally require a detailed understanding of the parent glass crystallization behavior. Understanding and optimizing crystallization behavior of multicomponent glasses, however, is a complicated task. Both experimental and modelling tools are currently being applied in development of advanced glass ceramics, but reliable modelling is limited and experimental approaches are resource demanding. In this paper, the use of both experimental and modelling techniques is illustrated by a few examples. As an experimental approach, techniques for characterization and control of high temperature glass melts are explained. These techniques are applied, for example, to control the redox state and the presence/dissolution of crystalline inclusions in the glass melt, which may affect the crystallization behavior and properties of the resulting glass. It is illustrated how these parameters in turn are influenced by the raw materials (chemistry and granulometry), the atmosphere above the melt and the method of melting, homogenization and cooling. As a modelling approach, thermochromical modelling is applied to investigate whether crystalized multicomponent glass ceramics reach thermodynamic equilibrium. This is illustrated by comparison between modelled and experimental results. Limitations of the modelling approach are described along with suggestions for model improvements. Adjustments of the model give indications of the degree of thermodynamic equilibrium obtained in the glass ceramics.

Pierre Florian, PhD | CNRS-CEMHTI; Vincent Sarou-Kanian | CNRS-CEMHTI; Alexey Novikov, PhD | CNRS-CEMHTI; Daniel Neuville | IPGP; Dominique Massiot | DNRS-ORLEANS

**Aluminum Local Environment and Dynamics in Aluminosilicate Melts: a High-Temperature NMR Approach**

We have developed experimental settings allowing us to perform NMR experiments from room-temperature up to 2,400°C using CO<sub>2</sub> laser as a source of heating. We early showed that changes of the coordination state of aluminum are a key mechanism controlling the macroscopic properties of aluminum-rich refractory melts such as alumina.

Recent investigations of sodium aluminosilicates across the glass transition temperature (up to 1,300°C) showed indeed a clear increase of the Al[5] concentration with increasing temperature. When considering melt fragility and heat capacity, our data demonstrate that Al[5] is a transient unit at high temperature in highly polymerized melts which increases the glass’ stability due to its ability to carry threefold coordinated oxygen atoms in its first coordination shell.

Rare-earth aluminosilicate melts (1,700°C-2,200°C) also show an important presence of “minor” Al[5] species yet not linked to the macroscopic shear viscosity as opposed to Ca-based compositions for which relaxation times for viscosity, electrical conductivity and 27Al NMR relaxation processes in the melt are the same. This similarity points to a (de)coupling between the rate of Al-O bond exchange and the structural relaxation involved in viscous flow and we are currently investigating this behaviour in Sr-, Ba- or Zn-based aluminosilicate melts.
**ABSTRACTS** in Alphabetical Order by Speaker Last Name

**William LaCourse**, Kruson Distinguished Professor of Glass Science | Alfred University.

**Design of SLS Glass Compositions for Accelerated Chemical Strengthening**

Theory, statistical modeling, and experiment all indicate that soda-lime silicate compositions with the improved properties required for more efficient chemical strengthening can be developed. Currently, more than 90% of chemically strengthened glasses are alkali alumino-silicates having high melting and processing temperatures that are not generally suitable for cost sensitive products, such as glass containers, consumer glassware, and float glass. However, SLS based compositions are rarely strengthened. Very low K-Na inter-diffusion coefficients lead to 16-24 hours exchange times in order to achieve acceptable compressive stresses and case depths. SLS glasses and post-forming treatments that permit a minimum 50% reduction in the processing time for 40-50 micron exchange depths, while maintaining efficient melting and reliable forming performance, are required. The present paper details both experimental results and theoretical considerations that indicate a possible path forward for commercial production of such glasses.

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**J.W. McCamy**, Sr. Scientist | Vitro Architectural Glass | Chen Hung, Sr. Research Associate | Vitro Architectural Glass | Ashtosh Ganjoo, Research Associate | Vitro Architectural Glass

**Modification of the Glass Surface during Manufacturing**

Modification of the glass surface with coatings or novel structures add functionality to the glass which enable energy savings, improvements in health, and new aesthetics with positive impact to the building and its occupants. Online processes for doing this are energy efficient and cost effective. However, though these processes are simple in concept, an in-depth knowledge of the chemistry and flow dynamics is needed to achieve the functionality and quality necessary for large-scale manufacturing. In addition, the interplay between the surface modification and glass forming processes are complex and an understanding of the material properties and thermodynamics is needed. The various methods for adding functionality, the critical parameters for those processes, and how they affect the forming process are reviewed.

We also describe a structure for improved light extraction in OLED solid state lighting and a newly developed online process to produce that structure. The requirements in glass properties and how those are achieved during the glass manufacturing process are discussed. Finally, we show the improvement in light output and the opportunity for reduction in energy use in solid state lighting using glass made with this process.

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**Erik Muijsenberg**, PhD, Vice President | Glass Service | Vice Chairman, ICG TC 15 & 21

**How Simulation Models an Improve Glass Quality and Furnace Efficiency**

Mathematical modeling of glass furnaces started around 1965. Such simulation models can reliably predict glass melting furnace behavior and then help to improve its design, productivity and energy efficiency. This paper will show the added value from new models with whom we can predict actual glass quality. What kind of melting efficiency can I expect from this new furnace? How many bubbles per kilogram will it produce? Or how fast can I make a product change? These are the questions a glass producer would like to have answered by the modeling. Mathematical models are a very good tool to help to select the best option, but they are not able (yet) to say exactly how many bubbles per kilogram of glass you will get. This is not only limited by the accuracy of the models, but also due to the fact that we do not how many bubbles per square meter per time unit it is nucleated. This depends strongly on the applied refractory material and also on how the furnace was constructed and heated up. If for instance, the first bottom lining is damaged during heat up and the patch comes into contact with the glass, this can lead to extensive bubble nucleation. But when the initial modeling was done nobody could expect or foresee this. The good news is that if we assume a certain bubble source and a certain amount of nucleated bubbles, then yes, the model can help us to select the best furnace. That means the furnace, will be able to remove most of the bubbles out of the glass before they end up in the product.

This can be done by first calculating the temperature and velocity in the glass melt. Then the redox and gas distribution dissolved in the melt. Lastly, we need to start bubbles from an origin and trace them. During the path travelling through the furnace gases can diffuse into and out of the bubble. For instance oxygen and SO$_2$ can be diffused into the bubble, make the bubble grow and ascend faster to the glass surface and leave the glass melt. In this presentation we want to show recent developments and examples.
Irene Peterson, PhD; Senior Research Associate | Corning Incorporated; Jennifer Rygel, PhD; Research Scientist | Corning Incorporated; Ying Shi, PhD; Senior Research Scientist | Corning Incorporated; Dong Ma, PhD; Research Staff Member | Oak Ridge National Laboratory; Donna Guillen | Idaho National Laboratory

**In-situ Measurement of Reactions in a Glass-Forming Batch by Neutron Diffraction**

The effects of batch particle sizes on reaction behavior were studied in a sodium aluminosilicate glass-forming batch using neutron diffraction. The phase reactions were measured in-situ during heating to 1,500°C using several different heating schedules, including constant heating rates, as well as ramp and hold (staircase) heating cycles. Diffraction data was collected using VULCAN, the Engineering Diffractometer at the Spallation Neutron Source at Oak Ridge National Laboratory. Unlike laboratory XRD beams, which analyze the surface region of finely ground powder, the intense time-of-flight neutron beam is capable of penetrating through a bulk sample of as-received (relatively coarse) industrial batch material, which allowed analysis of phase reactions in-situ using real batch materials.

Richard Pokorny | University of Chemistry and Technology, Prague, Czech Republic

**Mathematical Modeling of a Cold Cap during Vitrification of Nuclear Waste Glass**

The Hanford Waste Treatment and Immobilization Plant is tasked to immobilize radioactive waste from plutonium production in the form of stable glass. This glass will be formed by melting radioactive waste mixed with glass-forming and glass-modifying additives in an all-electric Joule-heated melter. When poured into the melter, the melter feed creates a cold cap, a layer of reacting feed components floating on the surface of molten glass. Without an accurate model of the cold cap, where the batch-to-glass conversion takes place, it is impossible to reliably predict the melting rate and the melter performance.

In this contribution, we will present the developed batch-to-glass transition model and various experimental techniques used to characterize the properties of the feed during the batch to glass transition. Between these belong (1) the feed expansion tests together with evolved gas analysis and in situ X-Ray computed tomography to address the growth and collapse of the primary foam layer; (2) heat conductivity measurements together with multi-phase heat transfer models for the cold cap energy balance; or (3) feed rheology tests to understand the mechanical properties of the feed from the initial fluid slurry to rigid sintered batch to viscous foam, which eventually collapses into almost bubble free glass. Although our work focuses on the nuclear waste feed, we believe our methodology can be used also in commercial glass-making industry.

Alexander Priven, PhD, Research Associate | Corning KOREA; Irene Peterson, PhD, Senior Research Associate | Corning Incorporated

**Pseudo Equilibrium Approach to Prediction of Batch Melting Kinetics**

A typical glass melting process, from the chemical viewpoint, includes chemical reactions and phase transformations from the initial solid phases to a final homogeneous, high-viscosity liquid. Because high viscosity hinders phase transitions in the liquid phase, glass melting usually takes place under thermodynamically non-equilibrium conditions. In turn, considerable deviation from thermodynamic equilibrium makes this process difficult to predict.

We suggest a simplified pseudo-equilibrium model that considers only solid-to-liquid phase transitions and does not consider re-crystallization of secondary solids from the liquid phase. According to this model, the melting process starts at the lowest temperature at which the liquid phase enters equilibrium with all or some part of existing solid phases. In the first case, it is the solidus temperature of the system; in the second case, the lowest solidus temperature for its subsystems formed by the existing solid phases. Further heating causes dissolution of solid phases up to the concentration at the solubility limit at given temperatures.

All of above-mentioned characteristics can be calculated from an equilibrium model where no solid phases, other than those existing in the batch, are taken into account. Such calculations can be performed by using software for thermodynamic simulations, such as FactSage™. To simplify the model, we start our simulations from the temperature at which the volatile species (H₂O, CO₂, etc.) are already removed from the batch.

We tested the suggested model for some silicate glasses with compositions within the applicability range of FactSage software. In spite of much simplification, the model appeared to properly predict the temperature range where most of the batch is dissolved. Applicability of the model to some special cases, e.g. batches containing alkali phosphates, is a subject of further investigations.

Takeshi Saito, Researcher | Taiyo Nippon Sanso Co.; Yasuyuki Yamamoto, PhD, Senior Researcher | Taiyo Nippon Sanso Co.; Yoshiyuki Hagihara, Manager | Taiyo Nippon Sanso Co.

**Novel Oxygen-Enriched Combustion Burner Using Self-Induced Oscillating Phenomenon**

This is the study focused on the development of novel oxygen-enriched combustion burner to achieve improvement of heat transfer characteristics and low NOx emission. Recently, the environmental issues have become more and more important, especially global warming is serious. Burning fossil fuels, main cause of CO₂ emission, brings a huge global warming effect. Therefore, the development of energy-saving technology is strongly desired. Oxygen-enriched combustion is one of the effective answers for energy saving and CO₂ emission reduction. On the other hand, conventional oxygen-enriched combustion technology has some problems; relatively high NOx emission, narrow heating area, and so on. Under such a background, better oxygen-enriched combus-
Bubble growth in glass melts and foaming behavior of batches with different water content during elevated temperature process were evaluated by in-situ observation method. From the results, fining onset temperatures were obtained. The fining models which the partial pressure of water vapor in the molten glass is taken into consideration will be presented. With the use of fining models, the effective fining conditions will be offered in the paper.

Qun Zu, Senior Engineer | Nanjing Fiberglass Research & Design Institute Sinoma Science & Technology Co., Ltd.; Sanxi Huang, Engineer | Nanjing Fiberglass Research & Design Institute Sinoma Science & Technology Co., Ltd; Yan Zhang, Engineer | Nanjing Fiberglass Research & Design Institute Sinoma Science & Technology Co., Ltd; Songlin Huang, Engineer | Nanjing Fiberglass Research & Design Institute Sinoma Science & Technology Co., Ltd.

**Composition Effects on Properties of High Strength and High Modulus Fiber Glasses**

Composition effects on mechanical properties, viscosity, and crystallization kinetics of MgO-Al₂O₃-SiO₂ based high-strength (HS) glass fibers and glasses were carefully examined by varying (Li₂O+B₂O₃)/MgO ratio (or LB/M for short). The HS glass fibers with two LB/M ratios had 29% higher tensile strength and 15% higher modulus than E-Glass fibers commercially used for a wide range of composite applications. While both mechanical property and glass viscosity were included, the study focused on the LB/M effects on HS glass crystallization and crystallization kinetics, which were carried out using a set of complementary techniques. Phase identification and crystal morphology survey were made. Crystallization kinetics of the HS glass fibers heat-treated under various conditions were also studied in detail to elucidate plausible mechanisms of crystallization in relationships to the composition variations. Findings from our study demonstrated that the combined, high concentration of Li₂O and B₂O₃, at the expense of MgO, or higher LB/M ratio, suppressed crystal growth in the glass. The results from DSC analysis showed two exothermic crystallization peaks suggesting multiple phase formation of the glasses under non-isothermal conditions during the sample heat up. Both cordierite and enstatite phases are stable at higher temperatures towards liquidus, yet beta-quartz solid solution was shown to be a transient phase at lower temperatures. The HS glass with higher LB/M ratio had higher activation energy for the primary crystalline phase formation, but lower active energy for the secondary crystalline phase with respect to its counterpart having lower LB/M.

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**Impact of Dissolved Water on Fining Behavior**

Water can be introduced into glass from raw materials and combustion atmosphere. It is widely recognized that water in glass has an influence on several properties such as viscosity, mechanical strength, chemical durability and fining behavior.

Bubble is one of the major defects to lower production efficiency. In the glass manufacturing process, sulfates and chlorides are commonly used as fining agents to remove the bubbles from the molten glass. Therefore, it is of great importance to understand their fining behaviors to produce glass products with less bubble defect.

The glass industry has converted air-fuel furnaces to oxy-fuel ones. An oxy-fuel furnace provides higher water vapor partial pressure in the combustion space which will cause an increase of water content in the molten glass. Thus, the effect of water on the fining behavior has attracted attention. To obtain the water vapor partial pressure in the molten glass, water solubilities of E-glass and borosilicate glass were determined at several temperatures.

Comprehensive Data – Emissions Regulations Summary - Recycling
NEW! Expert Segment Analysis – NEW! Plant Lists & Contacts Spreadsheets

INDUSTRY DATA

Contained in the report are vital metrics broken out by glass manufacturing segments; float, fiber, container, and specialty glass, detailed as historical trends, industry predictions, graphs, tables, and analysis

- Production volumes
- Revenue volumes
- Market share by segment
- Market share by region
- Capital expenditures
- Production facilities
- Employment & salaries
- Energy usage and cost
- Recycling analysis and trends
- New! Glass end markets data and trends
- Competitive industries comparative analysis
- Operational data – COGS, margin, payroll, capital, etc.
- Operating ratios and other relevant financial and industry benchmarks
- Historical trends
- Industry predictions
- Major manufacturing company profiles
- Inventory turnover
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and other relevant metrics...

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NEW! Experts in container glass, float glass and fiberglass manufacturing segments analyze the data and discuss past, current, and future trends in the segments.

SPECIAL SECTION ON EMISSIONS REGULATIONS

A detailed and comprehensive survey of emissions regulations relevant to glass manufacturing in North America and Europe, along with recommended best available techniques.

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Short wavelength sensor - low sensitivity to emissivity changes

Dedicated software - data points, areas of interest, automated alarms and long term data trending and system inter-connectivity (DCS, OPC)

Real time Thermal Data combined with high resolution visual image - allows true real time batch control, flame optimisation and the opportunity to improve energy efficiency without degrading refractory lifetime

24 Hour, 7 Day Monitoring - Shutterless operation guarantees accurate, reliable data with no blind time
To make glass better, put us in the mix.

Improving combustion can enable you to increase glass production, reduce fuel consumption, enhance glass quality, and reduce emissions, such as NOx, SOx, CO₂, and particulates. Let Air Products’ in-house modeling and melting experts help you get there.

For more than 70 years, we’ve delivered safe oxygen solutions, from our very first oxygen enrichment applications to our continuously evolving portfolio of low-emissions Cleanfire® oxy-fuel burners. You can count on Air Products for reliable gas supply and to help optimize your production—just like we have done for hundreds of furnaces all over the world.

Contact us to put the skills and experience of our global team to work for you. Optimal melting takes one key ingredient: Us.