November 7–10, 2016
Greater Columbus Convention Center  Hilton Columbus Downtown

77th Conference on Glass Problems

where glass manufacturers & suppliers meet

conference guide

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PROVEN ON OVER 20 GLASS FURNACES
Welcome to the 77th Conference on Glass Problems (GPC). The 77th Conference on Glass Problems is devoted to the technical issues facing professionals responsible for the successful operations of glass manufacturing companies.

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 partnership of industry, academia, and association oversight supports a conference that is both relevant and content rich. High standards are enforced for the technical sessions and the editorially reviewed manuscripts of the proceedings. Participation in the Conference on Glass Problems continues to grow.

As organizers, we strive to provide one of the most extensive platforms for glass manufacturing industry networking and exhibiting in North America, with comprehensive booth exhibits, and also hospitality salons, hospitality booths, and social events. Exhibition space is again sold out. We appreciate the participation and support of the industry’s leading solutions providers.

Evaluations from 76th GPC provided direction for planning the conference. In response to your feedback, we gave priority to presentations by manufacturers, and encouraged solutions providers to co-present with manufacturers, citing actual data from manufacturing facilities. Please help us continue to create a conference that best fits your needs by completing the online evaluation.

In response to your requests, we have increased technical education opportunities. On Monday, we begin with C. Philip Ross’ popular Introduction to Batch and Furnace Operations, which is an excellent short course for engineers early in their careers or for solutions providers looking to understand their clients’ concerns. For more experienced engineers, we are offering the short course, Energy Savings at Glass Furnaces, instructed by Oscar Verheijen of Celsius Glass & Solar. The third short course on Monday, Glass Defects, is taught by Filip Janos and Martina Jezikova of Glass Service USA.

As always, we conclude the conference on Thursday with a full-day technical symposium, Modeling Innovations & Applications in Glass Manufacturing. Organized by GMIC’s glass manufacturing and supplier members, this full-length symposium brings together some of the leading experts in the field providing in-depth education on the latest modeling technologies to support critical processes and address current challenges in glass manufacturing.

Thank you for enriching the 77th Conference on Glass Problems with your participation. We trust you will find it a valuable and rewarding experience.
WHO IS GMIC
The Glass Manufacturing Industry Council (CMIG) 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 can’t 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
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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: http://engineering.alfred.edu

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### SCHEDULE AT A GLANCE

**Monday, November 7, 2016**
- 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 – 11:00 p.m.: Hospitality Suites at Hilton

**Tuesday, November 8, 2016**
- 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 9, 2016**
- 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 10, 2016**
- 7:30 a.m. – 12:00 p.m.: Registration
- 8:00 a.m. – 4:00 p.m.: Modeling Innovations and Applications in Glass Manufacturing

### PROGRAM SCHEDULE

**SUNDAY, NOVEMBER 6, 2016**
- 6 p.m.: GPC ADVISORY BOARD DINNER MEETING

**MONDAY, NOVEMBER 7, 2016**
- 12 – 5:00 p.m.: STUDENT PLANT TOUR – HOLOPHANE CORPORATION

### SHORT COURSES

**MONDAY, NOVEMBER 7, 2016**
- 12 – 5:00 p.m.: FUNDAMENTALS OF BATCH AND FURNACE OPERATIONS TO BATCH AND FURNACE OPERATIONS
  - 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 U.S. Glass producers. Raw Materials, Glass Technology & 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.

- ENERGY SAVINGS AT GLASS FURNACES
  - Instructor: Oscar Verheijen, Ph.D., Senior Consultant, CelSian Glass & Solar B.V. – The short course provides an overview of tools to identify and quantify the energy savings potential of glass furnaces. These tools include various simulation tools, dedicated industrial measurements, and special sensors. The course will be based on a series of industrial examples.

- 1 – 4:30 p.m.: GLASS DEFECTS
  - **PART 1: BUBBLE ANALYSIS**
    - Instructor: Filip Janos, Glass Service USA, Inc.
  - **PART 2: SOLID DEFECTS ANALYSIS**
    - Instructor: Martina Jezikova, Glass Service USA, Inc.

This short course addresses many aspects regarding the detection and analyses of glass defects and the sources and mechanisms of glass fault formation. Additionally, the short course will review the possible source of these defects in general glass production facilities with special attention regarding float, container, fiber, tableware, and other glasses.

**Audience:** The short course is meant for entrants in the glass industry, including glass technologists and scientists, suppliers, or as extra education for even experienced engineers in the glass industry. The objective is to receive a better understanding of glass production defect identification and their possible causes.

- 5 – 5:30 p.m.: STUDENT MEETING – Edna Boies Hopkins
- 5 – 11:00 p.m.: HOSPITALITY SUITES AT HILTON

**TUESDAY, NOVEMBER 8, 2016**
- 8 – 8:45 a.m.: EXHIBITING
- 8:45 – 9 a.m.: OPENING REMARKS
  - Robert Weisenburger Lipetz, Conference Director, Glass Manufacturing Industry Council
  - S. K. Sundaram, Program Director, Alfred University
- 9 – 9:30 a.m.: KEY NOTE ADDRESS
  - C. Phillip Ross, Glass Industry Consulting – *A Perspective on the GPC and it’s Relevance to the Glass Manufacturing Industry*

**Wednesday, November 9, 2016**
- 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 10, 2016**
- 7:30 a.m. – 12:00 p.m.: Registration
- 8:00 a.m. – 4:00 p.m.: Modeling Innovations and Applications in Glass Manufacturing
10 – 10:30 a.m.  David Booth, President, Allstates Refractory Contractors, LLC – Furnace Operations and Design Considerations for Longer Campaigns

10:30 – 11 a.m. EXHIBITING

11 – 12:30 p.m. TECHNICAL SESSION: CONTROLS
Session Chairs: Glenn Neff, Glass Service USA, Inc. and Bruno Purnode, Owens Corning

11 – 11:30 a.m. Mark Powys, Project Manager, Gallo Glass; & Erik Muijsenberg, Vice President, Glass Service, Inc.—Gallo Glass - Energy Reduction with Model Based Predictive Control

11:30 a.m. – 12 p.m. David Kuhn, Manager Systems Innovation & Integration, Corning Incorporated – Smart Manufacturing for Continuous, High-Technology Glass Production

12 – 12:30 p.m. Peter Hemmann, Ph.D., President, STG Combustion Control GmbH & Co KG – Design of Optimal Control Strategy for Predictive Compensation of Gas Quality Fluctuations in Glass

12:30 – 2 p.m. LUNCH

12:30 – 2 p.m. EXHIBITING

2 – 4:30 p.m. TECHNICAL SESSION: ENERGY
Session Chairs: Phillip Tucker, Johns Manville and Martin Goller, Corning Incorporated

2 – 2:30 p.m. Matthias Lindig, Ph.D., Material Scientist, Nikolas SORG GmbH Lohr – Model Based Enhanced Regeneration Flow Conditions for Glass Furnaces


3 – 3:30 p.m. Stefan Laux, Ph.D., Director R&D, Praxair, Inc. – Advanced Heat Recovery for Oxy-Fuel Fired Glass Furnaces with OPTIMELT™ PLUS Technology

3:30 – 4 p.m. Oscar Verheijen, Ph.D., Senior Consultant, Celsian Glass & Solar B. V. – Improving Energy Efficiency of Glass Furnaces

4 – 4:30 p.m. Simone Tiozzo, Junior Project Manager, Stazione Sperimentale de Vetro – Optimization of Combustion Settings: An Energy Efficient Approach to the Reduction of Emissions by Glass Melting Furnaces

4:30 – 5:30 p.m. EXHIBITING

5:30 – 7:30 p.m. FREE TIME

7:30 – 11 p.m. HOSPITALITY SUITES AT HILTON

WEDNESDAY, NOVEMBER 9, 2016

8 – 9 a.m. EXHIBITING

9 – 9:30 a.m. KEY NOTE ADDRESS

Peter Garforth, Garforth International LLC, Energy Productivity Solutions – Corporate Energy Efficiency at a Tipping Point?

9:30 – 10 a.m. TECHNICAL SESSION: MELTING
Session Chairs: Jan Schep, O-I, Inc. and Andrew Zamurs, Rio Tinto Minerals

9:30 – 10 a.m. Oscar Verheijen, Ph.D., Senior Consultant, Celsian Glass & Solar B. V. – Impact of Redox in Industrial Glass Melting and Importance of Redox Control

10 – 10:30 a.m. EXHIBITING

10:30 a.m. – 12 p.m. TECHNICAL SESSION: MODELING AND FORMING
Session Chairs: Ken Bratton, Emhart Glass Research, Inc. and James Uhlik, Toledo Engineering Co., Inc.

11:30 a.m. – 12 p.m. Chris Windle, Technical Manager, DSF Refractories & Minerals Ltd – Tin Bath Block Evolution and Future Development: A Case of Toil, Endeavor, and Fears

12 – 1:30 p.m. LUNCH

12 – 1:30 p.m. EXHIBITING BREAKDOWN

1:30 – 4 p.m. TECHNICAL SESSION: REFRACTORIES
Session Chairs: Laura Lowe, HarbisonWalker International Company and Larry McCluskey, Anchor Hocking, LLC


2 – 2:30 p.m. James Crowe, Principle Product Specialist, Johnson Matthey, PLC – Extending the Life of Fused Cast Ceramics

2:30 – 3 p.m. Jean Gael Vuillermet, Ph.D., SEFPRO R&D Engineer, Saint-Gobain CREE – Nondestructive Analysis of Low Thickness AZS FC Tiles for High Performance Bottom Paving Solution and Over Coating

3 – 3:30 p.m. Dean Thomas, North American Sales, HarbisonWalker International – High Performance Superstructure Concept for Container Glass Furnaces

3:30 – 4 p.m. Gerald Hunt, Flue Gas Treatment Specialist, Lhoist North America - Sorbacal® – A Simple Solution for Acid Gas Compliance

4 – 5 p.m. GMIC MEMBER MEETING – Battelle Grand

THURSDAY, NOVEMBER 10, 2016

8 a.m. – 4 p.m. Modeling Innovations & Applications in Glass Production
**Hilton Columbus Downtown, November 10, 2016**

**Description:** The Modeling Innovations and Applications in Glass Production Symposium is focused on the latest technologies in the market to support critical processes and address current challenges in glass manufacturing processes. It provides a forum for the audience to gain technical knowledge and exchange experiences with each other in support of the advancement and application of glass modeling technologies.

**Audience:** Glass Manufacturers, Glass Equipment Suppliers, Material Suppliers, Process Designers, Design Engineers, CFD Modelers, and Engineering Service Providers.

**Objectives:** The participants should come away from the symposium with knowledge of the capabilities and new developments in modeling technology for glass manufacturing and production.

**PROGRAM COMMITTEE**
- Chairman: Brian J. Naveken – Furnace Design Engineer, Toledo Engineering Company
- Kevin Fulkerson – Manager of Computer Services, Toledo Engineering Company
- Jong Han – Senior Engineer, Owens Corning
- Aaron Huber – Senior Manager, Furnace Research Group, Process Technology, Johns Manville
- Christopher Hoyle – Vice President-Technical Director, Toledo engineering Company
- Daniel Landrum – Senior Furnace CFD Modeling, Owens-Illinois
- Hossam Metwally – Principle Engineer, ANSYS
- Erik Muijsenberg – Vice President, Glass Service
- Glenn Neff – Vice President, Glass Service
- Oscar Verheijen – Senior Consultant, Celsian Glass & Solar
- Justin Wang – Senior Process Engineer, Guardian Industries
- Robert Weisenburger Lipetz, MBA - Executive Director, Glass Manufacturing Industry Council

**SCHEDULE:**

- **PROGRAM I – INTRODUCTION**
  - 8 – 8:30 a.m.
    - Welcome – Robert Weisenburger Lipetz, Glass Manufacturing Industry Council
  - 8:05 – 8:30 a.m.
    - Brian J. Naveken, Toledo Engineering, Inc. Overview and History of Modeling

- **PROGRAM II – COMBUSTION & EMISSIONS**
  - 8:30 – 8:55 a.m.
    - Xiaoyi He, Ph.D., Air Products – CFD Simulation of Oxygen-Fuel Combustion in Glass Furnaces: A Perspective From Real World Applications
  - 8:55 – 9 a.m.
    - Q&A
  - 9 – 9:25 a.m.
    - Julien Pedel, Ph.D., Praxair – CFD Modeling in Oxy-Fuel Glass Furnaces for Increased Energy Efficiency and Emissions Education

- **PROGRAM III – GLASS MODELING**
  - 10 a.m. – 12 p.m.
    - 10 – 10:25 a.m.
      - Aaron Huber, Johns Manville CFD Modeling of All Electric Glass Furnaces
    - 10:25 – 10:30 a.m.
      - Q&A
    - 10:30 – 10:55 a.m.
      - Daniel Landrum, Owens-Illinois – Glass Modeling Case Study on a Regenerative Gas Fired Sideport Furnace
    - 10:55 – 11 a.m.
      - Q&A
    - 11 – 11:25 a.m.

- **PROGRAM IV – MODELING PARAMETERS**
  - 1 – 1:30 p.m.
    - 1 – 1:25 p.m.
      - Erik Muijsenberg, Glass Service Glass Quality Defined and How it is Modeled
    - 1:25 – 1:30 p.m.
      - Q&A
    - 1:30 – 1:55 p.m.
      - Kevin Fulkerson, Toledo Engineering, Inc. The Importance of Model Verification Using Production Data and Multiple CFD Applications
    - 1:55 – 2 p.m.
      - Q&A
    - 2 – 2:25 p.m.
      - Oscar Verheijen, Celsian Glass & Solar The Added Value of Time Dependent Glass Furnace Process Simulation

- **PROGRAM V – BENEFITS, LIMITATIONS & OTHER CAPABILITIES**
  - 3 – 4 p.m.
    - 3 – 3:25 p.m.
      - Jong Han and Patrick Prescott, Owens Corning Benefits and Challenges of Modeling and Numerical Simulations of Glass Fiber Manufacturing Processes
    - 3:25 – 3:30 p.m.
      - Q&A
    - 3:30 – 3:55 p.m.
      - Matthias Lindig, Ph.D., Material Scientist, Nikolas SORG GmbH Lohr – Model Based Enhanced Regenerator Flow Conditions for Glass Furnaces

- **CONCLUDING REMARKS**
  - 4 p.m.
    - Brian J. Naveken, Toledo Engineering, Inc.
Hospitality Booth & Salon Hosts

Monday, November 7 | 5 – 11 p.m.
Tuesday, November 8 | 7:30 – 11 p.m.

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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.

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HB 204, HB 206  
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www.praxair.com  
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RHI US Ltd.  
Bellows A - HS 505  
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Phone: +1-513-753-1254  
www.rhi-ag.com  
RHI AG is the market and technology world leader for high-grade ceramic refractory materials, and the only global Refractories supplier to offer products for ALL aggregates of the basic industry. A global player with Austrian roots, RHI employs roughly 8,000 people worldwide at 32 production sites in Europe, North America, Latin America, South Africa and China, with sales offices on four continents. The RHI umbrella includes brands such as Didier, Veitscher, Radex, Dolomiti Franchi, and Interstop. Recently RHI, launched “Glass Services” which offers smart solutions and expert services for glass production beyond Refractories.
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Phone: +1-502-329-7605
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Phone: +36 96 574 100  
www.motim.hu

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.  
(+1-724-499-5800; aeinc@windstream.net)

**NALCO Water, an Ecolab Company**  
**Booth # 314**  
1601 W. Diehl Road, Naperville, Illinois 60563  
Phone: +1-630-305-2692  
www.nalco.ecolab.com

NALCO Water is the global leader in water and hygiene treatment technologies and services. We utilize our expertise and innovation to partner with our customers to save water, reduce energy consumption, protect assets and improve process operations. Our highly trained site engineers will work with you to develop an effective engineering solution that meets your corporate cost, production, and sustainability goals.

**PaneraTech, Inc.**  
**Booth # 402**  
4125 Lafayette Center Drive, Suite 200, Chantilly, Virginia 20151  
Phone: +1 703-719-9666  
www.smartmelter.com

PaneraTech, Inc., is one of the most innovative sensor technology companies in the world, developing unique solutions that far surpass expectations. We are pioneers in developing the SmartMelter solution that measures and visualizes residual furnace wall thickness and identifies early stage glass penetration into the insulation for preventive maintenance and furnace life optimization.

**Parkinson-Spencer Refractories Ltd.**  
**Booth # 103**  
Holmfield, Halifax, West Yorkshire UK HX3 6SX, UK  
Phone: +1-44 1422-254 472  
www.parkinson-spencer.co.uk

Parkinson-Spencer Refractories Ltd manufacture and supply refractories, engineer products and systems for the glass industry.

Products include:

- **Refractories Division**
  - Feeder forehearth refractories for all types of forehearths
  - Dense bonded alumina glass contact blocks for the distributor and forehearth
  - Forehearth channel blocks in zircon-mullite
  - Furnace blocks
  - Pots for hand made glass industry

- **Technical Services Division**
  - Forehearth and distributor systems
  - Forehearth and distributor combustion systems
  - Forehearth and distributor control systems
  - Special cord dispersal stirrer systems

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**PCI Gases**  
**Booth # 204**  
12201 Magnolia Avenue, Riverside, California 92503  
Phone: +1-951-640-8748  
www.pcigases.com

PCI Gases manufactures and sells on-site oxygen generators ideally suited for the glass industry. It is estimated that over 20% of glass produced globally is melted using oxy-fuel technology. Oxygen is also used to reduce NOx emissions by 30-40% in air-fuel melters via technologies such as Oxygen Enriched Air Staging (OEAS). To expand the use of oxy-fuel and OEAS to potential new users, PCI’s VSAs provide on-site oxygen using an innovative approach to improve overall cost and reliability.
Plansee USA
Booth # 408
115 Constitution Blvd., Franklin, Massachusetts 02038
Phone: +1-508-553-3800
www.plansee.com

Plansee is the largest fully integrated partner worldwide for the glass industry – providing its customers with technically advanced designs manufactured from our high performance materials (molybdenum, tungsten, tantalum, niobium) which result in excellent corrosion resistance, coarse grain structure, and the highest purity.

Plansee’s leading edge technologies and high performance materials provide for an efficient glass melting process. Stop by Plansee’s booth to discuss the features of their molybdenum glass melting electrodes, tank reinforcements, stirring and gobbing equipment.

Plansee continues to contribute to making glass production more effective and environmentally friendly.

Pyrotek, Inc.
Booth # 214
1285 Claremont Road, Carlisle, Pennsylvania 17015-9727
Phone: +1-717-249-2075
www.pyrotek.info/glass

Improve quality and performance, lower costs, and narrow your vendor base with Pyrotek. A global company headquartered in North America, Pyrotek has experienced sales engineers around the world, who will work with you and your production team to decrease valuable time lost due to poor performance of expendable fore hearth refractories, I.S. machine parts and hot-glassware handling products.

Refractory Machining Services, Inc.
Booth # 201
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Phone: +1-724-285-7674
www.refrmachserv.com

Sawing, grinding and assembling of refractory materials to service the glass and steel industries.

RoMan Manufacturing™
Booth # 311
861 47th Street SW, Grand Rapids, Michigan 49509
Phone: +1-616-530-8641
www.romanmfg.com

RoMan Manufacturing™ designs, manufactures and distributes a wide range of closely coupled, water-cooled, AC transformer systems for a variety of glass manufacturing processes including: boosting, melting, bushing, finer, lehr, and forming. Close coupled transformers are installed at the heat source, versus air/oil cooled transformers which are installed anywhere from 20 to 100 meters away. This helps reduce the high cost of long and large copper bus bars and cables. It also, and of equal or higher importance, greatly reduce voltage drops due to resistance and reactance losses associated with air/oil cooled transformers’ long cabling and copper bus bar systems. Documented benefits of RoMan’s systems include: increased product quality due to decreased harmonics, and increased savings in energy, equipment cost and space requirements. Our single and three phase transformers are available from 1 KVA to 15 MVA. We also supply switch gear, copper buss, fin coolers, brass and aluminum castings and custom cut and machined industrial composite (insulation) materials. Visit www.romanmfg.com for additional information.

RoviSys
Booth # 410, HB 301, HB 303, HB 305
1455 Danner Drive, Aurora, Ohio 44202
Phone: +1-330-995-8103
www.rovisys.com

Engineering process control and information solutions for the glass industry. We offer solutions on all major platforms and technologies to meet your facility and corporate needs. From your batch house through your hot end, and in your warehouse, RoviSys has improved glass manufacturing worldwide for over 20 years.

Safety Controls Technology (SCT)
Booth # 411
6993 Pearl Road, Middleburg Heights, Ohio 44130
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.
Booth # 306
100 Hilbig Rd, Ste B, Conroe, Texas 77301
Phone: +1-936-828-3469
www.safinamaterials.com

SAFINA is a precious metal products manufacturer with a history dating back to the 1860s. SAFINA has long been a trusted supplier to the world renowned Czech glass-making industry. SAFINA’s products include platinum and Pt alloy crucibles, funnels, stirrers, plungers, and more. The company also makes a full line of thermocouple wires for temperature sensing applications as well as platinum coated ceramic parts.
EXHIBITORS

**S.I.G.MA. S.r.l.**  
**Booth # 312**  
Via delle Grigne, 12/A, 22070, Locate Varesino (CO) Italy  
Phone: +39 033 1823195  
www.sigmaref.it

S.I.G.MA. Group, specialized in the production of refractory materials for the glass industry since 1990, supplies the full high quality range of materials for furnaces. Thanks to two manufacturing facilities and continuous investments in state-of-the-art production equipment, S.I.G.MA. Group is a leader in Europe in terms of capacity, prices and lead times of shaped pieces.

Considering the growing demand of a faster and easier way of acquiring products S.I.G.MA. Group recently developed an e-commerce Refractory Shop to meet every need, both programed and urgent, as well update its customers with regards to product availability, special offers and technical innovation.

**Somex**  
**Booth # 108**  
Udaras Industrial Est., Ballyvourney, Macroom, Co. Cork, Ireland  
Phone: +353 (0) 26 65770  
http://somex.ie

Change is good.... if you are a glass container manufacturer, quality assurance or laboratory manager who would consider changing to an alternative equipment supplier for container testing, I would look forward to meeting you at the conference.

We design & build automatic & semi-automatic configuration of internal pressure test, vertical top load, pendulum impact etc., for testing glass containers. Reliability & life cycle cost are just 2 of the many reasons why some of the largest container manufacturers have validated and now use our testing machines.  
...we don’t only build machines, we build relationships.

**SORG USA**  
**Booth # 301**  
2970 Valley View Drive, Toledo, Ohio, 43615  
Phone: +1-724-366-6513  
www.sorg.de

The SORG Group through their member companies can supply turnkey installations and equipment from raw material delivery through the glass gob worldwide. This includes all aspects of the furnace lifetime cycle. From sustainable designs, construction, services, repairs, through demolition at the end of the campaign. SORG through EME, Nikolaus Sorg GmbH & Co. KG, and SKS delivers Made in Germany solutions to all sectors of the glass industry. Our latest products include the LoM burners and the BATCH3 system. LoM burners are low momentum, low maintenance oxy-fuel burners. BATCH3 consists of the IRD® Doghouse, EME-NEND® chargers and the proven Sorg® Batch and Cullet Preheating systems.

**Special Shapes Refractory Company, Inc.**  
**Booth # 302**  
1100 Industrial Blvd., Bessemer, Alabama 35022  
Phone: +1-205-424-5653  
www.ssrsco.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.**  
**Booth # 209**  
30 Montgomery Street, Suite 240, Jersey City, New Jersey 07302  
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.
EXHIBITORS

Taiyo Nippon Sanso Corporations (TNSC)
Booth # 2
Toyo Bldg., 1-3-26 Koyama, Shinagawa-ku, Tokyo 142-8558, Japan
Phone: +1-81-3-5788-4746

For more than 40 years, TNSC has developed advanced oxygen combustion technologies in various industries with hundreds of successful installations and operation.

Our novel “OFB®” series oxy fuel burner technology can significantly increase productivity, lower fuel consumption, reduce NOx emission and extend burner life.

Furthermore, we have newly commercialized the oxygen burner for innovative glass melting process called “In-flight melting process”. This technology would further improve your process.

Tanaka Kikinzoku Kogyo K.K.
Booth # 109
PGM Products Company, 7-3, Marunouchi 2-chome, Chiyoda-ku, Tokyo 100 6422, Japan
Phone: +81-3-5222-1321
www.tanaka.co.jp/english/

Tanaka Kikinzoku Kogyo is Japan based precious metal manufacturer. We have obtained the leading share in the Asian market for 135 years. TANAKA provides special platinum material such as O.D.S. platinum (called nanoplat™) and we are one of the world largest supplier of platinum equipment for high-grade glass manufacturers such as LCD glass, optical lenses, glass fiber, etc. This is our first time at GPC and we are looking forward for your visit.

Tiama Americas
Booth # 313
P.O Box 350427 – Toledo, Ohio 43635
Phone: +1 314-374-3100
www.tiama.com

Tiama Americas, based in Toledo (USA), is the American subsidiary of the French leader of inspection solutions: the Tiama Group. Tiama is a global provider of real-time process and quality controls for glass packaging industry.

50 year’s expertise for one-stop-shopping:

- Process monitoring solutions: I-Care (hot imaging), GIA (Gob weight control), and the new range: “Tiama HOT systems” (Hot mass, Hot move, Hot form...)
- Traceability solutions: laser code engraving and readers
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- IT intelligence tools for analysis and management of plant performances: “Tiama IQ range”
- Complete range of service activities: customer local support, multilingual on-line spare-parts catalogs, tooling, repairs, refurbishment

Toledo Engineering Co., Inc.
Booth # 10
3400 Executive Parkway, P.O. Box 2927, Toledo, Ohio 43606
Phone: +1-419-537-9711
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.

Tri-Mer Corp.
Booth # 405, 407
1400 Monroe St., Owosso, Michigan 48867
Phone: +1-989-723-7838
www.tri-mer.com

Tri-Mer Corporation offers UltraCat Catalytic Filter Systems that can be integrated with heat recovery and electrical power generation superior to ORC. The UltraCat filters are the only proven ceramic filter on the market, with over seven years of operating history in glass. No other filter is made like the UltraCat. Currently over 20 glass furnaces are meeting regulatory requirements with the Tri-Mer UltraCat system. Particulate (PM), SO2, HCl, metals, and NOx are removed in a single all-in-one system. Acid gases such as SO2, HCl, and HF are treated with integrated dry sorbent injection. NOx is destroyed by nanobits of SCR catalyst embedded in the filter walls when used in conjunction with integrated ammonia injection. Tri-Mer offers turnkey services: design engineering, in-house manufacturing, controls, CEMs, installation, startup, power generation, and aftermarket support. Tri-Mer is the largest supplier of ceramic filter systems in the world.

Umicore AG & Co. KG (Platinum Engineered Materials)
Booth # 212
Rodenbacher Chaussee 4, PO Box 1351 63457 Hanau, Germany
Phone: +49 6181 59-2010
www.pem.umicore.com

Umicore’s business unit, Platinum Engineered Materials, is a global technology leader for either cast or FKS®Platinum materials based single-source, tailor-made, engineered system solutions to the special glass industries. We support key players to reach the best possible performance with their special glass production processes at the interface of our Platinum Group Metal Components and its immediate periphery by means of our Process Excellence Model. Process excellence translates into total cost reduction (savings), increase of competitiveness (solutions), and reduction of risk (security).
United Recovery Services Group  
**Booth # 503**  
300 North Blackcat Road, Joplin, Missouri 64801  
Phone: +1-417-437-6670  
www.usassetsrecovery.com  
URSG is a full service precious metal recovery company specializing in HF acid glass removal/cleaning of precious metal components used in the glass industry. We also offer component disassembly services to recover precious metal from ceramic parts. Full de-alloying of platinum rhodium parts/assemblies with transfer of the metals back to your pool accounts with any major PGM vendor is also a standard offering.

Usable Glass Strength Coalition, LLC  
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600 N. Cleveland Avenue, Suite 210, Westerville, Ohio 43082  
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.

Vesuvius  
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Phone: +1-843-774-6026  
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Vesuvius is a community of experts. Present around the world, we deliver solutions to our customers to improve their efficiency. The services we offer encompass design and engineering, products and operations management. Our global network of plants brings us within reach of our customers, serving them in real time, with the capacity and flexibility they need to respond to their markets’ demands.

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Warner Power provides highly engineered power conversion products and services that improve process reliability and efficiency for the ceramics industry worldwide.

Zircar Refractory Composites, Inc.  
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Florida, New York 10921-0458  
Phone: +1-845-651-2200  
www.zrci.com
**Furnace Operations and Design Considerations for Longer Campaigns**

A discussion of operational tips, habits, and design considerations to ensure productivity and enhance furnace life. How to avoid problems before they threaten the safety and longevity of the furnace and avoid catastrophes. Taking a furnace from day one to 8-10 years or more of quality glass production. A few examples of over 40 years of furnace experience, good and bad, to be passed along to the next generation. In many cases, manufacturing companies are building and operating units that with little additional capital or forethought, could be much more profitable and productive in the long run. The considerations mentioned in this presentation are meant as ideas, suggestions, and tips to enhance both long term productivity and furnace life and avoid some of the catastrophic episodes we have seen over the years.

This paper could be elongated to become a seminar, but is meant to cover some of the most important issues we have seen currently and in the past. The importance of its control.

**Extending the Life of Fused Cast Ceramics**

Johnson Matthey PLC is a company that has been involved with precious metals since 1817, accumulating a vast amount of knowledge and experience. Development of a precious metal coating technology (ACT®) has been ongoing since the 1990s. In recent years the research focus has shifted from consumable refractories (O-rings, tube stirrers, etc.) to fused cast AZS furnace blocks. This has been driven by glass manufacturers looking for a solution to excessive refractory wear. This wear impacts both furnace life and glass quality. Until recently, the coating could only be applied to machined fused cast AZS surfaces. This paper details the latest innovation of applying the coating to the “as-cast” surface of fused cast AZS blocks and includes:

- Micro-graphical analysis and comparison of “as-cast” and “machined” AZS surfaces
- Details of the latest innovations in the laser pre-treatment process
- Examinations of the latest innovations in spraying technology
- Results of a three year plant trial

**Fluid Dynamics Analysis Leading to Innovative Glass Homogenization Device “ARCtwister”**

Quality of the glass melt prior to feeding is determined by thermal and compositional homogeneity across the feeding channel. Achieving that homogeneity with stirrers made from precious metals as well as from refractory is a widespread method in the glass industry. Homogenization of glass melts by stirring happens under laminar flow conditions due to the low Reynolds-numbers. As the glass viscosity conditions do not permit turbulence, good homogenization is hard to achieve. Compositional differences such as cords cannot be fully dispersed, they can only be stretched and folded until they are virtually invisible. Thermal homogenization relies on mass exchange. This poses the question: what stirrer geometry is both fluid-dynamically efficient as well as considering a multitude of other requirements such as low precious metal weight, longevity and robustness. In a project carried out by Umicore-PEM, the flow inside a stirring cell was studied by CFD-analysis and predominantly by physical simulation in order to develop an advanced stirring device. Cord was simulated by colored tracer liquid at different locations in a glucose model and different stirring concepts were tested and compared. The exercise revealed valuable insight into how the glass flow should be affected and what geometry an efficient stirrer should have when it can be made from strengthened PtRh-alloy. Finally, the study led to the development of the ARCtwister, a modular, self-supporting stirrer made from oxide dispersion strengthened FKS®PtRh-alloy. The stirrer creates a unique S-curved flow characteristic moving the glass volume vertically. It also transports the glass horizontally from the outside to the bowl center and vice-versa.

This concept provides very efficient homogenization even at low speeds. Its combination of stiff stirring members, tubes, arcuated blades and helices create an extremely rigid framework allowing for thin precious metal wall thicknesses.

The ARCTwister is a prime example of successful problem solving on many levels...

- The product’s homogenization functionality derives from fluid dynamic research.
- The design follows the principles of lightweight construction providing maximum stiffness with minimum use of precious metal.
- Modular placement of the stirring members allow the concept to be used in various glass vessels, in different sizes and stirring characteristics.

**Nondestructive Analysis of Low Thickness AZS FC Tiles for High Performance Bottom Paving Solution**

Based on SEFPRO R&D knowledge on microwave technology to analyze internal structure of AZS fused cast soldier block, we developed new tools to be able to prevent blind area obtained with conventional radar wave’s analysis on small thickness tiles. We will present the advantages of this new technique to obtain reliable internal structure pictures of AZS fused cast tiles used in bottom paving application for containers of float glass furnace. We will discuss the results we obtained and compare them to conventional radar analysis in term of reproducibility and performances. With the strength of this microwave technology, we can guaranty the high corrosion resistance of our fused cast tiles. Combined with tight joint machining and our double layer refractory mortar solution, SEFPRO is able to propose a reliable high performance bottom solution even in specific conditions such as high insulation to prevent heat loss, electrical boosting, or extra white glass melting.
Tunç Gürüney, Ph.D., Lead Engineer — Energy & Combustion Systems; Nege Arzan, Chief Senior Project Engineer — Energy & Environment, Şişecam; Hwanho Kim, M.Sc., Senior Research Associate, Air Liquide; Taekyu Kang, Ph.D., Staff Scientist, Air Liquide R&D DRTC; Süleyman Köç, Development Director, Paşabahçe; Osman Öztürk, Plant Manager; Luc Jarry, Glass and Metal Worldwide Market Manager, Air Liquide; Xavier Paubel, Combustion Domain Manager, Air Liquide ALTEC; Youssef Joumani, Ph.D., R&D Expert - Combustion Group, Air Liquide R&D

Oxy-fuel Tableware Furnace with Novel Oxygen and Natural Gas Preheating System

As the global demand for natural gas continues to rise and environmental regulation targets become increasingly stringent, glass manufacturers are faced with the challenge of reducing costs for melting glass under a variety of operating constraints without compromising glass quality and productivity. This enabled a stronger demand among glass manufacturers to invest in innovative waste heat recovery schemes and energy-reduction technologies. In order to position well in light of these recent trends, Şişecam undertook an effort to implement ALGLASS HeatOx technology offered by Air Liquide to its 200 ton per day oxy-fuel tableware furnace (Furnace B) in Paşabahçe Bulgaria EAD plant, leveraging a co-funding by European Commission LIFE+ program. Oxy-fuel combustion technology is already proven in the plant, leveraging a co-funding by European Commission LIFE+ program. Oxy-fuel combustion technology is already proven in the industry to increase production, decrease fuel consumption, and reduce emissions, while maintaining or even increasing product quality; by reducing or eliminating the introduction of inert nitrogen into the furnace. HeatOx technology further extends the aforementioned benefits of oxy-fuel combustion technology by preheating cryogenic grade gaseous oxygen and natural gas via recovery of otherwise-waste heat from flue gas using an intermediate heat transfer fluid, i.e. air. This paper will share experiences from the field including erection, start-up, and operation phases; present most up-to-date energy and emissions performance in 2016, and significant milestones and installation steps achieved towards the implementation of a fully operational HeatOx system—a world first at this scale, and type of glass production.

Peter Hemmann, Ph.D., President, STG Combustion Control GmbH & Co KG; Lucie Jouve, Product Manager — Hot End Area, TIAMA

Design of Optimal Control Strategy for Predictive Compensation of Gas Quality Fluctuations in Glass

More and more glass melting furnaces are facing increasing fluctuations of the natural gas composition. Keeping stable furnace temperatures requires suitable sensors and burner technology, but also an appropriate control strategy that compensates for the impact of gas quality modifications in a predictive way. A Classical Temperature and RATIO Control or gas flow modification based upon the WOBBE index are not sufficient. This paper concerns the sensors, burners and control algorithms for a PLC based control system, taking into account the physical and chemical relations and limited accuracy of most control information that is involved. For predictive compensation of gas quality fluctuations we have to do three jobs at the same time:

a) Consider the impact of the gas density on the gas flow measurement,

b) Identify the right setpoint for gas flow, considering the net calorific value of the gas, but also the modified energy losses from the flue gases and the modified energy inputs from the preheated air flow — it means the net calorific value and the thermal efficiency have to become active and variable control parameters,

c) Stoichiometric ratio of oxygen or air to gas is a function of the gas composition and it needs to be considered in a predictive way – with correction by Lambda Control for any air ingress or air loss accordingly. Depending upon a given burner design, we have to add:

d) Impact of modified burner impulse due to different gas flow,

e) Impact of combustion dynamics due to a different gas composition.

The paper presents a design for an appropriate control strategy for glass melting furnace combustion systems, to reach stable temperatures and a stable glass Redox situation, based upon a realistic accuracy of the measurement of the gas quality. There are also experiences about how to combine a WOBBE index based control for forehearth and feeders with the furnace control based on the net calorific value — using the same equipment to measure the actual gas quality.

Mathieu Hubert, Ph.D., Glass Scientist/Glass Technologist, Cel-Sian Glass & Solar B.V.; Anne Jans Faber, Senior Scientist, CelSian Glass & Solar B.V.; Hande Sesigur, Glass Technology Director, Sisecam; Sven-Roger Kahl, Manager Glass Technology, Ardagh Glass; Estela Alejandro, Physical Chemistry Laboratory Manager, Vidrala S.A.; Terutaka Maehara, Ph.D., Assistant Manager — Melting Solution Function, Asahi Glass Co.

Impact of Redox in Industrial Glass Melting and Importance of Redox Control

The color of a glass is mainly determined by the valency state of the multivalent ions it contains. Controlling the oxidation state of the melt is therefore a crucial parameter in the production of colored glasses, in terms of color stability. The redox state of the melt also greatly influences the fusing processes and thus the final quality of the product. In addition, the redox state of the coloring species in the melt at high temperatures affect the radiative heat transfers from the combustion system to the molten glass, and can therefore have a significant impact on the energy consumption of the furnace. Amongst the most largely produced type of glass, amber glasses owe their specific coloration to the presence of a so-called amber chromophore, a complex between a ferric iron and sulfides (Fe3+-S2-). When chromium is added to glasses containing an amber component, colorations such as feuille-morte, olive green, or antique green can be obtained. Tuning the total chromium content and the redox state of the melt are key issues in controlling these colors, and only slight variations in these parameters may lead to dramatic variations in coloration and process instabilities, hence to substantial production losses in industrial melting tanks.
In this paper, the key parameters governing the redox and stability of industrial glasses, and especially reduced glasses with an amber component, are presented. Special attention is given to the role of chromium on the color stability of iron- and sulfur-containing glasses in reduced conditions. Experimental results obtained in the lab are correlated to theoretical calculations and practical observations in industrial melting tanks. The results and observations presented highlight the crucial role played by redox in industrial glass making, and the importance of its control.

Gerald Hunt, Flue Gas Treatment Specialist, Lhoist North America; Melissa Sewell, Director Flue Gas Treatment, Lhoist North America

**Sorbacal® – A Simple Solution for Acid Gas Compliance**
The landscape of environmental regulations in the U.S. is complex and continues to evolve. State and Federal regulations as well as air permits mandate increasingly more stringent emission requirements for various hazardous air pollutants for both new and existing facilities for a number of acid gas species (i.e. SO₂, HCl, HF, SO₃) as well as mercury (Hg) and particulate matter. As a result of the need to comply with these stringent emission limits, there is a growing desire for a low cost/easy-to-install solution. Dry sorbent injection (DSI) technology is a low capital cost solution with a relatively small equipment footprint, low power consumption and easy to retrofit to a majority of existing facilities. As the DSI technology has matured the systems have become more reliable and the advancements in calcium based sorbent of the physical properties of Lhoist’s Sorbacal® SP and SPS enhanced hydrated lime products have demonstrated upwards of 90% SO₂ and 95+% HCl / HF reduction with DSI technology over a range of applications. This paper will present data from DSI demonstration testing performed at SO₂ and HCl control at a variety of applications using Lhoist’s enhanced hydrated lime products.

Holger Kreilkamp, Group Manager “Optics”, Fraunhofer IPT; Olaf Dambon, Ph.D., Head of Department “Finemachining & Optics”, Fraunhofer IPT; Fritz Klocke, Prof. Dr. Ing. E.h., Head of Fraunhofer IPT, Fraunhofer IPT

**Non-thermal Glass Molding of Complex LED Optics**
The advantages of LED lighting, especially its energy efficiency and the long service life have led to a wide distribution of LED technology in the world. However, in order to fully use the great potential that LED lighting offers, complex optics are required to distribute the emitted light from the LED efficiently. Nowadays, many applications use polymer optics which can be manufactured at low costs. However, due to ever increasing luminous power which goes along with increasing temperatures and UV radiation, polymer optics reach their technological limits. Due to its outstanding properties, especially its temperature resistance, resistance against UV radiation and its long term stability, glass is the alternative material of choice for use in LED optics. However, growing demands for complex yet low-cost glass optics pose a major challenge for glass manufacturers. Companies are continuously being confronted with the challenge arising from the trend towards increasingly complex geometries, ever higher levels of precision combined with a fast changing market and immense pressure on market prices.

This research is introducing a new replicative glass manufacturing approach, namely non-isothermal glass molding (NGM) in which glass preforms are reheated and molded into its final shape. New, flexible mold concepts are introduced to account for the optics’ ever increasing complexity. Besides, alternative mold materials in combination with ultra-precision mold manufacturing technologies, namely ultra-sonic assisted diamond turning are used to guarantee highest form accuracy of the used molding tools. The key to success for a fast time to market is the integration of FEM simulation at the early stage of process development, which will also be presented in this research.

David Kuhn, Manager, Systems Innovation & Integration, Corning Incorporated; Jeffrey Ahrens, Advanced Controls Innovation Manager, Corning Incorporated; Michelle Pastel, Manager, Technology & Engineering Development, Corning Incorporated

**Smart Manufacturing for Continuous, High-Technology Glass Production**
Smart manufacturing systems have been described by the National Institute of Standards and Technology (NIST) as “fully-integrated, collaborative manufacturing systems that respond in real time to meet changing demands and conditions in the factory, in the supply network, and in customer needs.” These systems, which include data management and data analysis, provide real-time actionable information that can be used to optimize and build system intelligence into manufacturing operations. The ability to utilize smart manufacturing systems is essential for high-technology glass production. In liquid crystal display applications screen resolution, material strength, weight, and shape are all elements that require advanced manufacturing to produce industry leading glass products. Timely measurements, data analysis, process models, and process controls are key components of a smart manufacturing framework as is the integration of these components through the automation of manufacturing tasks and the digitization of workflows that include both machines and human users. As with any continuous production process, these technologies are important for achieving high quality and high yields in glass manufacturing. This talk will describe the smart manufacturing approach, the needs that it satisfies, and benefits that may be realized. Further, a smart manufacturing framework that applies to continuous production of high-technology glass will be described. This will be illustrated through examples where novel advanced process controls are enabled through data integration, measurements, and modeling to improve process performance.
**ABSTRACTS in Alphabetical Order by Speaker Last Name**

**Stefan Lux**, Dr. Ing., Director R&D, Praxair, Inc.; **Uyi Iyoha**, Ph.D., Associate Director Business Development, Praxair, Inc.; **KT Wu**, Ph.D., Development Professorial, Praxair, Inc.; **Sho Kobayashi**, Ph.D., Corporate Fellow

**Advanced Heat Recovery for Oxy-Fuel Fired Glass Furnaces with OPTIMELT™ PLUS Technology**

Praxair’s OPTIMELT™ regenerative Thermo-Chemical Regenerator (TCR) system was first demonstrated on a 50 tpd container glass furnace in September 2014 and has been operating reliably since then. The technology 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. Operation of the TCR system on the 50 tpd furnace resulted in ~16% to 18% reduction in energy consumption compared to the baseline oxy-fuel furnace, flue gas temperature reduction from 1,500°C at the furnace exit to about 650°C after the TCR, and the recovery of about 60% of the sensible heat in the flue gas. To further improve the performance of the system, the TCR technology is being further advanced by combining it with another heat recovery step to more efficiently recover waste heat and cool down the flue gas to about 400°C. This advanced heat recovery system, OPTIMELT™ PLUS TCR technology, recovers about 75% of the sensible heat in flue gas.

This paper will summarize two years of extensive operational experience, performance, and maintenance requirements of the TCR system on the 50 t/d commercial container glass furnace. In addition, the technical concept including detailed engineering design, technology implementation and balance of plant equipment of the advanced OPTIMELT™ PLUS TCR technology will be presented for a 240 t/d container furnace.

**Matthias Lindig**, Dr. Ing., Manager R & D, Nikolas Sorg GmbH Lohr

**SORG Furnace Design Solution Breaks the 3GJ/t Benchmark Limit**

Glass melting furnaces are counted among the high energy consuming industrial fabrication facilities. Improvements of the furnace design aiming for energy savings is a continuous demand of the glass manufacturers. Greenhouse gas emission reduction and actions against global warming are today’s additional demands, becoming more and more of a driving force for further investigations.

There are a lot of approaches and inventions aiming for more energy efficiency. Most of them were not implemented full scale since a visible improvement was not achievable with the proposed solutions. The fast melting does not necessarily come with more energy efficient operation.

The Sorg Company has done considerable investigations on more energy efficient concepts. One of the key issues was a very comprehensive description of the heat transfer from the heat source to batch and glass. The final Sorg concept for the high energy efficient melter is characterized by a high pull conventional melter with a special pre-melting section. This concept allows a more convenient heat transfer and energy exploitation. The first installation following the idea of this new concept has already demonstrated the benefit. The specific energy consumption of less than 3GJ/t glass was already achieved. Further improvements will be possible with a more enhanced installation built on the basic idea. The concept will be explained, calculation and modeling results will be given to illustrate the advantage against the conventional melting technology, and also against alternative heat recovery systems.


**Gallo Glass - Energy Reduction with Model Based Predictive Control**

The paper will describe how Model Based Predictive Control (MBPC) was implemented at Gallo Glass in the USA on three of their four furnaces. Furthermore, MBPC is being implemented in one of the new furnaces of Gallo.

A well designed furnace (and forehearth) can be controlled in the economical optimum with MBPC. MBPC optimizes energy input, keeping the balance between temperature stability, glass quality, and energy consumption. Operating the furnace using flexible gas firing and electric heating/boosting with fully automatic MBPC allows the glass producer to operate the furnace in the most optimal, cost-effective way.

The technology can bring energy costs savings in range of +/- three percent (3%).

**Andy Reynolds**, Managing Director, Fives Stein

**New Oxy-Combustion Crown Design for Efficient Flue Gas Heat Recovery**

Oxy combustion in glass melting tanks has the particular advantage to create a reduced amount of flue gas compared to aero-combustion. Still, quite some energy is contained in the flue gas when leaving the tank at the typical temperatures of 1,450°C (in the case of soda-lime glass melting).

For this reason, special heat recovery tank sections have been proposed in the past to recover a part of this energy by exchange with the batch blanket. The drawback of such zones is the increased tank length with additional wall losses that quickly set back the advantage of better energy recovery from the flue gas.

It is crucial for the economic viability of a heat recovery tank section that a high mean heat flux from the flue gas to the batch blanket is achieved. This heat flux must stem uniquely from the flue gas, and not from parasitic radiation from the crown and flames of the tank center. In the past, this has been solved by separation walls. However, the addition of this separation wall has limited benefit for the heat recovery from flue gas.

In order to create a sufficient radiative heat flux from the flue gases, it was traditionally believed that a larger gas volume is required in order to achieve a good emittance. A detailed internal study revealed that this is not an appropriate approach for the optimization of the heat flux from the flue to the batch blanket.

It revealed that the best arrangement for a high impinging radiative flux to the blanket is a reduced crown height!
Dean Thomas, North American Sales, HarbisonWalker International; Bryn Snow, Manager-Applications Glass-Technology, HarbisonWalker International; Timothy Close, Research Engineer, HarbisonWalker International

High Performance Superstructure Concept for Container Glass Furnaces

Superstructures in container glass furnaces are critical to the performance of the melter. The key performance indicators of a melter influenced by a superstructure are: glass quality, furnace life, and energy efficiency and emissions. Using a combination of available technologies enables furnace designers to address all key performance indicators of the melter. When compared to traditional technologies, high quality sintered AZS materials provide engineering alternatives that result in more energy-efficient melters, and improved glass quality, while maintaining the desired campaign life. High emissivity coatings enable heating of a melter to operate more efficiently, lower emissions through the stack, and improve alkali resistance of the hot-face refractories. Combination of sintered AZS materials, high emissivity coatings, and strategic design of the refractory lining will impact all of the key performances indicators making a high performance superstructure possible.

Simone Tiozzo, Junior Project Manager, Stazione Sperimentale de Vetro; Walter Battaglia, Head of the Environmental Department; Stazione Sperimentale de Vetro; Alessandro Migatta, Analyst Environmental Department; Stazione Sperimentale de Vetro; Roberto Dall’ lgna, Head of the Energy and Furnaces Department, Stazione Sperimentale

Optimization of Combustion Settings: An Energy Efficient Approach to the Reduction of Emissions by Glass Melting Furnaces

The adoption of the Paris Agreement in December 2015 by more than 190 countries marks an historic milestone in the climate change prevention and environmental protection awareness all over the World. Being an extremely energy intensive sector, the glassmaking industry is going to be faced with increasing pressure to lower its specific energy consumption, and thus its production of CO₂, and to decrease even more its NOx and SOx emissions.

To achieve this goal, many technological “upgrades” are being developed, such as new compact flue gases treatment systems capable of unprecedented efficiencies and durability, or advanced systems for more extensive recovery of waste gases heat. The first step in reaching a better energy efficiency and a lower production of NOx, SOx and CO₂, however, is to simply exploit at its fullest potential, the equipment already installed in each furnace, running it in the most optimized way possible.

To support the glass producers in this task, Stazione Sperimentale del Vetro (SSV) has developed an experimental approach for the fine tuning of the burners of glass melting furnaces, leading to sizeable NOx and SOx emissions reductions, and to slightly improved energy consumption (and thus CO₂ production).

In particular, depending on the furnace design and degrees of freedom, the optimization of combustion settings is reached through a tailored series of maneuvers and incremental modulations of parameters such as: combustion ratio and injection pressure of each burner, nozzle design and diameter, relative angles of injection between fuel and combustive, distribution and shaping of the flames over the melt, furnace pressure, etc.

James Uhlik, Director of Technical Services; Toledo Engineering Co., Inc.; Christopher Hoyle, Vice President – Technical Director; Toledo Engineering Co., Inc.

Plant Audits – Case Studies of Design, Engineering, Construction, Operation Problems and Solutions

The case study examples will be selected from audits performed at these type of manufacturer’s factories: float, container, lighting, and fiberglass. Problems and solutions include refractory design/selection, wear issues experienced during the campaign, hot repairs and temporary engineering solutions, and operational process adjustments. The intent is to illustrate real-world production problems, practical solutions, and the value of non-resident process reviews. This typically results in defect reduction and campaign life extension through applying principles of operation optimization and improved maintenance techniques.

Oscar Verheijen, Ph.D., Consultant, CelSian Glass and Solar B.V.; Marco van Kersbergen, Glass Technologist, CelSian Glass & Solar B.V.; Stef Lessmann, Glass Technologist; CelSian Glass & Solar B.V.

Improving Energy Efficiency of Glass Furnaces

Since the beginning of the 20th century major steps have been realized in improving energy efficiency of glass melting furnaces. Energy consumption values for container glass went from typically 10 GJ/ton to about 4 GJ/ton (normalized at 50% of cullet). Although the largest share of potential energy savings have been accomplished, the majority of glass furnaces operate at energy levels over 40% higher than feasible.

To support the glass industry in further reducing energy costs and improving process sustainability, CelSian applies a systematic approach to determine energy efficiency performances of industrial glass furnaces and to quantify the energy savings potential for individual glass furnaces. Different methods and software tools are developed and applied to assess and improve glass furnace energy efficiency. These methods include energy-efficiency benchmarking, industrial validated glass furnace energy balances, and simulation tools to optimize glass furnace design and operation, and to improve on regenerator design, and advanced process control technologies.

This paper discusses the various components of CelSian’s “energy efficiency improvement platform” with emphasis on industrial assessment of glass furnace energy balances and prediction of improvement in glass furnace energy efficiency by means of calibrated simulation models. The paper is illustrated by means of a series of industrial examples.
Chris Windle, Technical Manager, DSF Refractories & Minerals, Ltd.; R.A. Webster, Ph.D., Development Research, DSF Refractories & Minerals

**Tin Bath Evolution and Future Development: A Case of Blood, Sweat, and Fears**

Since the advent of the float glass process devised by Sir Alastair Pilkington in the early 1950s, the performance of the tin bath has been crucial; indeed fundamental to product quality. Profitable exploitation of the float glass process commenced in the early 1960s, while ever increasing campaign objectives and production output over the following decades imposed high demands on the tin bath blocks.

The problems encountered with tin bath blocks were all unique; they required extensive investigation, novel thinking, and a truly collaborative approach between the glass maker and refractory manufacturer. In addition, the kinetics of many undesirable effects were extremely slow, taking years to become apparent. Therefore, the “fear” that many baths could be affected by the same problem as block compositions were common to all.

Mutual development continues today as new issues manifest, and expectations of 20 years’ minimum operation are realized. Tin bath blocks are a key intrinsic component of the bath construction; they have a direct positive or adverse impact on glass quality. An inappropriate composition for the bath block can lead to a multitude of problems which result in lost production, and high cost issues. The right formula of bottom block will provide continuous, trouble-free production for many years.

The issues encountered through the decades are well known—tadpoles, a glassy refractory deposit attached to the underside of the glass ribbon with a tail extending for hundreds of feet; open bubble defect, hydrogen pulled preferentially through the block (thermal transpiration) bursting through the tin; 7” splitting, constrained stress leading to fracture and the liberation of refractory slabs, and finally nepheline flaking, a consequence of the reaction between the alumino-silicate bath block and sodium ions from the glass ribbon.
Introducing AMETEK Land’s new innovation for the glass industry: an enhanced thermal imaging Near Infrared Borescope (NIR-B) designed specifically for the use in glass-melt tanks, with an optional auto-retract version for additional instrument protection.

The NIR-B Glass is a short wavelength radiometric infrared borescope imaging camera, designed to produce high definition (656 x 494 pixel) thermal images, along with providing accurate temperature measurements from any selected points in the image.

The camera measures temperatures in the range 1000 to 1800 °C (1832 to 3272 °F) and is suitable for float glass, container glass, borosilicate glass and fibre glass melt furnaces.

**PROVEN APPLICATIONS OVER A 65 YEAR HISTORY IN THE GLASS INDUSTRY**

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