SCHEDULE AT A GLANCE

Monday, November 3, 2014

11 a.m. – 6 p.m.	Registration
11:30 a.m. – 4:30 p.m.	Student Plant Tour
12 – 5 p.m.	Fundamentals of Batch and Furnace Operations
12 – 5 p.m.	Glass Furnace Designs and Furnace Operation—Modeling of Glass Melting & Combustion Process & Advanced Furnace Control
12 – 5 p.m.	EPA ENERGY STAR®/GMIC Joint Energy Efficiency Symposium
5 – 5:30 p.m.	Student Ambassador Meeting
5 – 11 p.m.	Hospitality Suites*
5:30 – 7:30 p.m.	GPC Advisory Board Dinner

Tuesday, November 4, 2014

7:30 a.m. – 5:30 p.m.	Registration
8 – 9 a.m.	Exhibiting
9 – 10:30 a.m.	Glass Melting Session
10:30 – 11 a.m.	Exhibiting
11 a.m. – 12:30 p.m.	Forming Session

Tuesday, November 4, 2014 (cont'd)

12:30 – 2 p.m.	Lunch & Exhibiting
2 – 4:30 p.m.	Energy and Environmental Session
4:30 – 5:30 p.m.	Exhibiting
7:30 – 11 p.m.	Hospitality Suites*

Wednesday, November 5, 2014

8 a.m. – 4 p.m.	Registration
8 – 9 a.m.	Exhibiting
9 – 10 a.m.	Refractories Session
10 – 10:30 a.m.	Exhibiting
10:30 a.m. – 12 p.m.	Sensors and Control Session
12 – 1:30 p.m.	Lunch & Exhibiting
1:30 – 4 p.m.	Modeling Session
4 – 5 p.m.	GMIC Membership Meeting

Thursday November 6, 2014

7:30 a.m. – 12 p.m.	Registration
8 a.m. – 4 p.m.	Hot Sensors Symposium
11:50 a.m. – 12:30 p.m.	Lunch

*Takes place at the Hilton Columbus Downtown

EPA ENERGY STAR®/GMIC

EPA ENERGY STAR®/GMIC Joint Energy Symposium - Energy Management as a Competitive Edge in Glass Manufacturing

Monday, November 3, 2014

Corporate energy management programs not only save energy and money across operations but also position a company to withstand energy risks. This workshop will help companies take energy programs to the next level and prepare for their energy future.

12:00 – 12:05 p.m. **WELCOME – Robert Weisenburger Lipetz**, Executive Director, Glass Manufacturing Industry Council

Walt Tunnessen, CEM, Manager, Industrial Sector Program ENERGY STAR®, U.S. Environmental Protection Agency

12:05 – 12:45 p.m. **Energy Management as a Business Advantage – Peter Garforth**, President, Garforth International

Having a long-term energy strategy makes good business sense. Learn how to initiate action in your company.

12:45 – 1:15 p.m. **Building a Corporate Energy Management Program – Walt Tunnessen**, CEM, Manager, Industrial Sector Programs ENERGY STAR®, U.S. Environmental Protection Agency

Every successful corporate energy program follows certain key steps. Learn about them and how to put them in place in your company.

1:15 – 1:45 p.m. **Evolving Energy Management at PPG – Jeff Yigdall**, Director, Engineering & International Business, PPG Industries, Inc.

Learn about how PPG built energy management into its organization and the tools that have been useful in moving the program forward.

1:45 – 2:15 p.m. **How to Get Projects Implemented – Bruce Bremer**, President, Bremer Energy Consulting Services, Inc.

Identifying projects is the easy part. How do successful companies get projects implemented? Learn successful strategies for getting the work done.

2:15 – 2:30 p.m. **BREAK**

2:30 – 3:15 p.m. **Make Sure Obvious Systems are Addressed – Patrick Jackson**, Manager, Global Energy, Corning Incorporated

Lighting, compressed air, and motors are all easy targets for savings. This presentation will walk you through how to identify opportunities in each of these systems.

3:15 – 4:00 p.m. **Benchmarking Energy Use in Glass Manufacturing – Gale A. Boyd**, Director Triangle Census Research Center & Senior Research Scholar, Duke University

Tracking, baselining and measurement are critical to energy management. Benchmarking uses energy data and enables long-term tracking and goal setting. What is the value of benchmarking energy in an energy program? How do you do it? This presentation will address these questions and lay out an approach that any company can use.

4:00 – 5:00 p.m. **Plant Energy Assessment Made Easy: Treasure Hunts – Bruce Bremer**, President, Bremer Energy Consulting Services, Inc.

The energy treasure hunt process uses internal staff to identify energy savings at a plant. Learn how to perform a plant energy assessment through a team you assemble.

5:00 p.m. **ADJOURN**

PROGRAM SCHEDULE

Monday, November 3, 2014

11:30 a.m. – 4:30 p.m. STUDENT PLANT TOUR – departs at Greater Columbus Convention Center

Fundamentals of Batch and Furnace Operations Short Course

12 – 5 p.m. | E160

Instructor: **C. Philip Ross**, President, Glass Industry Consulting International (GICI)

Glass Furnace Designs and Furnace Operation—Modeling of Glass Melting & Combustion Processes & Advanced Furnace Control Short Course

12 – 5 p.m. | E162

Instructors: **Andries Habraken**, B.ASc, Senior Consultant, Computational Fluid Dynamics, CelSian Glass & Solar B.V. and **Oscar Verheijen**, Senior Consultant, CelSian Glass & Solar B. V.

EPA ENERGY STAR®/GMIC Joint Energy Symposium—Energy Productivity as a Competitive Edge in Glass Manufacturing

12 – 5 p.m. | E161

5 – 5:30 p.m. | E160 STUDENT MEETING

5:30 – 7:30 p.m. ADVISORY BOARD DINNER

5 – 11 p.m. HOSPITALITY SUITES

Tuesday, November 4, 2014

8 – 9 a.m. EXHIBITING

9 – 10:30 a.m. | Ballroom 5 Technical Session: **Glass Melting**
Session Chairs: **Glenn Neff**, Glass Service USA, Inc. and **Martin Goller**, Corning Incorporated

9 – 9:30 a.m. **Dr. Michael S. Pambianchi**, Research Director, Glass Research, Corning Incorporated ***Glass Challenges in Consumer Electronics***

9:30 – 10 a.m. **Carol Click**, Manager Glass Science Group, Owens-Illinois, Inc. – ***Effect of Dissolved Water on Physical Properties of Soda-Lime Silicate Glasses***

10 – 10:30 a.m. **Henry Dimmick Jr.**, Owner and Chief Executive Officer, American Glass Research – ***Comparison of SEM/EDX Analysis to Petrographic Techniques for Identifying the Composition of Stone in Glass***

10:30 – 11 a.m. EXHIBITING

11 a.m. – 12:30 p.m. Technical Session: **Forming**
Session Chairs: **James Uhlik**, Toledo Engineering Co., Inc. and **Kenneth Bratton**, Bucher Emhart Glass.

11 – 11:30 a.m. **Jonathan Simon**, Senior Scientist, Bucher Emhart Glass – ***Multi Gob Weight Production***

11:30 a.m. – 12 p.m. **Jonathan Simon**, Senior Scientist, Bucher Emhart Glass – ***Closed Loop Control of Glass Container Forming***

12 – 12:30 p.m. **Steven Brown**, Principal Mechanical Engineer, Bucher Emhart Glass; **Dubravko Stuhne**, Production Technical Specialist, Vetroconsult – ***"Hard Glass" – Commercial Progress of Thermally Strengthened Container Glass***

12:30 – 2 p.m. | E162 LUNCH

12:30 – 2 p.m. EXHIBITING

2 – 4:30 p.m. | Ballroom 5 Technical Session: **Energy and Environmental**
Session Chairs: **Uyi Iyoha**, Praxair, Inc. and **Warren Curtis**, PPG Industries, Inc.

2 – 2:30 p.m. **Julien Pedel**, Development Specialist, Praxair, Inc. – ***Oxygen Enhanced NOx Reduction (OENR) Technology for Glass Furnaces***

2:30 – 3 p.m. **Steven B. Smith**, Independent Consultant – ***U.S. Air Regulations Involving Glass Manufacturing***

3 – 3:30 p.m. **Richard Pont**, Technical Director, Global Combustion Systems, Ltd. – ***New Combustion Technique for Reducing NOx and CO_2 Emissions from Glass Furnaces***

3:30 – 4 p.m. **Diego Filippi**, Chemical Engineer, Area Impianti SpA – ***Environment and Energy Flue Gas Treatment and Heat Recovery Integrated System in Glass Industry***

4 – 4:30 p.m. **Stefan Laux**, Director R&D Praxair, Inc. – ***Regenerative Thermo-Chemical Heat Recovery for Oxy-Fuel Fired Glass Furnaces***

4:30 – 5:30 p.m. EXHIBITING

7:30 – 11 p.m. HOSPITALITY SUITES

Wednesday, November 5, 2014

8 – 9 a.m EXHIBITING

9 – 10 a.m. | Ballroom 5 Technical Session: **Refractories**
Session Chairs: **Laura Lowe**, North American Refractories Company and **Larry McCloskey**, Anchor Acquisition, LLC

9 – 9:30 a.m. **David Michael**, Senior Research Engineer, North American Refractories Company – ***Basic Material Developments for Glass Industry Regenerators***

9:30 – 10 a.m. **Sebastien Bourdonnais**, Project Manager, Saint-Gobain SEFPRO – ***SEFPRO Cruciforms: Modern and Competitive Regenerator Designs for Glass Industry***

10 – 10:30 a.m. EXHIBITING

10:30 a.m. – 12 p.m. Technical Session: **Sensors and Control**
Session Chairs: **Jan Schep**, Owens-Illinois, Inc. and **Elmer Sperry**, Libbey, Inc.

10:30 – 11 a.m. **Yakup Bayram**, Chief Technology Officer, PaneraTech, Inc. – ***Detection of Early Stage Glass Penetration and Weak Refractory Spots on Furnace Walls***

11 – 11:30 a.m. **Henning Katte**, Chief Executive Officer, Ilis GmbH – ***Fast and Objective Measurement of Residual Stresses in Glass***

11:30 a.m. – 12 p.m. **Fred Aker**, Sales Director West and Marketing Manager, Nikolaus Sorg GmbH & Co. KG – ***Feeder Expert Control System for Improved Containers***

12 – 1:30 p.m. | E162 LUNCH

12 – 1:30 p.m. EXHIBITING

1:30 – 4 p.m. Technical Session: **Modeling**
Session Chairs: **Bruno Purnode**, Owens Corning and **Andrew Zamurs**, Rio Tinto Minerals

1:30 – 2 p.m. **Jian Jiao**, Associate Engineer, Owens-Illinois, Inc. – ***3-D Transient Non-isothermal CFD Modeling for Gob Formation***

2 – 2:30 p.m. **Oscar Verheijen**, Senior Consultant, CelSian Glass & Solar B. V. – ***Modeling of Heat Transfer and Gas Flows in Glass Furnace Regenerators***

2:30 – 3 p.m. **Liming Shi**, Engineer II, Owens-Illinois, Inc. – ***Energy Analysis for Preheating and Modeling of Heat Transfer from Flue Gas to a Granule***

3 – 3:30 p.m. **Oscar Verheijen**, Senior Consultant, CelSian Glass & Solar B. V. – ***Experimental Simulation of Process Steps in Industrial Glass Furnaces***

3:30 – 4 p.m. **Arvind Atreya**, Professor, University of Michigan – ***Heat Transfer in Glass Quenching for Glass Tempering***

4 – 5 p.m. | Ballroom 5 GMIC MEMBER MEETING

SAVE THE DATE!

The 76th Conference on Glass Problems

November 2 – 5, 2015 | Columbus, Ohio

The Exhibit and Technical Sessions will take place in the Greater Columbus Convention Center. The Hospitality Suites will be located across the street at the Hilton Columbus Downtown.

Instrumentation and Control Innovation in Glass Manufacturing

A Symposium Organized by the Glass Manufacturing Industry Council

Hot Sensors Symposium

Thursday, November 6, 2014 | D131

The Hot Sensors Symposium on Instrumentation and Control Innovation in Glass Manufacturing is focused on the latest technologies in the market to support critical processes and address current challenges in the glass manufacturing process. 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 sensors and controls technologies.

Program Committee:

Co-Chairs: **C. Keith Bagarus**, Director Global Automation, RoviSys; **Dale A Gaerke**, Director-R&D Controls and Electrical Engineering, I-O; **Euan Evenson**, Associate Director Program Development, Praxair; **Aaron Huber**, Furnace Research Manager, Johns Manville; **James MacPhee**, Senior Engineer, Melting/Fiberizing Sciences, Owens Corning Composite Materials; **Erik Muijsenberg**, Vice-President, Glass Service Inc.; **Glenn Neff**, Vice-President, Glass Service Inc.; **Robert Roth**, Process Control Engineer, O-I; **Oscar Verheijen**, Senior Consultant, CelSian Glass & Solar B.V.; **Jeffery Watts**, Global Furnace Operations Leader, O-I; **Robert Weisenburger Lipetz**, MBA, Executive Director, Glass Manufacturing Industry Council

8:00 – 8:30 a.m. **INTRODUCTION – *Historical Review of Sensors and Controls in Glass Manufacturing*** – **Keith Bagarus**, Director Global Automation, RoviSys – Symposium Cochairman

8:30 – 9:30 a.m. **PROGRAM I – CURRENT NEEDS**

8:30 – 8:55 a.m. ***Current Needs in Controls and Sensors Technology*** – **Dale A Gaerke**, Director - R&D Controls & Electrical Egr., O-I – Symposium Cochairman

8:55– 9:00 a.m. Q&A

9:00 a.m. – 1:30 p.m. **PROGRAM II – BENEFITS AND APPLICATIONS OF CRITICAL MEASUREMENTS**

9:00 – 9:25 a.m. ***Using High Temperature Cameras to measure Level, Width, Temperature, Gob, Onion, and other process glass applications in the glass industry*** – **Thomas Canty**, President, JM Canty

9:25 – 9:30 a.m. Q&A

9:30 – 9:50 a.m. Break

9:50 – 10:15 a.m. ***Interferometric Radar Technology for Noncontact Glass Level Measurement*** – **Claudio Viti**, Sales Manager, Glass Service Srl and **Daniele Mecatti** PhD, R&D Engineer, Glass Service Italy

10:15 – 10:20 a.m. Q&A

10:20 –10:45 a.m. ***Re-engineering TDLAS Sensor Systems for the Glass Industry*** – **Dr. Andrew D. Sappey**, CTO, Zolo Technologies

10:45 – 10:50 a.m. Q&A

10:50 – 11:15 a.m. ***Application of Online Energy Balance Monitoring at Industrial Glass Furnaces*** – **Oscar Verheijen,** Senior Consultant, Celsian Glass & Solar B.V.

11:15 – 11:20 a.m. Q&A

11:20 – 11:45 a.m. ***Advanced Temperature Sensing Technologies for Improved Glass Conditioning*** – **Nate Youel**, Applications Engineer – Optical Temperature Sensing, BASF

11:45 – 11:50 a.m. Q&A

11:50 a.m. – 12:30 p.m. | D132 Lunch

12:30 – 1:30 p.m. **PROGRAM II CONTINUED – CRITICAL MEASUREMENTS**

12:30 – 12:55 p.m. ***Industrial Experiences With a Laser Based in-situ CO/O_2 Sensor for Combustion Control*** – **Oscar Verheijen**, Senior Consultant, CelSian Glass & Solar B. V.

12:55 – 1:00 p.m. Q&A

1:00 – 1:25 p.m. ***Industrial Experiences With a Zirconium Oxide Based in-situ CO/O_2 Sensor for Combustion Control*** – **Dr.-Ing. Peter Hemmann**, President, STG Combustion Control GmbH&Co KG

1:25 – 1:30 p.m Q&A

1:30 – 3:20 p.m. **PROGRAM III – CONTROL SYSTEMS**

1:30 – 1:55 p.m. ***Pixelizing the Image for Batch Line Control*** – **Erik Muijsenberg**, Vice President – Glass Service, Chairman ICG TC 21 & 15

1:55 – 2:00 p.m. Q&A

2:00 – 2:25 p.m. ***Architecture and Maintenance of a Control System for Durability, Economy, and Flexibility*** – **Doug Child**, Director, US Glass and Solar Industries, Siemens Industry, Inc

2:25 – 2:30 p.m Q&A

2:30 –2:50 p.m. Break

2:50 – 3:15 p.m. ***The Future of Control Room Design*** – **Paul Krumrich**, CEO, Sensory Environment Design

3:15 – 3:20 p.m. Q&A

3:20 – 3:50 p.m. ***Roundtable Panel Discussion - Future Challenges and Innovations*** – Moderated by **Dale A Gaerke**, Director-R&D Controls and Electrical Engineering, I-O; **Panel Members: Keith Bagarus**, Director Global Automation, RoviSys; **Thomas Canty**, President, JM Canty; **Dr.-Ing. Peter Hemmann**, President, STG Combustion Control GmbH&Co KG; **Paul Krumrich**, CEO, Sensory Environment Design; **James MacPhee**, Senior Engineer, Melting/Fiberizing Sciences, Owens Corning Composite Materials; **Daniele Mecatti**, R&D Engineer, Glass Service Italy; **Erik Muijsenberg**, Vice-President, Glass Service Inc.; **Robert Roth**, Process Control Engineer, O-I; **Dr. Andrew D. Sappey**, CTO, Zolo Technologies; **Oscar Verheijen**, Senior Consultant, Celsian Glass & Solar B.V.; **Claudio Viti**, Sales Manager, Glass Service Italy; **Jeffery Watts**, Global Furnace Operations Leader, O-I; **Nate Youel**, Applications Engineer – Optical Temperature Sensing, BASF; **Doug Child**, Director, US Glass and Solar Industries, Siemens Industry, Inc.

3:50 – 4:00 p.m. ***Concluding Remarks*** – **Keith Bagarus**, Director Global Automation, RoviSys – Symposium Co-Chairman

Fred Aker, MBA, Sales Director West and Marketing Manager, Nikolaus Sorg GmbH & Co. KG; **Erik Muijsenberg**, MSC Mechanical Engineering, Vice President, Glass Service, Inc.

Feeder Expert Control System for Improved Containers

Feeder control systems for improved containers in recent years numerous efforts have been undertaken in container glass production to achieve better control and to improve production efficiency. This is especially true in regard to lightweighting glass containers. This in particular requires stable and reproducible conditions in the glass conditioning systems. Repeatability is crucial. Especially the ability to return to known good operating conditions quickly following frequent job changes. SORG and Glass Service will present results concerning ongoing investigations to improve and automate these critical forehearth processes.

Arvind Atreya, Dr., Professor, University of Michigan; **Carlos Garciamoreno**, Program Manager, GE Aviation; **David Everest**, PhD, LEED AP, CEE, Siemens Building Technology

Heat Transfer in Glass Quenching for Glass Tempering

Results of an experimental study of heat transfer characteristics in single and two-phase stagnation point flows pertinent to glass quenching in the glass tempering process are presented. Two-phase flows were generated by injecting water mist into the air far upstream of the nozzle exit. This resulted in a temporal and spatially invariant size distribution of the droplets. PIV measurements were made at the nozzle exit to determine the magnitude and uniformity of air velocity profile in both single and two-phase flows. The two-phase flows were also characterized by measurements of drop size distribution and number density using images of droplets resulting from laser induced fluorescence. Steady state experiments were performed for plate heat fluxes ranging from 10 to 50kW/m2, Reynolds number ranging from 2,000 to 122,000 and water/air mass flow ratios up to 4.75%. Single-phase flow results indicate that the Reynolds number dependence of the Nusselt number is ~Re0.68. Two-phase flow results show a maximum heat transfer enhancement of 26%. For plate temperatures above 200°C and for the drop size distributions tested, it was visually determined that the water droplets do not impinge on the plate surface. Therefore, the heat transfer enhancement was attributed to the evaporation of water droplets within the thermal boundary layer. This is an important condition to prevent spatially non-uniform quenching and the resulting shattering of glass. By changing the water/air mass flow ratio, the cooling curve for a two-phase flow can be adjusted to meet the requirements of the industrial process.

Yakup Bayram, Chief Technology Officer, PaneraTech, Inc.; **Alexander C. Ruege**, Principal Engineer, PaneraTech, Inc.; **Eric K. Walton**, Chief Scientist, PaneraTech, Inc.; **Peter Hagan**, Product Development Engineer, PaneraTech, Inc.; **Elmer Sperry**, Technical Leader, Batch & Furnace Design Engineer, Libbey, Inc.; **Dan Cetnar**, Furnace Engineer, Libbey, Inc.; **Robert Burkholder**, Research Scientist, The Ohio State University; **Gokhan Mumcu**, Assistant Professor, University of South Florida; **Steve Weiser**, Director of Engineering, O-I, Inc.

Detection of Early Stage Glass Penetration and Weak Refractory Spots on Furnace Walls

Erosion of the refractory lining in molten glass furnaces is a major problem for the glass manufacturing industry. When erosion on the walls is not detected early enough, it may lead to a molten glass leak through the refractory lining and may result in the suspension of production for several weeks. In some cases, a catastrophic accident may also result. The glass penetration typically starts small within the insulation layer and takes anywhere from a few weeks to several months to penetrate through the insulation layer and result in major catastrophic furnace leak. Therefore, detecting an early stage glass penetration within the insulation layer and identifying weak refractory linings will result in safer and longer furnace operation through preventive and proactive maintenance.

To address this major industry need, we are developing a non-destructive sensor technology for tomographic imaging of insulation and refractory lining. This sensor will identify early stage glass penetration into insulation and identify weak refractory spots for preventive and proactive maintenance. We have already developed a sensor that measures the residual AZS thickness on operational glass furnaces. We have also showed the feasibility of mapping interior walls of insulation layers for glass penetration in an operational furnace. Lastly, the same sensor technology is capable of detecting voids and defects in cold refractories.

At the conference, we will discuss the underlying fundamentals behind the proposed sensor technology, the measurement results pertaining to feasibility and in-situ tests on operational furnaces, and the path forward to an integrated sensor system for smart (self-sensing) furnaces.

Sebastien Bourdonnais, Material Science Engineer, Saint-Gobain SEFPRO; **David Lechevailer**, PhD, R&D Senior Engineer, Saint-Gobain Northboro Research Center; **Michel Gaubil**, PhD, R&D Manager, Senior Scientist, Sain-Gobain CREE

SEFPRO Cruciforms: Modern and Competitive Regenerator Designs for Glass Industry

Modern glass manufacturing has become these years a challenging global market. Energy consumption and environmental regulation are now major concerns. For more than 40 years, SEFPRO has developed innovative solutions for regenerative glass furnaces with highest thermal performances and adapted to different running conditions. This presentation summarizes the state-of-the-art practices with typical designs and choices of materials to match this challenging objective and help glass makers in manufacturing high quality glass at competitive cost. Several design optimizations on the regenerator chambers and on the checkers choice to reach minimum specific consumption will be presented, with guidelines for right checker material choice withstanding a full campaign with minimum maintenance. This suppose the checker pack can perfectly resist to usual operating conditions such as reducing conditions for NOx control, carry over attack and thermal cleaning.

Steven Brown, Principal Mechanical Engineer, Bucher Emhart Glass; **Kenneth Bratton**, Manager of Forming Process Engineer, Bucher Emhart Glass; **Tim Ringuette**, Senior Mechanical Engineer; Bucher Emhart Glass; **Dubravko Stuhne**, Production Technical Specialist, Vetroconsult

Hard Glass – Commercial Progress of Thermally Strengthened Container Glass

A developmental program and market introduction is underway between Bucher Emhart Glass and Vetropack Austria. In this program, a new strengthening machine has been installed and is running in Vetropack's glass plant located in Poechlarn Austria. The market introduction is based on a 330mL beer bottle being produced for a local Austrian brewer that is a light weighted version (200 gram) of an existing returnable bottle (300 gram) – a weight reduction of 33%. This paper will present the results of some initial filling line tests together with lessons learned along the way. It will also include the results of a study performed for Bucher Emhart Glass and Vetropack by Stazione Sperimentale del Vetro (Murano, Italy) regarding the differences between annealed and heat strengthened ware in terms of the resistance of the glass to impact and handling induced defects.

Carol Click, Manager Glass Science Group, Global R&D, Owens-Illinois, Inc.; **Udaya Vempati**, Scientist I, Owens-Illinois, Inc. and Terence Clark

Effect of Dissolved Water on Physical Properties of Soda-Lime-Silicate Glasses

Dissolved gases in glass melts are known to influence properties of the melts as well as the resulting glass and dissolved water is thought to be one of the most influential of all the dissolved gases. In this work, the effect of vacuum processing and the ensuing changes in dissolved water concentration on various physical properties of soda-lime-silica glasses were studied. Glass melts with varying dissolved water concentration were prepared by melting frit at atmospheric and sub-atmospheric (≈100 torr) pressures at 1450 °C. The physical properties of these melts and the resulting glasses were determined by rotating spindle viscometry, beam bending viscometry, and UV-Vis spectroscopy. The densities of the glass samples were also determined. Results from these experiments are discussed in relation to prior work in the field and the implications of changes in properties on the glass making process are discussed.

Henry Dimmick, Jr., CEO, American Glass Research; **Brian Collins**, Research Scientist, American Glass Research; **Gary Smay**, Manager Consulting Services, American Glass Research

Comparison of SEM/EDX Analysis to Petrographic Techniques for Identifying the Composition of Stone in Glass

Stones are a problem that can adversely affect glass production in container, flat glass, specialty, and fiberglass manufacturing. Consequently, it is important to quickly and correctly identify the source of the stone and implement appropriate corrective actions. Historically, the analysis of stones required time consuming petrographic analyses. Recently, glass technologists have adopted a method of analyzing stones consisting of a scanning electron microscope (SEM) together with the use of X-ray analysis (EDX). These current methods have the potential of providing accurate, detailed information about the stone in a much shorter time than usual petrographic analyses. This paper compares data derived from analyses of stone identification using an SEM/EDX to the results obtained from petrographic techniques.

Xu Ding, PhD, Engineer Manager Forming Process Automation and Simulation, Bucher Emhart Glass; **Jonathan Simon**, PhD, Sr. Scientist, Bucher Emhart Glass; **Angelo Dinitto**, Product Manager, Bucher Emhart Glass; **Andreas Helfenstein**, Development Engineer, Bucher Emhart Glass

Multi Gob Weight Production

Capability of producing multiple containers with different weights on the same machine line can give the glass plant more flexibility of organizing production jobs, save cost on mold equipment, and reduce production lost due to job changes. Bucher Emhart glass has developed the multi gob weight control system including multi weight feeder and the knowledge for how it can be applied. This paper presents recent multi gob weight control algorithm developments and its application with the multi feeder system. The control algorithm makes the multi gob weight set up procedure quick, accurate, and easy for the end user. Plant trial results are included to validate the control algorithm development.

Diego Filippi, Chemical Engineer, Area Impianti SpA; **Francesco Zatti**, Technical Director, Area Impianti SpA; **Alessandro Monteforte**, Chemical Engineer, Area Impianti SpA; **Gianluca Taramelli**, Chemical Engineer, Area Impianti SpA

Environment and Energy Flue Gas Treatment and Heat Recovery Integrated Systems in Glass Industry

Flue gas treatment in glass industry is getting more involved and elaborate to meet environmental emission requirements. Traditionally, three compulsory systems are available to abate pollutants and acids (dusts, NOx, SOx): Electrostatic Precipitators, Bag Filters and Ceramic Candle Filters eventually connected to an SCR reactor. Additionally, flue gas treatment specialists are trying to develop new technology solutions to optimize and increase operating and environmental performance, even using the so called "Lost Third" of Energy, coming out with glass furnace gases.

Two typologies of heat recovery are generally possible: thermal and electric; cogeneration is also a third, mixed opportunity. Generally speaking, Rankine cycle is used to produce power normally realized in two ways:

- by means of water steam generation (direct exchange with flue gases);
- by means of organic fluid (indirect exchange, using thermal oil heated by flue gases).

Where reliability and low maintenance are basic decision elements, Organic Rankine Cycles (ORC) are the most common choice and probably the best available technology. New generation organic fluid turbines are becoming more efficient and comparisons on same cases show that yearly power production with ORC is at least as high as traditional steam cycle, with lower investment in terms of manpower and time spent on this "appendix" of the glass furnace.

The subject of the presentation is the evaluation of the most reliable solution in terms of heat recovery linked with FGT, related to a specific plant situation, and a deep analysis of a typical heat path, considering technical and economic aspects.

Jian Jiao, Associate Engineer, O-I, Inc.; **Oluyinka Bamiro**, Engineer I, O-I, Inc.; **David Lewis**, Technical Leader, Gob Forming, O-I, Inc.; **Larry Zhu**, CAE Manager, O-I, Inc.

3-D Transient Non-isothermal CFD Modeling for Gob Formation

To achieve a quality final product in the glass container industry, it is critical to determine the "ideal" glass gob shape to be produced from the feeder after shearing. Large deviations from an ideal gob shape may result in severe consequences for the gob delivery system and molds. The formation of ideal or desired gob shape is dependent upon operational parameters such as glass temperature/viscosity, uniformity, plunger stoke and heat-loss management. A Computational Fluid Dynamics (CFD) model provides an efficient and cost effective way of studying the effects of these parameters when optimizing gob shapes that are subject to the aforementioned operating parameters and conditions.

For the current study, two CFD approaches were used to create a 3-D transient non-isothermal CFD model in order to study the effects of flow and the thermal condition of molten glass on gob formation.

In the first approach, a numerical model was developed by utilizing the ANSYS POLYFLOW solver in conjunction with both the Mesh Superposition Technique and the Lagrangian adaptive re-meshing technique to model plunger motion and gob formation respectively.

In the second approach, a hybrid model using both ANSYS FLUENT and POLYFLOW was developed, in order to achieve higher computational efficiency and a reduction in computational time. The hybrid model consists of two parts: (1) the flow and thermal condition of the molten glass is modeled by FLUENT using the moving deforming mesh technique for plunger motion, and (2) the gob forming process is modeled in POLYFLOW by mapping/transferring the glass flow and temperature information from FLUENT. The hybrid model used in the second approach shows significant improvement in computational performance with reasonable accuracy.

Henning Katte, CEO, ilis GmbH

Fast and Objective Measurement of Residual Stresses in Glass

Mechanical stresses can strongly impair the fracture strength and processing ability of glass products. Testing for residual stresses close to production is therefore an important constituent of quality control. For decades manually operated polariscopes and polarimeters have been the standard method for testing the level of residual stress in glass, e.g. according to ASTM C148. However, the measuring results obtained with such devices are strongly dependent on the operator and therefore subjective. The results of statistical Gage R&R tests show that the reproducibility achieved with this method is not acceptable. A newly developed imaging polarimeter features the objective measurement of inherent stresses in glass – as random sample test or directly in the production process. The camera-based instruments are capable of measuring and visualizing stresses in glass in real time and can be used flexibly wherever conventional polariscopes and polarimeters are still used nowadays. A comprehensive Gage R&R study shows substantial improvements in respect to absolute accuracy and practical reproducibility of the measurement.

Stefan Laux, Director, R&D, Praxair, Inc.; **Alonso Gonzalez**, President, Pavisa; **Enrique Solórzano**, Engineering Manager, Pavisa; **Cuauhtemoc Lagos**, Application Engineer, Praxair Mexico; **Gerardo Lugo**, Business Development Manager, Praxair Mexico; **KT Wu**, Development Professional, Praxair Inc.; **Robert Bell**, Development Engineer, Praxair Inc.; **Arthur Francis**, Development Specialist, Praxair Inc.; **Hisashi Kobayashi**, Corporate Fellow, Praxair Inc.

OPTIMELT™ Regenerative Thermo-Chemical Heat Recovery for Oxy-Fuel Fired Glass Furnaces

The operation of glass furnaces with oxy-fuel combustion in combination with advanced heat recovery is a compelling low cost solution. Praxair has developed a regenerative heat recovery system for oxy-fuel fired furnaces that uses regenerators in a similar way to which conventional regenerators are used for air preheating. The OPTIMELT™ Thermo-Chemical Regenerator (TCR) technology stores waste heat from the hot flue gas and uses this energy to endothermically reform a mixture of natural gas and recirculated flue gas to hot syngas resulting in efficient thermo-chemical heat recovery.

The TCR system is simple and operated at atmospheric pressure without requiring catalysts or separate steam generation. TCR reduces fuel consumption of an oxy-fuel fired furnace by about 20% and offers an attractive conversion option for existing air-regenerator furnaces, with more than 30% fuel reduction compared to the air-fuel base case. The presentation will highlight key technology development steps and include operational data and results from the first installation of OPTIMELT™ TCR on a 50 t/d commercial container glass furnace.

David Michael, Senior Research Engineer, North American Refractories Company; **Laura Lowe**, Senior Application Engineer, North American Refractories Company; **H. Edward Wolfe, Sr.** Mineralogist, North American Refractories Company

Alteration of Basic Brick in Glass Tank Regeneration

This paper reviews the chemical reactivity of basic refractories used in glass tank regenerators with V_2O_5 in oil-fired furnaces, with sodium sulfate and with alkali. The rationale for using magnesia brick with high levels of forsterite in situations where V_2O_5 attack is anticipated is given. A post-mortem examination showing depletion of CaO in basic brick exposed to sodium sulfate is shown. Laboratory work on reactivity of basic brick with sodium sulfate is also presented to show the effect of CaO depletion on strength of basic refractories. Alkali attack on forsterite-bonded brick is discussed. A new type of forsterite-bonded brick containing no ZrO_2 with properties similar to those of magnesia-zircon brick but with substantially better alkali resistance is introduced.

Michael S. Pambianchi, PhD., Research Director, Glass Research, Corning Incorporated

Glass Challenges in Consumer Electronics

The consumer electronics industry is incorporating specialty glass into its products more and more, including display substrates, encapsulation, touch panels, and cover glass. These glasses need to meet demanding attributes while remaining cost effective in an industry with aggressive cost targets. We describe some of the specialty glass opportunities found in consumer electronics and the challenges in addressing them.

Julien Pedel, PhD, Development Specialist, Praxair, Inc.; **Uyi Iyoha**, PhD, Business Development Manager, Praxair, Inc.; **Piero Zucca**, Combustion Application Development Engineer, SIAD; **Hisahi (Sho) Kobayashi**, PhD, Corporate Fellow, Praxair, Inc.; **Jaoquin de Diego**, European Market Combustion Manager, Praxair Euroholding S.L.; **Euan Evenson**, Program Development Manager, Praxair, Inc.; **Geert Cnossen**, Project Manager, Praxair, Inc.

Oxygen Enhanced NOx Reduction (OENR) Technology for Glass Furnaces

Container and flat glass manufacturers in the USA and EU are facing increasing pressure from regulatory agencies to further decrease NOx emissions from glass furnaces. In the past, air-fired glass furnace operators have been able to reduce NOx emissions and comply with regulations by modifications of the primary air combustion system, such as the optimization of natural gas injection method. However, complying with new European Union NOx targets (~1.5 to 2.4 lb NOx/ton of glass for container glass and ~2.5 to 4 lb NOx/ton of glass for float glass) will be difficult to achieve in many furnaces through these optimization steps.

Combustion staging by reducing the stoichiometric ratio (air/fuel ratio) of the primary air-gas flame and introducing a secondary oxidant stream at various locations in the furnace has shown to successfully reduce NOx emissions. Well known approaches are oxygen enriched air injection or cold air staging. However, the use of cold air has a substantial energy efficiency penalty. Praxair has developed Oxygen Enhanced NOx Reduction (OENR) technology which uses a pure oxygen stream to attain NOx emissions levels below 1.5 lb/ton, without adversely impacting the energy efficiency of the furnace or disturbing the air-fuel flame, as is sometimes observed with cold air staging. This paper presents and discusses CFD results and data from commercial demonstrations of Praxair's OENR technology and shows that the technology is a cost effective approach to significantly reduce NOx emissions, while maintaining good glass quality and increasing fuel efficiency.

Richard S. Pont, Global Combustion Systems Ltd.; **N Fricker**, University of South Wales; **I Alliat**, GDF SUEZ-CRIGEN ; **Y Agniel** O-I Manufacturing; L Kaya, Turkiye Sise Cam

New Combustion Technique for Reducing NO_x and CO_2 Emissions from a Glass Furnace

The European Glass Industry has the problem of reducing both CO_2 and other emissions such as NO_x from its primary regenerative melting furnaces. To address this problem a new combustion concept has been developed by a consortium of GDF-SUEZ, Global Combustion Systems and the University of South Wales with financial assistance from the UK's Carbon Trust. It comprises a novel, patented firing technique (AUXILIARY FIRING) that reduces NO_x formation at source on primary regenerative glass melters, while simultaneously reducing fuel consumption and CO_2 emissions. It avoids or reduces the need for post-furnace NO_x clean-up which can be expensive in capital and increases life-cycle CO_2 emissions.

If confirmed over longer term testing and on cross-fired furnaces, the results of this project will enable the European glass industry to meet upcoming NO_x emission limits on their primary glass melters by reducing NO_x formation at source, without the need to install large, expensive and energy-hungry post furnace clean up techniques. Elimination of NO_x clean-up will yield simultaneous reductions in NO_x and glass life-cycle CO_2 emissions.

This paper outlines the technique, optimisation using modelling methods and the results obtained when applied to industrial scale glass furnaces at O-I Manufacturing France and SISECAM Turkey.

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n°296042

Liming Shi, PhD., Engineer II (CAE), Owens-Illinois, Inc.; **Udaya Vempati**, PhD., Scientist I (Glass), Owens-Illinois, Inc.; **Sutapa Bhaduri**, PhD., Discipline Leader, Chemistry and Materials Science, Owens-Illinois, Inc

Energy Analysis for Preheating and Modeling of Heat Transfer from Flue Gas to A Granule

To reduce energy consumption of an oxy-fired glass furnace, energy loss via the flue gas and through the furnace walls should be minimized since they account for approximately 40 % of the energy usage. One way to minimize flue gas energy loss is to pre-heat the raw batch materials and/or cullet. Energy analysis was conducted to evaluate the maximum amount of energy recoverable and that required for the pre-heating. The maximum pre-heating temperature was calculated under conditions of constant and reduced rate of natural gas usage. Since the flue gas temperature from an oxy-fired furnace is on the order of 1350°C, the maximum temperature for batch pre-heating that could be potentially employed was above 500 °C. However, handling loose batch at such high temperatures is likely to be physically difficult to accomplish reliably. On the other hand, batch in an agglomerated form, such as granules, may be pre-heated easily. Analysis of the heat transfer from flue gas to a single granule was investigated first through computational fluid dynamics (CFD) modeling. Parameters studied included the average diameter and thermal conductivity of the granule, the inlet flue gas temperature, and the flue gas velocity and composition. The data was used to evaluate the time needed to preheat a single representative batch granule to a given target temperature under various heating conditions. In addition, the time-dependent temperature and velocity distributions for the modeled geometry were determined. The results show that granule diameter and gas velocity both have a significant impact on the rate of granule heating.

Jonathan Simon, Senior Scientist, Emhart Glass Research; **Andreas Helfenstein**, Controls Development Engineer, Emhart Glass SA

Closed Loop Control of Glass Container Forming

Recently developed closed loop control systems offer a new means to help container glass manufacturers meet the ever increasing industry and customer expectations for improved yield and quality. In these closed loop systems the process is automatically adjusted based upon actual measured values. Such closed loop controls, have now been developed and introduced into commercial production in two key areas: 1) Blank Cooling Control and 2) Plunger Up Control in which the blank mold temperatures and the rise/dwell time of the plunger respectively are automatically controlled. The technical development of these new control systems, the challenges that needed to be met, and the experience of glass manufacturers adopting these systems will be presented.

Steven B Smith, Independent Consultant

U.S. Air Regulations Involving Glass Manufacturing

Recently developed closed loop control systems offer a new The basics of environmental rulemaking is reviewed as well as the role of the states. An overview Part 70, Title V permitting is provided, what various Title V permits exist today, why permit variations occur and when a state should be notified about work on a permitted process. Greenhouse gas requirement are in place today at the Federal level and at the state level one state has set limits and requirements for controls but various agreements foretell expansion of such rulemaking to other jurisdictions.

Oscar Verheijen, Dr., Ir., Senior Consultant, CelSian Glass & Solar B.V.; **Andries Habraken**, Ing., Senior Consultant CFD, CelSian Glass & Solar B.V.; **Heike Gramberg**, Dr.-Ir., CFD Engineer, CelSian Glass & Solar B.V.

Modeling of Heat Transfer and Gas Flows in Glass Furnace Regenerators

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 limit 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 detailed 3D CFD simulations in order to determine the turbulent flows in the complete regenerator, the local temperatures of the gases and complex shaped regenerator bricks and the convective and radiative heat exchange between gases and checkers for both flue gas and air phase. This paper reports on results of detailed modeling of regenerators by CelSian's CFD model GTM-X. Next to 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, depending on type of checkers and regenerator and port neck design is shown. In addition, critical areas for chemical fouling – either by sodium sulfate condensation or by attack of (especially the binder phases of) refractory material – is discussed as function of flue gas composition.

Oscar Verheijen, Dr., Ir., Senior Consultant, CelSian Glass & Solar B.V.; **Hans Van Limpt**, Dr.-Ing., Manager Product Development, CelSian Glass & Solar B.V.

Experimental Simulation of Process Steps in Industrial Glass Furnaces

The conversion of raw materials into a homogeneous glass melt without bubbles and inclusions can only be achieved if essential process steps like: melting-in of batch, dissolution of sand and removal of gas bubbles taking place in a glass furnace. Preferably the process conditions in the furnace do not lead to unwanted side effects like refractory corrosion and high emissions. Experimental laboratory set-ups to simulate different process steps in the glass melting process have been developed by CelSian Glass & Solar B.V. and applied to optimize glass furnace operation. The High Temperature Melting Observation System (HTMOS) is used to observe the melting-in, foaming and fining process and to investigate the melting characteristics and gas evolution during heating of the melting batch under a simulated atmosphere.

Refractory corrosion in the regenerators and combustion chamber are in many cases a result of high evaporation and carry-over rates. On laboratory scale the impact of batch and glass composition, furnace atmosphere, gas velocities and temperature on evaporation and carry-over rates can be investigated and measures to reduce the evaporation and carry-over rates can be derived. A method is applied to study the corrosion of regenerator refractory materials. Refractory samples are exposed to cooling flue gases that contain alkali compounds, SOx and other flue gas species. Oxidizing as well as reducing conditions can be simulated. Results of these experimental studies such as melting and fining behavior, evaporation kinetics and thermodynamic data, semi-empirical relations from carry-over and refractory corrosion experiments are used in CFD modeling studies to improve the performance of industrial glass furnaces.