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Foreword

The 77th Glass Problem Conference (GPC) is organized by the Kazuo Inamori School of Engineering, The New York State College of Ceramics, Alfred University, Alfred, NY 14802 and The Glass Manufacturing Industry Council (GMIC), Westerville, OH 43082. The Program Director was S. K. Sundaram, Inamori Professor of Materials Science and Engineering, Kazuo Inamori School of Engineering, The New York State College of Ceramics, Alfred University, Alfred, NY 14802. The Conference Director was Robert Weisenburger Lipetz, Executive Director, Glass Manufacturing Industry Council (GMIC), Westerville, OH 43082. Donna Banks of the GMIC coordinated the events and provided support. The themes and chairs of five half-day sessions were as follows:

**Operations**
Elmer Sperry, Libbey Glass, Toledo, OH and Uyi Iyoha, Praxair Inc., Tonawanda, NY

**Controls**
Glenn Neff, Glass Service USA, Inc., Stuart, FL and Bruno Purnode, Owens Corning Composite Solutions, Granville, OH

**Energy**
Phil Tucker, Johns Manville, Denver, CO and Martin Goller, Corning Inc., Corning, NY

**Melting**

**Forming**
Kenneth Bratton, Emhart Glass Research Inc., Windsor, CT and James Uhlik, Toledo Engineering Company, Inc., Toledo, OH
Refractories
Laura Lowe, North American Refractory Company, Pittsburgh, PA and Larry McCloskey, Anchor Acquisition, LLC, Lancaster, OH
This volume is a collection of papers presented at the 77th year of the Glass Problems Conference (GPC) in 2016. This conference continues the tradition of publishing the papers that dates back to 1934. The manuscripts included in this volume are reproduced as furnished by the presenting authors, but were reviewed prior to the presentation and submission by the respective session chairs. These chairs are also the members of the GPC Advisory Board. I appreciate all the assistance and support by the Board members.

As the Program Director of the GPC, I am thankful to all the presenters at the 77th GPC and the authors of these papers. This year’s meeting concludes with a record total attendance of 497 and also 44 students. I appreciate all the support from the members of Advisory Board. Their volunteering sprit, generosity, professionalism, and commitment were critical to the high quality technical program at this Conference. I also appreciate continuing support and leadership from the Conference Director, Mr. Robert Weisenburger Lipetz, Executive Director of GMIC and excellent support from Ms. Donna Banks of GMIC in organizing the GPC. I look forward to continuing our work with the entire team in the future.

Please note that The American Ceramic Society and myself did minor editing and formatting of these papers. Neither Alfred University nor GMIC is responsible for the statements and opinions expressed in this volume.

S. K. SUNDARAM
Alfred, NY
November 2016
Acknowledgments

It is a great pleasure to acknowledge the dedicated service, advice, and team spirit of the members of the Glass Problems Conference (GPC) Advisory Board (AB) in planning this Conference, inviting key speakers, reviewing technical presentations, chairing technical sessions, and reviewing manuscripts for this publication:

Kenneth Bratton—Emhart Glass Research Inc. Hartford, CT
Warren Curtis—PPG Industries, Inc., Pittsburgh, PA
Martin Goller—Corning Incorporated, Corning, NY
Uyi Iyoha—Praxair Inc., Tonawanda, NY
Michelle Korwin-Edson**—Owens Corning Composite Solutions, Granville, OH
Robert Lipetz—Glass Manufacturing Industry Council, Westerville, OH
Laura Lowe—North American Refractory Company, Pittsburgh, PA
Larry McCloskey—Anchor Acquisition, LLC, Lancaster, OH
Glenn Neff—Glass Service USA, Inc., Stuart, FL
Adam Polcyn*—PPG Industries, Inc., Pittsburgh, PA
Bruno Purnode—Owens Corning Composite Solutions, Granville, OH
Jans Schep—Owens-Illinois, Inc., Perrysburg, OH
Elmer Sperry—Libbey Glass, Toledo, OH
Phillip Tucker—Johns Manville, Denver, CO
James Uhlik—Toledo Engineering Co., Inc., Toledo, OH
Justin Wang*—Guardian Industries Corporation, Geneva, NY
Andrew Zamurs—Rio Tinto Minerals, Greenwood, CO

In addition, I am indebted to Donna Banks, GMIC for her patience, support, and attention to detail in making this conference a success.

*Joined the AB at the 76th GPC.
**Joined the AB at the 77th GPC.
GLASS PLANT AUDITS – THREE CASE STUDIES IN GLASS PRODUCTION PROBLEMS AND THEIR SOLUTIONS

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Toledo Engineering Company, Inc.
Toledo, OH

ABSTRACT

Over the multi-year length of a glass plant campaign, problems arise with root causes traceable to design, engineering, construction and the operational parameters which can change over time. This presentation’s intent is to illustrate real-world production problems arising from those changing needs, practical solutions, and the value of non-resident process reviews such as performed by the member companies of the TECO Group. It often takes an experienced or non-routine study of the problem(s) to first determine the root cause, and then engineer how to best resolve it. Problems and solutions can include: refractory design/selection for maintenance, wear issues experienced during the campaign, hot repairs and temporary engineering solutions and operational process adjustments. This can typically result in glass quality improvements and campaign life extension through applying principles of operation optimization and improving maintenance techniques. The results are often significant improvements in glass quality, pack yields and the plant’s bottom line. This presentation will discuss three problem instances - in a throated furnace, the waist area of a float furnace, and sidewall refractory replacement maintenance activities.

INTRODUCTION

Ask anyone involved in the day to day operation of making glass - sometimes it seems as if their plant is a living, breathing entity. And sometimes, they become ill…

GLASS PROBLEM ONE – FURNACE WITH A SORE THROAT

TECO was asked to assist with an increasingly evident non-conforming glass attribute from a throated furnace in Europe. The problem was a distortion line in the rolled glass sheet being called a “water mark” by plant personnel, which tested as a high density alumina-zirconia layer approximately 60-75 microns thick, shown below in Figure 1.

When first detected preliminary thinking was that it was a lamination problem (mechanical action on the glass), such as roller mark, lip issue, roller cooling problems, etc. Many initial actions were undertaken to find the root cause and eliminate this defect. These actions included:

- The cover of the lamination area was adjusted.
- Various machine positions were instituted.
- Several machine changes with different rollers were tested, smaller rollers with different cooling, etc.
- A bottom roller with chrome coating was used.
- Refractory lip was changed.
This is a typical operational progression, where the urgency of continuing glass losses force increasingly costly (in terms of lost production and/or equipment replacement) adjustments to the process in a search for improvement. Meanwhile a sample of the distortion line was sent out for laboratory analysis. The results are shown in Figure 2.

Based on the analysis report, an average of five composition measurements yielded higher levels of alumina and zircon content than what was normally found in the base glass. Therefore, increased focus was placed on the batch, the glass furnace and the forehearth operation and structures, which had been previously been operated consistently and at steady state for some period of time.

Technical service personnel from Toledo Engineering Co., Inc. (TECO) and Zedtec, Ltd. were invited to the facility to help the customer assess the situation. Together, the combined team completed several problem solving exercises and developed an evaluation plan. During this investigation, the physical inspection of the furnace interior was performed, as the viewing ports allowed. Figure 3 shows the interior of the Zedtec glass conditioning forehearth - the inspection of the forehearth provided assurance that there was no undo wear, the structure was intact and the glass level was as per the design of 50 mm below top of block.
Finally, the inspection of the furnace interior provided that while the structure and
superstructure refractory appeared to be in proper condition, the glass level as observed did not
appear to be at the design level of 50 mm below top of block — there appeared to be much less
glass freeboard, as shown in Figure 4. To check this observation, first a simple length of tubing
was used as a water level, and when checked, showed that the furnace construction was correct,
with both the furnace and forehearth top of block set to the same elevation. The actual glass level
observation did not make sense, so not only was the water level used several more times, but an
optical engineering level measurement was contracted locally, and these readings also verified the
correct construction. Engineering 101 teaches us that liquids seek their own level, yet the visual observations appeared contrary to this. The team assembled and discussed the next steps.

![Furnace Glass Level Visual Estimate](image)

**Figure 4. Furnace Glass Level Visual Estimate**

Although seemingly improbable, a theory developed that perhaps there was restriction in the throat, possibly a buildup of denser glass that was ‘wicking off’ and presenting in the final product as the aforementioned watermark. The throat became the focus of the discussion, and a plan was developed to retrofit a drain onto the throat bottom, to remove a possible accumulated buildup of denser glass:

Plant management acted quickly to institute this solution. The results after draining the throat for a few hours, during which periods of inhomogeneous glass streaming were evident, was that the furnace glass level returned to the designed 50 mm below top of block. While seemingly improbable, an accumulation of denser glass in the throat area had slightly restricted the glass flow, requiring a higher furnace glass level and head pressure to maintain the operating glass level in the forehearth.

The distortion line in the glass was the presentation of this problem - a buildup of denser glass which restricted glass flow - and was solved by installation of a periodic drain capability in the bottom of the furnace throat, as shown in Figure 5.
GLASS PROBLEM TWO – FURNACE WITH A SAGGING WAISTLINE

TECO was asked to assist a float glass manufacturer who had recently changed a large refractory structure in the waist area of their float furnace, to relieve a possible source of refractory contamination in their glass ribbon. In normal circumstances, this should be a straightforward procedure, the replacement of the A arch (see Figures 6 & 7 below).

The A arch, as can be seen in the Fig. 1, is a high and narrow design that helps shield the downstream area of the waist during normal openings of the upstream access area, in front of A, for routine maintenance in that area. The old A arch, replaced by the customer, is shown in Figure 8.