NO. 1 2003

SGT NEWS

Compiled and published by dmg world media (uk) ltd on behalf of the Society of Glass Technology

INTERNATIONAL CONGRESS ON GLASS

The International Congress on Glass held several sessions on glass melting, heating, cooling and forming. There were contributions from practical glassmakers as well as representatives of companies at the leading edge of future developments of glass making. The authors contributing to these sessions have submitted their papers and been accepted for publication in the special proceedings volumes of Glass Technology.

An integrated approach to mathematical modelling of flow and heat transfer in the melting and delivery ends of a glass furnace was given by M K Choudhary and T A Powers of Owens Corning Science and Technology Centre and W H Fausey, P Budk and J Chmelar of Glass Service, Czech Republic. Their paper describes results from a mathematical modelling based study of fluid flow and heat transfer phenomena in the melting and delivery (i.e. channel and forehearth) ends of an oxy-fuel fired glass furnace. The 3D mathematical model used in this study not only integrates phenomena taking place in the various sub-domains (i.e. batch, combustion and melt in the melter) of the two sections (melting and feeder ends). It also integrates the two sections themselves. The model was used to study the impact of bubbling on flow and heat transfer phenomena and glass quality. The integration of the melting and delivery ends made it possible to relate glass quality parameters (e.g. the stones) in the delivery end to specific locations where the stones originate on the melter surface.

Emhart Glass Manufacturing and F Deideweg looked at ***how to affect the temperature distribution in blank and blow moulds***, comparing FEM calculations and measurement results. Looking at the 3D temperature distribution in blank and blow moulds used in the hollow glassmaking industry the understanding of the 'correct' temperature field, mainly at the glass contact area, is of major importance. One key problem in making high quality containers is to achieve favourable contact temperature for the parison and also for the final bottle. Within this paper, investigations appertaining to the above topic were undertaken in a numerical approach: ***(1)*** with the help of a commercial finite element program the stationary temperature distribution (averaged over the cycle time) can be calculated. All cycle data, cooling air pressure, heat transfer coefficients for forced and natural convection, radiation and the heat flux from the glass into the moulds have to be taken into consideration; ***(2)*** most cast iron or bronze alloy moulds are cooled by compressed air passing through axial holes; ***(3)*** using the heat flux from the glass into the moulds as one key boundary condition, a 1D transient model has to be incorporated into the overall calculation set-up; and ***(4)*** transient effects. To validate the calculated results lots of temperature measurements inside the moulds were undertaken. It could be found reasonable agreement between measured and predicted values in most cases, but there are still some uncertainties especially on the blank mould side.

Using as an example of television glass melt A M Efimov of Vavilov State Optical Institute, St. Petersburg, Russia and P A van Nijnatten of TNO Institute of Applied Physics, The Netherlands looked at the ***high temperature optical properties of glass melts in the 0.95-4.5 μm range***. The optical properties of the commercial TV glass melt in the 2200-10500cm-1 (4.5-0.95μm) range for temperatures of 1100°C, 1200°C, 1300°C and 1400°C were investigated. The absorptivity spectra are obtained with a high temperature optical test facility that uses the techniques of the transmittance and emittance spectroscopies. The spectra of the optical constants, individual components of the absorptivity spectra, inherent frequencies of the corresponding oscillators and oscillator strengths are calculated with the dispersion analysis method for glasses. The assignments of the spectral components to particular impurity species and the effect of temperature on the inherent frequencies and strengths of oscillators found were discussed.

Optimum parison shapes for blowing glassware were investigated by P Moreau, C Marechal and D Lochegnies of University of Valenciennes, France. A numerical model using a finite element and

inverse method is developed to find the optimum parison shape for the robotised forming of a hollow glass product. For the standard hollow glass products, the adjustment of forming parameters ensures the success of forming. However, for the skew products with a high wall convexity, the determination of the geometry of the parison is necessary. Indeed, the geometry of the parison comes into contact with the mould during its closing. We propose here an original strategy of optimisation allowing the effective determination of the geometry of the parison. This is described by a Bézier curve and the position of the poles of this curve is given by a numerical optimiser using finite element models and the inverse method. The parison geometry of robotised blowing of a reference glass product is optimised with the help of this method and the validity of numerical predictions is clearly shown in comparison of the design objectives.

Structural improvements to molybdenum glass melting electrodes have been developed by C E D Rowe and J Miles of HC Starck. Although molybdenum has been used for booster and primary electrodes in the glass melting industry since the 1960s experience has shown that purity and metallurgical structure can have a marked effect on the life and performance of the electrode. Impurities and porosity in the molybdenum can cause adverse colouration and gas bubbles in the glass while impurities in the glass can cause electrode erosion and corrosion. Fine grained material exhibits a greater resistance to corrosion but is prone to sagging especially in the case of side and bottom entry electrodes. Ideally the grains should be large and elongated along the electrode axis. Electron beam melted and forged electrodes offer higher purity than conventional powder metallurgical material combined with a coarse elongated grain structure ensuring long life and stability in service. A coating of $MoSi_2$ may be applied to and chemically bonded to the surface of electrodes to prevent oxidation during start-up where the electrode may be in contact with air.

M Taguchi, K Fujita, H Iwase, Y Urabe, T Hashimoto and S Kawamoto of Nippon Sheet Glass, Japan have developed ***a method for highly accurate identification of the effective thermal conductivity of glass***. For clear and tinted glass, it can be obtained by fitting the experimental and simulation temperature profiles. From simulation, it has been found that the experimentally measured thermal conductivity of glass at high temperatures contains an error of approximately 30%. To apply this method, an experimental furnace has been designed with sufficient volume to avoid the effect of radiation from the walls. By properly selecting the thickness of refractory and insulators the authors were able to substantially reduce horizontal heat flux and make it possible to obtain an accurate vertical heat flux. Then an effective thermal conductivity was found by matching the calculated temperature distribution with the measured one. This procedure can provide the conductivity with a high accuracy in the range of 1000°C -1500°C. The obtained effective thermal conductivity was applied to a float glass melting tank simulation based on a high speed GSMACFEM model and as a result of systematic simulation, have found a way to substantially improve the temperature distribution of molten glass in the tank.

G Albayrak, F Akmaz and M Oran of Glass Research Centre, Sisecam, Istanbul, Turkey summarised the ***key considerations in the production of coloured soda-lime-silica glasses*** and offered remarks and results of some applications that have proved useful in changing the colour of glass on the run.

In their alternative interpretation of ***the batch melting mechanism***, M Cerchex and E Trifu of National Glass Institute, Romania explained that because of the differences between the experimental and practical batch melting and of the difficulties in reproducing the conditions of the glass batch entering the melt, most results presented in the literature are incomplete or open to interpretation. A new interpretation is made, based on thermal and thermogravimetric analyses related to the fact that at increased heating rate, the independent melting of soda or of double carbonate, if formed, is predominant. One of the conclusions of this work is that a well prepared batch must not contain unreacted lime at about 900°C.

Magic angle spinning nuclear magnetic resonance (MAS NMR) spectroscopy has been used by A R Jones, R Winter, G N Greaves and C Targett-Adams of University of Wales, Aberystwyth and I H Smith of Pilkington Technical Centre, UK to investigate atomic rearrangement during the batch melting of a soda-lime-silica glass. The changes in the local environment of ^{29}Si in the glass forming system $76SiO_2–20Na_2O–4CaO$ at various stages of melting was followed from the initial quartz to the final glass composition. Spectra were collected ex situ from quenched samples held at 1450°C for up to an hour. The glass formed in the early stages of melting is modifier rich and dominated by Q3 species, and contains undissolved quartz. The undissolved quartz is identified by a narrow resonance peak at -107ppm, which decreases in intensity with melting time, until all the quartz has dissolved after 26 min. Q4 species become more abundant in the glass network as more quartz dissolves and this is accompanied by a progressive change in the Q4 chemical shift towards higher shielding. The Q4 in the final glass is de-shielded with respect to that in the quartz, due to interactions with modifiers in distant coordination spheres. FWHM and chemical shift values for the Q3 species suggest that these are least affected by the dissolution of quartz, presumably because their cation environment in the glassy phase is stable through the melting process. Intermediate crystalline phases formed during the early stages of batch reaction have also been detected by MAS NMR.

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