AIGMF Executive Committee Meeting

Goa, India

(November 12, 2024)

ALL-ELECTRIC MELTING :

THE PROVEN TECHNOLOGY FOR A SUSTAINABLE, RENEWABLE & LOW CARBON FUTURE.

Grahame Stuart

Technical Sales Manager

ELECTROGLASS

The Specialists in Electric Glass Melting and Conditioning

HYDROGEN NO DOUBT HAS ITS PLACE IN THE FUTURE OF GLASS MELTING, BUT DOES ALL-ELECTRIC MELTING OFFER AN OPPORTUNITY TO IMPLEMENT GREEN TECHNOLOGY MUCH SOONER WHILST USING WELL PROVEN TECHNOLOGY.

Grahame Stuart – Technical Sales Manager.

It's an exciting yet challenging time to work in the glass industry.

Energy price instability, raw material cost increases, reduced consumer confidence and a need to modernise for a greener tomorrow are all challenges that we face every day. We are moving from a conservative industry that evolved at a steady pace over the last 50 or so years, to an industry that is seeing huge changes almost overnight and with this comes more uncertainty and a risk of further financial losses and costs.

Over the last few years much has been written about the future of glass manufacturing as we transition to Net Zero Carbon Emissions by 2050. A lot of what has been discussed has focused on green hydrogen and carbon capture, both of which rely heavily on renewable, emission free electricity to be effective.

So, my question is, is hydrogen really the solution for the sustainable, energy efficient, low carbon glass industry of the future and how does it compare to natural gas. And could All-Electric melting offer a cheaper, easier and more cost effective solution and in a much shorter time frame.

Grahame Stuart

Technical Sales Manager.

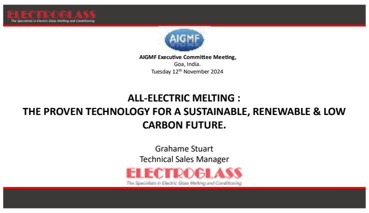
Electroglass Ltd.

About the Author

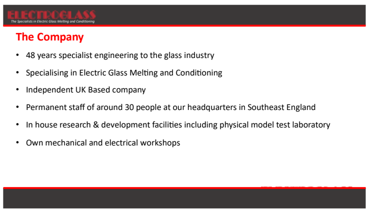
Since joining Electroglass almost 24 years ago, Grahame has held key roles in a number of the company's activities. These have included hands-on equipment installation, maintenance and servicing, followed by wider responsibilities in system design, engineering, commissioning and customer training. He has been actively involved in the company's research and development work and customer operational advice and support.

Since taking on his current position of Technical Sale Manager, he is responsible for marketing and promotional activities and for system and equipment design and sales. He leads the company's direct sales activities, handling the technical correspondence with potential and existing customers in response to enquiries, coordinating preparation of tenders for larger projects, making sales tours and targeted technical sales visits to customers in various countries. He leads our technical sales team at numerous trade shows around the world, has authored a range of articles that have appeared in leading glass industry publications and delivered technical presentations at a number of industry conferences and seminars.

SLIDE ONE



SLIDE TWO

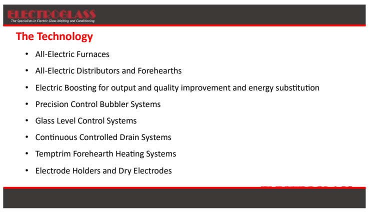


Thank you for allowing me to speak here today. I would like to start with a little bit about Electroglass, a company I have worked for now for almost 24 years.

We are an independent company with over 48 years' experience in the design and supply of electric glass melting and conditioning systems.

We have a permanent staff of around 30 people based at our headquarters in Southeast England. Our facilities include our own research and development facilities, including a physical model test lab as well as our own mechanical and electrical workshops, and design and project offices.

SLIDE THREE

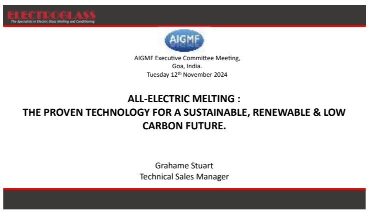


As specialists in electric melting and conditioning we offer all-electric furnaces, all-electric forehearth systems for both volatile and non-volatile glasses, electric boosting, bubbling, glass level systems, drains, electrode heating for gas forehearths in the form of our Temptrim systems and of course, electrode holders and dry electrodes.

SLIDE FOUR

In India, we are proud to be represented by Thorngate Sales Corp and Mr Shiva Singh will be glad to assist you locally at any time.

SLIDE FIVE



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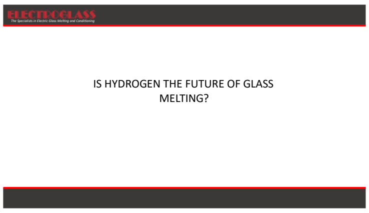
SLIDE SIX



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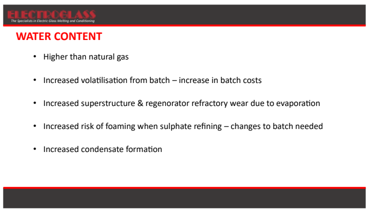
SLIDE SEVEN



Firstly, the water content of hydrogen is significantly higher than natural gas.

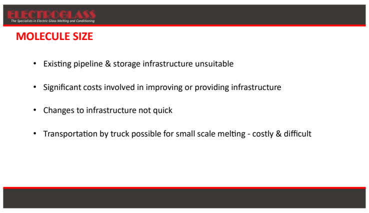
This can lead to higher volatilisation of the batch meaning higher batch costs.

Increased water content can lead to increased wear to superstructure and regenerator refractories.

There is also the risk of increased foaming when sulphate refining meaning changes to batch compositions may be needed.

Lastly, there is also increased risk of condensate formation leading to glass defects.

SLIDE EIGHT



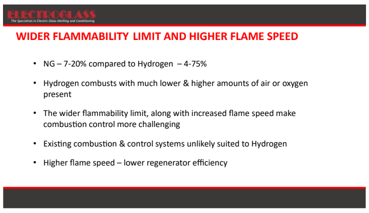
Hydrogen has a much lower molecular weight when compared to natural gas and this smaller molecule size causes issues for existing infrastructure.

The risk of leaks mean existing pipelines and storage facilities may be unsuitable for transportation and storage of hydrogen.

Replacing or updating this infrastructure will be costly and will take a significant amount of time.

Although transportation of hydrogen by truck is an option it is only really suited to either small scale melting or trials and comes with additional costs and challenges.

SLIDE NINE



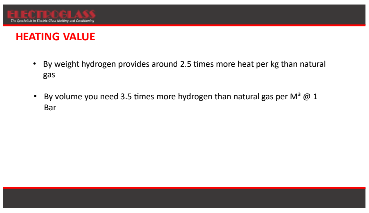
The flammability range of hydrogen is significantly wider, and the flame speed much higher than natural gas.

With natural gas having a range of 7-20% compared to hydrogen with a range of 4-75%. Basically, hydrogen will combust with a much lower and much higher ratio of air or oxygen present.

This and an increased flame speed makes combustion control more challenging and may mean existing combustion systems are unsuitable for use with hydrogen.

The increased flame speed may also lead to a reduction in regenerator efficiency.

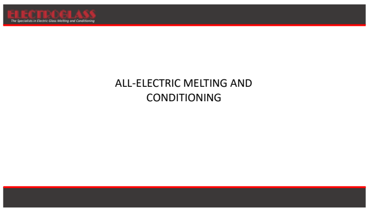
SLIDE TEN



By weight hydrogen provides significantly more heat per kilogram than natural gas.

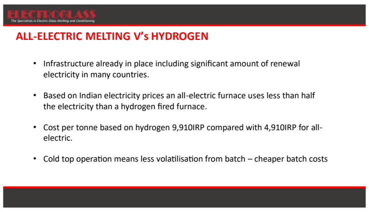
But remember, that the molecular weight of hydrogen is less than natural gas, so you need much more of it – around 3.5 times more.

SLIDE ELEVEN



So, hydrogen will never be a like for like alternative to natural gas and comes with significant challenges that will require investment and development to overcome. All-electric melting is already here.

SLIDE TWELVE

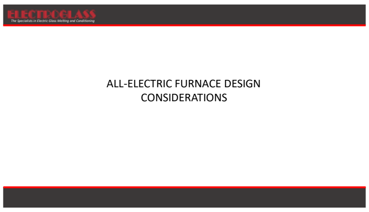


Much of the infrastructure needed for all-electric melting is in place. And any scale up in terms of increased energy need is likely to be less significant than needed for hydrogen generation.

The cost in terms of energy of a tonne of glass from hydrogen is around double the cost of a tonne of glass produced using an all-electric furnace.

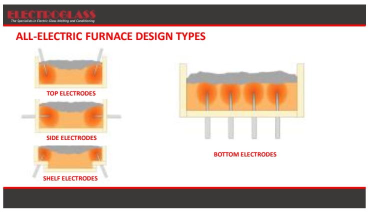
A well designed all-electric furnace operating cold top will result in less volatilisation from the batch meaning a more stable final glass composition and reduced batch costs.

SLIDE THIRTEEN



So, all-electric melting may offer a viable alternative to hydrogen, but there are design considerations to take into account when selecting an all-electric furnace.

SLIDE FOURTEEN



All-electric furnace designs can be grouped into 4 types.

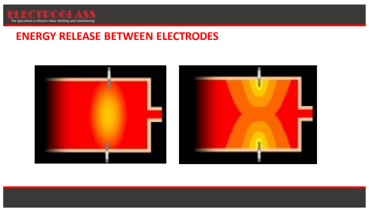
Top electrodes, where the electrodes pass through the batch blanket into the glass around the furnace perimeter.

Side electrodes, where the electrodes pass through the furnace sidewalls into the glass around the furnace perimeter.

Shelf electrodes, where the electrodes pass through a shelf into the glass around the furnace perimeter.

And Bottom electrodes, where the electrodes enter the glass through the furnace bottom allowing them to be distributed throughout the furnace and away from the furnace sidewalls.

SLIDE FIFTEEN

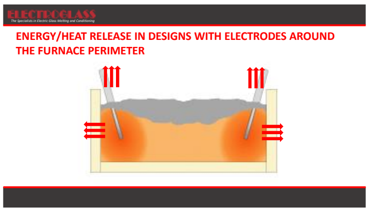


To understand each of these designs we must first consider how energy is released between electrodes in glass.

Many envisage that energy is released across the full current path between the electrodes thereby heating the glass evenly.

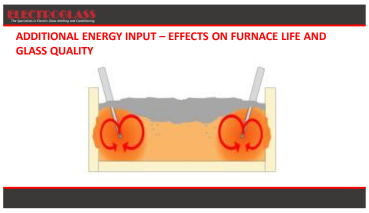
In reality the energy release is very different, with a high proportion of the energy released close to the electrodes and very little along the current path.

SLIDE SIXTEEN



Because of this, all-electric furnaces with the electrodes around the perimeter such as top, side or shelf designs will have higher temperatures close to the sidewalls. And suffer from a thinner batch blanket above and around the electrodes and a much thicker batch blanket towards the centre of the furnace where the energy release is at its lowest.

SLIDE SEVENTEEN

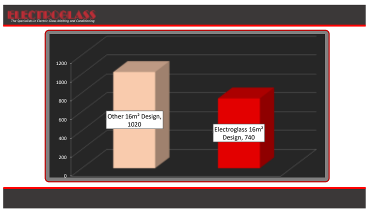


These designs also generate much of their convection current close to the furnace sidewalls.

This strong convection along with the higher temperature and energy release leads to accelerated sidewall wear reducing furnace life or increasing refractory maintenance.

It also risks pulling unmelted material from the underside of the batch blanket down into the melt leading to the risk of increased glass defects.

SLIDE EIGHTEEN



These differences in furnace design can lead to very different energy consumptions. This graph shows the energy consumption for two designs of all-electric furnace, both 16m² producing the same glass type, but with different electrode arrangements. The Electroglass design utilises only bottom electrodes whereas the other design uses electrodes from the top, through the batch blanket around the perimeter of the furnace. The difference in energy consumption in the Electroglass design is around 40% lower.

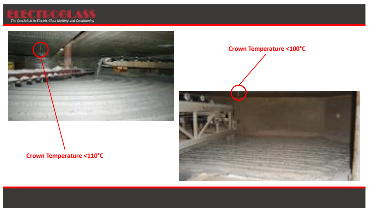
SLIDE NINETEEN

This image is of a 35 tonnes/day Electroglass All-Electric furnace producing fluoride opal glass for tableware manufacture and as we can see the batch covers the entire melting surface and is very even and calm in appearance. For furnaces of this size and up to around 70 tonnes/day we use an oscillating non-contact batch charger.

SLIDE TWENTY

This image is of a much larger Electroglass All-Electric furnace for soda lime glass with a design pull of 250 tonnes/day for oxidised flint and 215 tonnes/day of reduced colours for container production. For larger furnaces, over around 70 tonnes/day we use a different batch charging arrangement utilising two fixed position batch conveyors and a rotary spreader in contact with the batch to ensure even distribution.

SLIDE TWENTY ONE

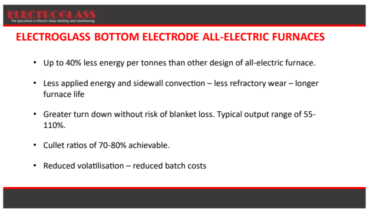


An even distribution of batch results in a very low crown temperature typically around 100-110°C meaning a significant reduction in losses and energy consumption. It also results in fewer volatile losses leading to reduced superstructure wear, reduced batch costs and a more consistent final glass composition.

SLIDE TWENTY TWO

But batch blanket coverage varies greatly depending on furnace supplier and these two images show how differences in furnace design and the use of top and side electrodes can result in much less stable conditions, much higher heat loss and much higher energy consumption.

SLIDE TWENTY THREE



A reduction in applied energy and keeping heat and convection away from sidewalls leads to reduced refractory wear and longer furnace operating life.

The even blanket means increased pull flexibility with every Electroglass furnace capable of a turn down to 55% of design output at 30% cullet.

They can also work at higher cullet ratios making them suitable for the greener future needed within the industry.

A full batch blanket also means fewer volatile losses helping to lower batch costs and improve final glass analysis stability.

SLIDE TWENTY FOUR

This image shows items from no fewer than 10 different Electroglass furnaces with outputs ranging from 16 tonnes/day up to 250 tonnes/day covering borosilicate, barium, fluoride opal, cosmetic soda lime flint, and standard soda lime glasses in flint for architectural glass and reduced greens and amber container glasses.

The popular view is that reduced glass cannot be made in an all-electric furnace and this is true for some designs, but the stable melting conditions created within our bottom electrode furnaces and a knowledge of electric glass melting chemistry requirements mean we can and have produced reduced glasses with great success.

SLIDE TWENTY FIVE

I will finish this section with some images of various Electroglass all-electric furnace. This image is of a 30 tonnes/day furnace producing fluoride opal tableware.

SLIDE TWENTY SIX

Next is a 250 tonnes/day furnace producing flint and coloured container glass.

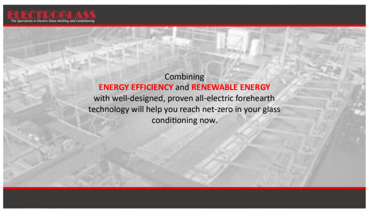
SLIDE TWENTY SEVEN

And this one is a 30 tonnes/day furnace producing 47 expansion for kitchenware production.

SLIDE TWENTY EIGHT

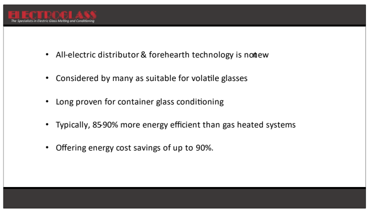
And lastly a 60 tonnes/day furnace producing flint cosmetic glass.

SLIDE TWENTY NINE



I would like to finish with a few minutes looking at all-electric forehearths where combining ENERGY EFFICIENCY and RENEWABLE ENERGY with well-designed, proven all-electric forehearth technology can help you reach net-zero in your glass conditioning now and also reduce operating costs.

SLIDE THIRTY



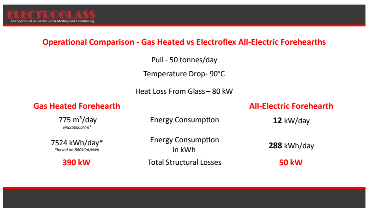
All-electric distributor and forehearth technology is not new.

It's been established for decades with many considering it the reserve of the specialist glass maker where excellent volatilisation control is needed in glasses such as borosilicate and fluoride opal.

But in reality certain designs have a long history of effective use for conventional glasses such as soda lime for container production.

And today it is not unusual to see operating energy cost savings of more than 90% with our established range of Electroflex forehearths.

SLIDE THIRTY ONE



The data here makes an operational comparison between a gas heated forehearth and a purpose designed Electroflex all-electric forehearth.

This forehearth has an operating pull of 50 tonnes/day and a temperature drop of 90°C from entry to conditioning zone meaning a heat loss from the glass of around 80kW.

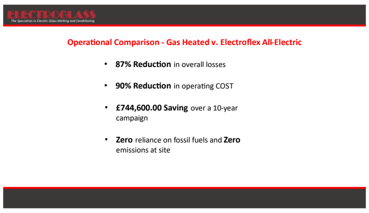
The gas heated design has an energy consumption of 775m³/day, which is around 7524 kilowatt hours.

And an overall structural and combustion loss for the entire forehearth of around 390kW.

By comparison, the all-electric forehearth has an energy consumption of just 12 Kw or 288 kilowatt hours.

The overall structural losses in this case are just 50kW meaning additional heat must be lost through centre line dampers, with just a small amount of power to ensure excellent thermal homogeneity of the glass when arriving at the spout entrance.

SLIDE THIRTY TWO



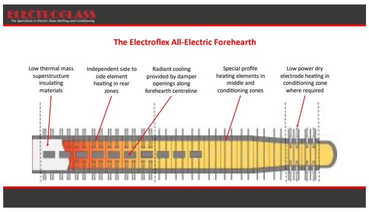
So, what we have achieved is a massive improvement in energy efficiency with an 87% drop in overall losses.

A 90% reduction in operating cost.

An operational cost saving of almost £750,000 over the campaign.

And zero reliance on fossil fuels and zero emissions at site.

SLIDE THIRTY THREE



To truly benefit from a move to all-electric conditioning an approach that offers a purpose-built design without the compromises carried over from other gas or electric forehearth design types should be employed.

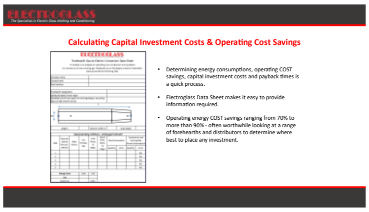
Key to this approach is the selection and use of low thermal mass insulating materials to significantly improve thermal efficiency and the use of radiant heating elements to carefully regulate heat loss during the cooling and conditioning process.

The use of passive cooling systems such as damper openings along the forehearth centreline in the rear and middle sections provides a better gradual heat loss profile than forced air cooling and fewer damper openings. It also ensures better top to bottom and side to side thermal homogeneity throughout the forehearth length meaning higher THI is reached at the spout entry.

Element type and zoning is an important part of the design process. In our Electroflex Forehearths for container glass a combination of element types and designs can be used depending on where heat is required, the width of forehearth and the elements position.

Where dark or low transmission glasses are to be produced some form of in-glass electrode heating may be considered within the conditioning zone.

SLIDE THIRTY FOUR



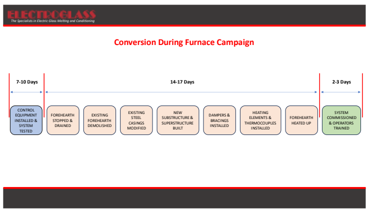
It is a relatively quick and easy process for us to calculate energy consumptions, operating cost savings, capital costs and associated payback times of adopting the Electroglass all-electric solution.

We require minimal information and provide a simple excel document to enable to glass maker to gather the necessary information.

Once we receive this information we can provide budget estimates and details of operating costs and capital investment payback to allow further discussions to take place.

With operating energy COST savings ranging from 70% to more than 90% it is worthwhile looking at a range of forehearths and distributors to determine where best to place any investment.

SLIDE THIRTY FIVE



Many would consider that conversion from a gas to an all-electric forehearth is something to be tackled at a major furnace repair or shutdown. This view is changing as the cost savings and environmental benefits become more and more significant.

It is possible to install our design of Electroflex forehearth during a short shutdown of individual forehearths, without waiting for a major repair. Such an operation typically requires a forehearth stoppage of as little as 14 days.

The Electroglass modular power and control system requires minimal field wiring and it can be installed and power and thermocouple cables run and the system tested in the days leading up to the forehearth stoppage.

The forehearth can then be stopped and all refractory and insulation materials removed. In some cases, it may not be essential to replace the glass contact and substructure refractories.

The existing casings will remain and some modifications will be made to accept new superstructure bracing and damper arrangements.

The new substructure, glass contact and superstructure materials of Electroglass design are then installed and superstructure bracings, damper assemblies, and busbars added. Heating elements, thermocouples and safety guarding complete the build making the forehearth ready for heat-up.

Heat-up times vary depending on glass contact material, but typically range from between 4 and 7 days.

Electroglass engineers will be available throughout the conversion and will carry out system commissioning and operator training as part of our project package.

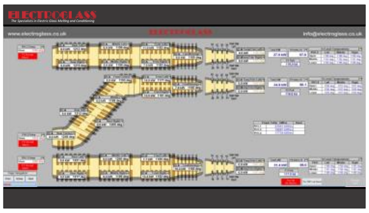
SLIDE THIRTY SIX

I would just like to close with a few screenshots and images of one our latest projects in the Far East, three forehearths, each 48" wide for flint and coloured container glasses. These each achieved their contracted goals, reducing structural losses by between 80% and 84%, reducing operating costs between 93% and 94%, achieving thermal homogeneity indexes of up to 98% and saving the customer around $6,000,000.00 over the next 10 year campaign.

SLIDE THIRTY SEVEN

SLIDE THIRTY EIGHT

SLIDE THIRTY NINE



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Thank you for listening.

CONTACT INFORMATION

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