Conference examines highly efficient melting methods

Glassmakers from 17 different countries attended the 13th Czech conference on glass melting.

The Czech Glass Society’s 13th conference on electric and other highly efficient ways of glass melting was held at Plzen, in the Czech Republic, in September. So successful was the event that the organisers had to find a larger venue at very short notice to accommodate the 140 people who came to find out more about the latest technologies.

Electric melting uses energy that is often more expensive than gas, but uses less energy. It was patented as a technology in 1902 but the technique is thought to date back to 1899.

Josef Smrcek, managing director of Electroheat, says electric boosting increases the efficiency of gas furnaces but to achieve an all-electric furnace consumption of 0.7 kWh/kg it is necessary to slow the flow of the glass melt. Slow flow currents allow lower melting temperatures, increase pull, and allow the use of little or no refining agents. They also allow shallower melting tanks.

“Furnaces with slow currents make it possible to decrease the temperature to 1400°C, needing a passage time of two hours,” Mr Smrcek says. “It allows pulling twice as today’s passage time is sufficient, it allows a shallower basin and it means you can use less or even no refining agents and use only Stokes’ law on ascending bubbles.”

The multiple pull rate up to 5t/m² per day decreases heat losses to 20% and the melting heat by 0.03 kWh/kg with a cut of 0.7 kWh/kg possible, helping increase furnace life by cutting corrosion. Such a furnace would be ecologically friendly because it would use less or no refining agents. The furnace would also be compact with no large auxiliary equipment, with natural heat recuperation through the batch layer. It would also be possible to lower the temperature of the emerging glass by cooling the walls below the electrodes, and the bottom, with air and by creating insulated channels in the walls to prevent radiation. This would give hotter air that could be used in preheating.

Professor Stanislav Kasa, from the Institute of Chemical Technology in Prague, says it is important to use all electric furnaces for the melting of crystal glass. “The quality of produced glass melt is one of the most important reasons,” he says.

Professor Kasa presented examples showing the importance of modelling methods for the influence of the positioning, connecting and the shape of Mo electrodes on the distribution of current density on their surfaces.

“This distribution represents one of the most important data in assessing the optimum frequency of feeding current if the method of low frequency current melting is used to protect Mo electrodes against corrosion,” he says.

Professor Kasa compared the performance of furnaces with horizontal electrodes, vertical top-electrodes and oblique top-electrodes. He found it was not possible for rod electrodes to reach uniform load along their entire lengths, that the tip of the electrode always bears the greatest current load, that the magnitude of electrode load depends on whether the measured place of the electrode is turned away from other electrodes and turned towards the electrode with the same phase and that the uniform distribution of electrode load can be reached only by changing the electrode’s shape.

“Very close correspondence between the technological data from the model and that obtained from a furnace, shows it is possible to use modelling methods as significant sources of data for designers of glass melting furnaces,” Professor Kasa says. When comparing electric melting with other forms of melting using fossil fuels, Professor Kasa says it shows a number of advantages.

The environment in and around glassworks is improved by the removal of combustion products from a furnace and by reducing the amount of dust. Volatile components in the batch are reduced by up to 40% for fluorides and 10-20% for lead oxide.

Glass produced is more homogenous because all electrically heated glass melts have the same thermic course, which leads to the reduction of...
poor quality products by more than 20%. The proportion of products rejected because of stones is reduced using electric melting compared with other types of melting.

Electric melting gives more tolerance for mistakes made during the preparation of the batch. Such errors are inadmissible when using gas-fired furnaces because they increase cords in the glass.

Melting with all-electric furnaces also creates fewer difficulties when heating up the furnace to full productivity and useable production after an interruption for holidays, repairs and so on. Such heating up and preparation usually takes between half a day and a full day for a fossil fuel furnace but electric furnaces can often start production immediately with no delay.

Professor Kasa also claims that electric furnaces can be rebuilt much quicker than can other furnaces, because of their simplicity. “The shut-down of an electric furnace does not usually last longer than 10-20 days,” he says.

Because an electric furnace can usually react faster and easier to outside changes than can other furnaces, it is easier to keep its pull constant. And Professor Kasa says. “However, exceeding the limits of the specific pull of this type of furnace can shorten the longevity of its melting parts.”

Now a new type of all-electric melting furnace has been developed for melting crystal glass, as part of a new research project. “The project has resulted in all-electric furnace with top electrodes passing into the melt perpendicularly through the batch,” Professor Kasa says. “The furnace longevity will be longer than five years and can increase up to 25 tonnes/day. Specific energy consumption is 0.9 kWh/kg, but other furnaces need 1 kWh/kg. The disadvantage is that the Mo electrodes cannot be moved, but this disadvantage will be removed in later developments of the furnace using oblique or shaped top electrodes.”

The Novy Bor factory of Bohemia Crystalex Trading has been using electric melting for more than 30 years, and last month the company started its third electric melting tank. The company has been using top electrodes for more than five years but it is still too early to analyse the corrosion of the melting basin and other parts of the tank.

“We think top electrodes are a good solution for cold top melting furnaces,” says the company’s Stanislav Kasa showed the importance of modelling methods.

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Jaroslav Saroch. “We only use one glass composition and our tanks have very similar pulls, but Sorg’s top electrode VSM melters work with different glass compositions and can pull between five and 180 tonnes of glass per day.

“Have no fear of top electrodes. They are a flexible, user-friendly system in comparison to horizontal electrodes for electric melting tanks.” But Mr Saroch says electrodes can be devastated by alloys of molybdenum and antimony.

Czech glassmaker Sklarny Kavalier has been using electric melting since 1969. Ales Selzak, from the company, says control of electric furnaces depends on the collection of a very large amount of data about the condition of the furnace. “It is possible to anticipate future behaviour of the melt from past trends,” he says. Information that must be collected includes total pull rate, power consumption, thickness of the cold layer, arch temperature, glass melt temperature, and the electrical resistance of the melting area. And people are still vital. “In spite of considerable progress, melting of glass in an all-electric furnace is not possible without an operator,” Mr Selzak says.

Another leading Czech glassmaker, Preciosa, uses an electric furnace with tin oxide electrodes supplied by IAL of the UK. Ladislav Novak of Preciosa says the company tries to keep a consistent pull to stabilise the performance. Its nominal furnace output is ten tonnes in 24 hours, melting 30% lead crystal for use in costume jewellery and trimmings for chandeliers.

Antonín Lisy, from the Institute of Chemical Technology in Prague, says the distribution of temperature in the glass melt and the generated flow connect with released electric energy around the electrodes, but also between them. “Temperature distribution and generated flow are in principle influenced by the location of electrodes and their connection to the power supply,” he says.

“Measuring temperature fields by thermo vision camera is fast and accurate and this method can also be used for quantifying power relations in chosen sections of the furnace.” They might also be used to evaluate the character of the glass flow.

Dr Petr Schill, from Glass Service in the Czech Republic, was presented with an award at the start of the conference for his contribution to the mathematical modelling of glass melting. In his paper at the conference, Dr Schill showed a mathematical simulation for the evaluation of physical fields influenced by the electrical conducting sludge layer that accumulates in a vitrification melter.

The model quantifies the increase of maximum refractory temperature and the decrease of Joulean heat generated inside molten glass, dependent on sludge layer thickness and shape. The critical sludge layer thickness leading to the side electrodes has been calculated.

“It results in a very high refractory and sludge temperature of 1350°C which can result in rapid melter corrosion,” Dr Schill says. “This critical configuration could happen in a real melter and indicates weak points of melter design and operation.”

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Mathematical modelling showed that the replacement of bottom electrodes by refractory might not bring any advantage because the operational parameters would not change. The same goes for the material from which bubbler tubes are made, and the electrical conductivity of the tube material will not affect melter operation.

Frantisek Novotny, also from the Institute of Chemical Technology, recommends regulation of Scott’s transformers and has developed a model of regulation options for use in glass melting furnaces. “Providing both ends are perfectly balanced, the transformers will work optimally,” he says.

Another expert from the Institute of Chemical Technology, Jiri Matej, explains that the corrosion of molybdenum electrodes is still not fully understood despite years of investigation. “In particular, the mechanism of the action exerted by alternating current still eludes description,” he says.

Mr Matej surveyed recent data on the effects of alternating current. “Alkalis play an important role in the mechanism of molybdenum corrosion in glass melts,” he says. “The alkali content also exerts influence on the frequency corresponding to the maximum suppression of corrosion and it influences probably the onset of the anodic passivation too.” Layers of reaction products on the electrode surface play a significant role in the corrosion mechanism and in affecting the corrosion by alternating current, Mr Matej says.

Milan Hajek, from the Institute of Chemical Process Fundamentals, examined the production of basalt fibres by microwave melting. “The microwave method of providing high homogenous melt for the production of basalt fibres is believed to open new industrial fibre production from a readily available source of raw material,” he says.

Lubomir Nemec, from the Czech Academy of Science, says the important features of electric furnaces are high temperatures in melting and refining, covered level in the melting tank, air atmosphere in the working end and vertical movement of the working flow. “High temperatures support fast refining, intensive foaming is dangerous in the batch layer, and higher concentrations of sulphates and chlorides plus vertical circulation might lead to agent precipitation,” he says. “The flexible character of electric heating predetermines it to new arrangements of melting and refining.”

Wolfgang Simader, from Plansee, discussed special coatings including his
company’s SIBOR coating. He also looked at glass tank reinforcements and melting electrodes. Jan Valenta, from the VSS engineering company in Prague, looked at how the cooling and design of electrode holders can influence their lifetimes.

Bernhard Fleischmann, from the German glass technology association HVG-DGG, introduced a device to measure emitted heat radiation in the combustion chamber of operating glass furnaces. “Methods to increase the direct heat transfer of the flame can be transferred from the laboratory to industrial scale furnaces,” he says. Methods have been provided to increase the flame emissivity locally due to local soot formation, increasing direct heat transfer without increasing the crown temperature.

Davor Spoljaric, from the gases group Messer, discussed the possibilities for NOx reduction in oxy-fuel combustion. “The oscillation of natural gas in different types of oxygen burners has shown a 50% decrease of NOx values,” he says. “This can be used for burners like P-LON but they have to be operated with at least two pieces to stop pulsation in the furnace. The dilution burner obtained by far the lowest NOx values, less than 100ppm at a furnace temperature of 1550°C.

Air Products, a sponsor of the conference, presented three papers to delegates. Jan Viduna discussed oxy-fuel burners, in particular his company’s Cleanfire HR design. “Results show the Cleanfire HR is suitable for all types of furnaces and gives higher radiation, better coverage, reduced flame momentum and lower NOx emissions,” he says. Mr Viduna also looked at the hybrid furnace design developed by Air Products, which uses oxy-fuel burners over the unmelted batch and air-fuel burners downstream. “Compared to oxy-fuel alone the hybrid furnace delivers similar production levels, improves glass quality, reduces material for high temperature insulation. The company modified the microporous matrix by using a new inorganic structure through mineral synthesis to allow its products to cope with much higher temperatures. “The representative applications seem to be melting tanks, feeders and feeder bowl insulation,” Mr Nevyhosteny says. “Much lower heat losses help to stabilise the glass temperature in the feeder.”