Control of Glass Melting Furnaces

TEMPERATURE MEASUREMENT WITH PLATINUM THERMOCOUPLES

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Adequate instrumentation and control of glass melting furnaces can yield large savings in fuel and marked increases in throughput. Among the variables to be controlled the temperatures of both the molten glass and the atmosphere above glass level are of great importance and a great deal of attention has been given to the best means of indicating these temperatures and thus of controlling glass temperature. In this article the author reviews Russian and British practice in this field and compares certain details of procedure and instrumentation.

An accurate and reliable system of temperature measurement with a long working life has obvious attractions for operators of glass melting furnaces. This is true regardless of the end product of the operation, whether this be bottles, press-ware, fibre, sheet or plate. The manufacture of glass essentially consists of the fusing together of many refractory compounds, and thus any system that can efficiently and effectively control the melting procedure is certain to result in a lowering of costs and an improvement in quality.

The ideal system is one that is installed when the furnace is being built and that operates for the whole of its working life.

No longer is a single reading regarded as adequate to indicate the “melting temperature” of the glass, and temperature sensors should be positioned so as to present a complete thermal pattern within the furnace. This entails the location of sensors in the hearth, side walls and roof of the melting and working compartments of the furnace. The signals from these sensors should then activate mechanisms that increase or decrease the fuel supplies.

The role of platinum:rhodium-platinum thermocouples in this field is not difficult to perceive. All normal glass melting operations take place above 1000°C and below 1700°C, and this is precisely the range in which noble metal thermocouples are universally accepted as the standard means of temperature measurement. Their stability, accuracy and reliability are well established. The life of any thermocouple is, however, greatly influenced by the effectiveness of its sheath. Therefore in designing the ideal temperature measuring system employing platinum:rhodium-platinum thermocouples much thought must be given to sheath design.

In a practical as opposed to an ideal system, compromises have to be made because of the limitations imposed by available materials. Sheaths are attacked; thermocouples drift from calibration, and frequently the site where the instrument engineer wishes to place his thermocouple is not available.

Temperature Control in a Russian Glass Works

An interesting paper has recently been published in Russia by V. M. Obukhov (1) giving details of the procedures adopted in the continuous glass melting tank at the Dzerzhinski Glass Smelting Plant in Gusev.
Crown thermocouples installed in a continuous glass melting furnace at the Smethwick works of Chance Brothers Limited. The platinum : rhodium-platinum couples are protected by refractory sheaths; those for below-glass level operation have outer sheaths of rhodium-platinum alloy.

In the course of this paper the author attempts to answer several questions:

- When and where to use thermocouples and/or radiation pyrometers?
- Which is the best thermocouple combination to use?
- How best to protect the thermocouple to ensure a long working life?
- What use to make of the responses of the temperature sensors?

The author is in no doubt that noble metal thermocouples offer the most accurate and reliable method of measuring temperature and should be used wherever possible, and he has replaced all his optical pyrometers with couples. In the Gusev melting tank are fitted eight thermocouples in the combustion area, four in the furnace hearth and four in the side walls. The thermocouple combination chosen is 6 per cent rhodium-platinum : 30 per cent rhodium-platinum, which can be used continuously up to temperatures of 1600°C and intermittently up to 1800°C. No compensating leads are required and the e.m.f. changes very little in the 20°C to 300°C interval. For example, a 50°C change in the cold junction temperature will cause an error of less than 1°C in the measured temperature at 1400°C. Extensive use is made of the "thermopile" principle—three thermocouples connected in series—to increase the signal strength.

The side wall thermocouples provide a means of checking whether the melting is proceeding uniformly on both sides of the furnace, while the hearth thermocouples record temperature changes taking place over several hours. Signals from the thermocouples in the combustion zone are used to control the fuel flow to the burners to ensure a balanced temperature distribution. Interlinked thermopiles produce an "unbalance" signal to activate the control mechanism.

The paper pays appropriate attention to the design and installation of the thermocouple sheaths. Two basic types are used, corundum for above-glass working, and a platinum alloy for below-glass level working. The design of the sheath assembly for below-glass working is shown in the diagram overpage. The sheath material used here is stated to be a 10 per cent palladium-platinum alloy, but this seems to be a little difficult to understand as there is no reason to suppose that this alloy...
is to be preferred to the 10 per cent rhodium-platinum alloy normally used in the western world glass industry. Indeed, the rhodium alloy has both greater strength at high temperatures and better resistance to oxidation.

The author recommends that the sheath should not protrude into the furnace for more than 20 mm in the melting end and more than 50 mm in the working end. Side wall thermocouples near burners are mounted flush with the furnace wall. These recommendations are in line with western practice.

The working life of the thermocouple necessarily reflects the efficiency of its protective sheath and the nature of the ambient conditions. The author quotes the thermocouple life in the crown of a gas-fired furnace as not less than nine months near burners and much longer in less aggressive areas. In oil-fired furnaces using sulphur bearing fuel and in positions near burners lives of four to six weeks are more normal.

**Instrumentation in a British Glass Works**

There is, of course, nothing revolutionary in the concept of obtaining a thermal ‘picture’ of a furnace and then using this information to control fuel supply. As long ago as 1959 N. I. Walker (2) described the system already installed in a continuous oil-fired glass melting tank in the Smethwick works of Chance Brothers Limited. This system, with minor modifications, is still operational today and the diagram on the opposite page shows the disposition of crown and side wall thermocouples.

Walker’s system is rather more sophisticated than the Gusev installation in that more use is made of the signals of the temperature sensors. The importance of the thermocouple installed in the base of the furnace is also stressed. The side wall and crown temperatures are of no real concern unless they exceed 1600°C, when the operators begin to worry about their refractories. The most economical furnace temperature is the minimum required in the superstructure to produce a given quantity of glass of given quality, and it is found that in a continuous melting tank the temperature read by the sensor installed in the base of the furnace is the most important criterion when considered in relation to the superstructure temperatures.

The sheath design used by Walker is similar to the Gusev sheath except that 10 per cent rhodium-platinum is used instead of 10 per cent palladium-platinum, and the more normal platinum : 13 per cent rhodium-platinum thermocouple instead of the 6 per cent rhodium-platinum : 30 per cent rhodium-platinum. The latter combination, although giving a lower thermal e.m.f., is
probably slightly superior in terms of stability for long installed life.

Both Obukhov and Walker claim that the application of these control systems has resulted in very large savings of fuel and, associated with this, an increased glass throughput from the furnace due to operating under stable conditions.

References

Manufacture of Two-ply Glass Tubing

Glass Tubes & Components Limited of Lemington are using a novel piece of equipment to produce two-ply glass tubing for use in sodium vapour lamps. This apparatus makes the fullest use of the ability of platinum alloys to operate continuously at temperatures at which glass is molten, and yet have sufficient high temperature strength and corrosion resistance to maintain excellent dimensional stability.

The tubing for sodium vapour lamps must be two-ply, the inner sheath being resistant to attack by sodium vapour, the outer resistant to weathering. The new equipment, designed by Glass Tubes & Components and constructed by Johnson Matthey, contains some 220 ounces of platinum and platinum alloys, and is approximately two feet in length. It comprises a platinum alloy valve placed inside a solidly constructed sheath of platinum-alloy-clad high temperature steel. The equipment is maintained in the base of the glass melting furnace, the outer sheath itself acting as a mandrel to form the outer skin of the two-ply tube. The sodium resistant glass flows continuously into the space between the valve and the outer sheath and is drawn through the apparatus to form the inner skin of the two-ply tube. The thickness of the sodium-resistant layer is controlled by the valve setting.

The new apparatus allows continuous working and has resulted not only in an increased output but in an improvement in efficiency over the hand-drawing methods formerly used.