A High Temperature Vacuum Furnace

NEW DESIGN OF PLATINUM ALLOY ELEMENTS

By J. P. Rayner, B.Sc.(Eng.)

Furnace Department, Johnson Matthey & Co Limited

One of the largest furnaces to be heated by platinum alloy windings has recently been installed in the Johnson Matthey Research Laboratories. This is a precision-controlled vacuum furnace, for use up to 1400°C, having a chamber 4 inches in diameter and 28 inches in length. Of this total length, 18 inches – from the back wall to within 10 inches of the front of the chamber – can be maintained at a uniform temperature.

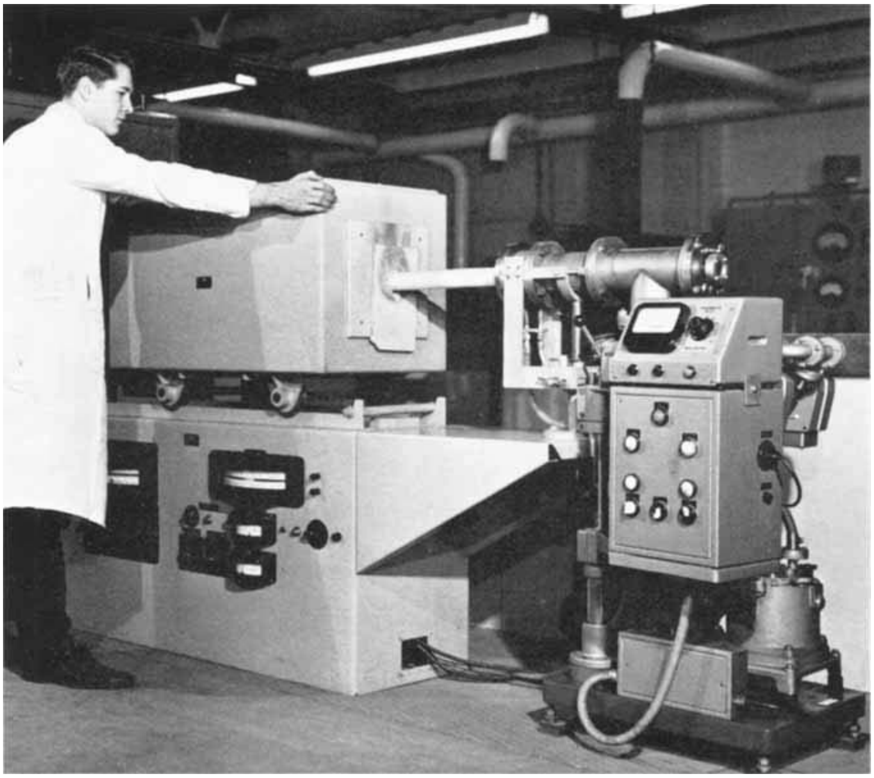
The furnace runs on rails on top of its control cubicle. It may be automatically withdrawn from the vacuum tube by a variable speed motor when slow withdrawal is required, or it may easily be withdrawn manually with the automatic drive declutched. This arrangement was preferred to the more conventional alternative of moving the more delicate vacuum pumping equipment.

The automatic withdrawal system reduces heat treatment cycle times, and thus enables a greater throughput to be obtained. At the end of a soak period the furnace is switched off and withdrawn from the vacuum tube at the maximum speed at which the hot vacuum tube can leave the furnace without suffering thermal shock. By this means the charge is cooled much more rapidly than if it were left in the furnace hot zone and could only follow the natural cooling rate of the furnace. When the charge has reached a temperature at which it will be unaffected, air is admitted into the system and the seal at the head of the vacuum tube is broken, the charge withdrawn and a new charge inserted. The furnace is returned manually to cover the vacuum tube unless the furnace temperature is too high, when the automatic drive is used.

The long rear zone of the furnace is controlled by a galvanometer type programme controller having an 8-inch scale covering the range 0 to 1600°C. The platinum:13 per cent rhodium-platinum thermocouple connected to this instrument is located near to the back of the furnace. A thermocouple within the short front winding is connected in series opposition to a reference thermocouple near the back of the furnace, the resultant e.m.f. is fed to a small centre zero galvanometer controller which controls the power to the front winding. With this simple circuit the long level temperature zone is readily obtained and maintained.

Element current is controlled by simple on/off switching of mercury relays. Transformers within the control cubicle supply the elements with a maximum of 150 volts. If the elements were run at normal mains voltage there would be a risk that a metallic charge might short circuit the element windings, as the electrical resistance of the vacuum tube wall would be very low at the maximum furnace temperature of 1400°C. Two four-position transformer tap changing switches enable both the front and back element voltages to be further reduced when the furnace is being used in the lower parts of its temperature range.

To guard against the expensive damage that could occur to either charge or furnace if failure of a component in the main control circuit led to an uncontrolled temperature



The high temperature platinum-wound vacuum furnace installed in the Johnson Matthey Research Laboratories

rise, an additional simple over-temperature control circuit, quite separate from the main control circuit, is provided. It consists of a thermocouple, a small 0 to 1600°C controller, and a contactor which opens to cut off all the power to the furnace when the thermocouple temperature reaches the set point on the controller. The over-temperature controller is usually set 20 to 50°C above the maximum operating temperature.

To indicate the temperature of the charge as distinct from that of the furnace, a thermocouple may be placed within the vacuum tube through a special seal in the vacuum head.

The heating of this large size of furnace by platinum alloy elements has been made possible by the extensive development by Johnson Matthey during recent years of fabricated elements. Previously most platinum alloy elements were made by winding the wire on to fully fired ceramic tubes. Unavoidable expansion differences led to stressing and fracture of the thin wires at high temperatures, particularly when the tubes were above 2-inch bore. Production of a furnace having 4-inch bore wound tube elements would thus not have been contemplated.

In the fabricated element the winding wire is buried in the ceramic tube before the tube is fired. Fabricated elements have not only proved to be more reliable than the wound tube type in the smaller sizes, they have been found to be very reliable in the larger sizes. The compactness of the fabricated construction leads to increased thermal efficiency, and the elimination of the fired tube between the winding and the chamber makes possible even faster heating rates.

The thermal efficiency of this furnace is such that the losses at 1400°C amount to only 3 kilowatts.