THE TEMPERATURE IN THE UPPER PART OF THE REGENERATOR IS MEASURED WITH A THERMOCOUPLE IN A PROTECTIVE JACKET INSTALLED SECURELY IN ONE OF FOUR HOLES IN A STEEL PLUG. THE PRECISION OF MEASUREMENT DEPENDS ON THE CORRECT POSITIONING OF THE PROTECTIVE JACKET.

The closed end of the jacket protrudes 250–450 mm beyond the surface of the regenerator lining. The overall length of the thermocouple should be about 2 m and that of the jacket 1–1.2 m.

For blast furnaces of a capacity up to 1500 m³ it is the practice to use standard thermocouples 1500 mm in length with an 800 mm long porcelain jacket. The durability of these jackets at a regenerator temperature of 1100–1200°C is adequate, viz. 3–4 months on average.

In large blast furnaces (1800–2300 m³) the service conditions of the thermocouples are more demanding in that they involve a temperature up to 1300°C, constant temperature variations every two hours, i.e., cooling to 1100°C, pulsed gas flow, abrasive action of refractory dust from the checker and lining, and constant stress along the jacket due to the temperature gradient.

The relatively severe service conditions of the thermocouples made it necessary to vary the design of the jackets. Sometimes they consist of a porcelain tube 30 mm in diameter combined with a 500 mm long carborundum sheath with an outside diameter of 50 mm (Karaganda Metallurgical Combine). The average life of such a jacket is 15–20 days. At the Cherepovets Metallurgical Plant use is made of a porcelain tube 1000 mm in length and 30 mm in diameter fitted with a 150 mm long corundum end-piece 10–15 mm in diameter. The life of a composite jacket is 1.5–3.0 months on average.

At the Magnitogorsk Metallurgical Combine (MMC) the temperature in the regenerators of 2300 m³ blast furnaces was hitherto measured with standard thermocouples with platinum–rhodium and platinum electrodes and porcelain protective jackets. The life of the jackets did not exceed two or three days on average but in some cases reached 10 days. The jackets frequently broke due to sudden heating on installation, notably during the winter months, so that directions were issued to the effect that the thermocouple

<table>
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*After one day no change was noted in any jacket.
†Two corundum jackets remained in service for 60 days.
must be introduced slowly (30-40 min) into the crown. The thermocouples are installed by hand so that the slow rate of the job worsens working conditions. Another reason for the short life of porcelain jackets is low thermal resistance. The jacket fails at the site of the highest stresses, e.g., in the middle section along its length.

To overcome these limitations use was made of 1000 mm long airtight jackets fabricated from high-alumina and corundum bodies. The outside diameter of the jackets is 25 mm, the inside diameter 15 mm, and the open porosity nil. The apparent density of the corundum jackets is 3.78 g/cm³, and the Al₂O₃ content of the porcelain jackets is 24.3-30.0%, that of the high-alumina jackets 40-50% and that of the corundum jackets 98.5%.

A total of ten of each type of jacket were installed and tested in the regenerators of MMC blast furnaces. The results are given in Table 1. The porcelain and high-alumina jackets failed after 3-10 days. The microstructure remained unaffected. Spalling occurs along 1/2 to 1/3 of the jacket length owing to the low thermal resistance to the frequent temperature changes.

The corundum jackets proved to be more resistant to spalling. Their durability was 20-30 days but this is well below the required durability of two months at least. The failure mechanism of corundum jackets is more complex. Apart from the 0.5 mm wide cracks caused possibly by the thermal loads the corundum specimens contained a network of microcracks up to 0.1 mm wide along the corundum crystals.

This disused jacket breaks up easily under light pressure, possibly as a result of the pulsating gas flow which produces vibration in addition to the thermal effect so that the monolithic structure of the jacket is disrupted.

It was suggested that the vibration could be damped out to some extent by using a thermoplastic but still strong fused quartz material but the results were doubtful since the crystallization of the quartz glass would accelerate the failure of the jacket.

Measurements of the permeability of quartz jackets after long-term heating at 800°C showed that they become gas-permeable after heating for 200 h as a result of the formation of cristobalite in the quartz glass.

The failure hazard is at a maximum in that part of a quartz jacket in which thermal shocks are absent and the temperature remains steady at 700-800°C. This limitation could be overcome by means of a jacket the lower part of which is quartz and the upper part porcelain or corundum. The two parts would be difficult to join, however, without impairing the impermeability of the jacket. In a gas-permeable jacket the electrodes of the thermocouple are rapidly destroyed.

The feasibility was investigated of using fused-quartz jackets. The jackets were fabricated to a length of 1000 mm, an outside diameter of 25-27 mm and a wall thickness of 3-3.5 mm. The jackets were fitted into the steel component of the thermocouple and sealed in with asbestos rope-packing impregnated with an aluminophosphate binder. The durability of the first batch of these jackets was high, viz. 5-8 months.

Petrographic and x-ray analyses showed that the jacket consists of an external and an internal zone the thickness of which varies with the length of service. The outer layer consists of glass bright-yellow