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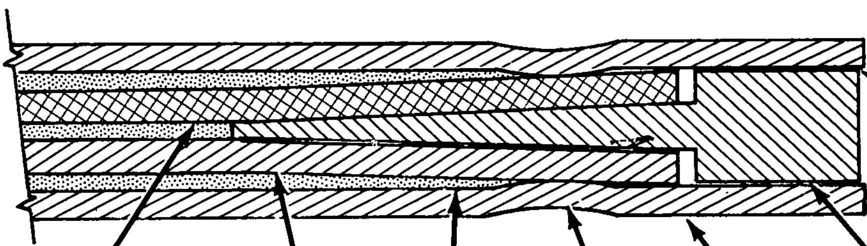
Tungsten–Rhenium Alloy Thermocouples Effective for High-Temperature Measurement



The problem:

To measure temperatures in the range of 2760°C (the temperature reached on the thermocouple rods of a UO_2-fueled reactor under maximum design power). In existing high-temperature thermocouples, a reaction occurs between the BeO insulation and the tantalum sheathing at approximately 2200°C. BeO itself melts at about 2550°C. Both of these temperatures are below the desired temperature measurement range. Improved sensors are needed which are chemically, metallurgically, and electrically stable above 2760°C.

The solution:

Tungsten–rhenium alloy thermocouples, specifically, insulated, sheathed W/W+26Re and W+5Re/W+26Re thermocouples, are effective for temperature measurement in excess of 2920°C. These thermocouples have a high thermoelectric output, excellent sensitivity, and a reasonably linear emf-temperature relationship to temperatures up to 2760°C.

How it's done:

The thermocouple developed for high temperature measurement is shown. When selecting materials for this measurement device, a W/W+26Re thermocouple was first fabricated, but an extreme brittleness was present in the tungsten leg. A leg of tungsten+5Re has been used to replace the tungsten leg since it is less brittle and easier to fabricate.

Thorium oxide is used as the insulating material. Of the refractory oxides, only ThO_2 has a melting point high enough to permit use as an insulating material in the 2760°C thermocouple. The only other possibilities were MgO and HfO_2, with melting points of 2800° and 2777°C, respectively; both of these melting points are too close to the desired maximum service temperature.

Tungsten, rhenium, tantalum, and their alloys were considered for reference sheathing, since their melting points are above 2760°C. Tantalum was eliminated because of its high affinity for oxygen; tungsten because of its brittleness after exposure to high temperature; and rhenium because of its high cost. Since the alloy W+26Re is workable and more ductile than tungsten, it serves as the reference sheathing.

Hot-junction construction, using a tungsten seal plug, was incorporated into the design of these

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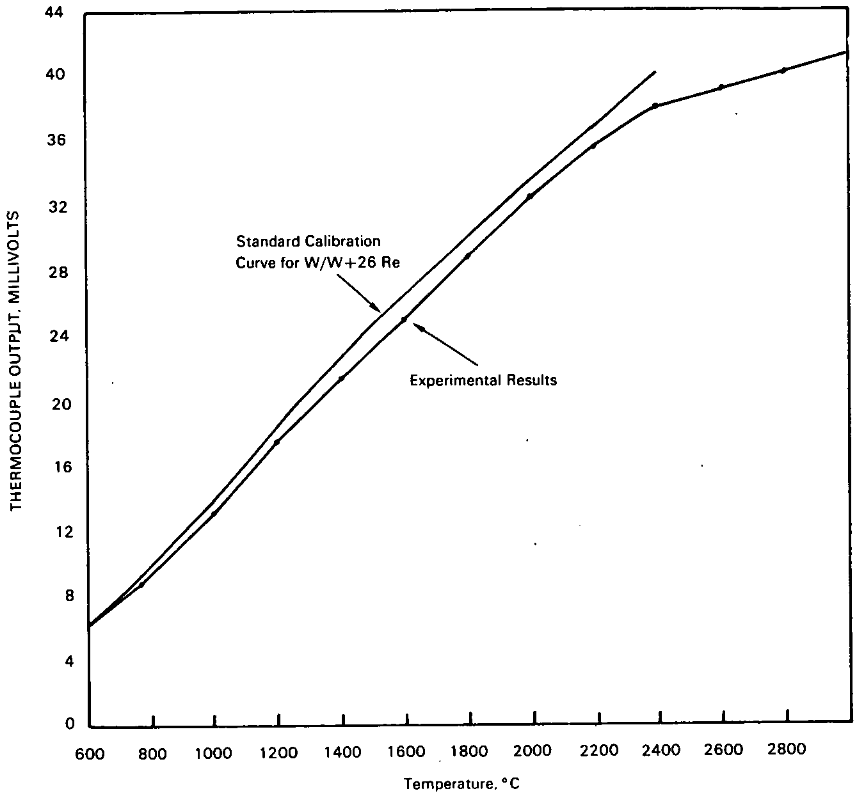

CALIBRATION OF W/W+26 Re THERMOCOUPLES

thermocouples to obviate a welded junction which would have been brittle and fragile. This fabrication should aid in preventing premature failures during installation or low-temperature operation.

The thermocouples have been tested and calibrated to 3000°C in two separate test series. Each calibration point required approximately 15 to 20 minutes to ensure temperature stability. No apparent chemical interaction takes place between the thermocouple components. Typical results of this calibration are shown in the graph.

Notes:

1. Radial and longitudinal cracks, in the thermocouple legs, believed to be introduced during fabrication, are found in varying degrees.
2. This information should be of interest to manufacturers of high-temperature furnaces and to those engaged in high temperature research.
3. Complete details are contained in: *Tungsten–Rhenium Alloy Thermocouples and Their Use in a UO_2-Fueled Reactor*, by E. J. Brooks and W. C. Kramer, ANL-6981, Argonne National Laboratory, Argonne, Illinois, November 1965. The report is available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151; price $3.00, microfiche $0.65. The report includes information on design and testing of the thermocouples, experimental measurements, difficulties in use, and suggestions for improvements for further research.
4. Inquiries concerning this innovation may be directed to:

   Office of Industrial Cooperation
   Argonne National Laboratory
   9700 South Cass Avenue
   Argonne, Illinois 60439
   Reference: B68-10109

Source: E. J. Brooks,
Idaho Division
and W. C. Kramer,
Metallurgy Division
(ARG-10059)

Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

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