

Off-center hot spots: Double thermocouple determination of the thermal gradient in a 1.27 cm (1/2 in.) CaF₂ piston-cylinder furnace assembly

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ABSTRACT

Double-thermocouple experiments were carried out at 10 kbar in a 1.27 cm (1/2 in.) piston-cylinder apparatus to map the thermal gradient and locate the peak temperature of a CaF₂-graphite furnace assembly over the temperature interval 900–1500 °C. An unexpected but reproducible result was that the thermal peak is displaced upward significantly (toward the steel base plug) from the vertical center of the graphite heater tubes.

The hot spot of our assembly, defined as the region no more than 10 °C cooler than the peak temperature, is displaced upward from the center of the furnace and moves slightly toward the center with increasing temperature. At a maximum temperature of 914 °C, the center of the hot spot was 2.6 mm above the mid-point of the furnace, while at 1510 °C, the highest temperature investigated, the center of the hot spot was 2.2 mm above the center of the furnace. The hot spot varies in width from 3.2 mm at lower temperatures to 2.2 mm at 1510 °C. We attribute the upward displacement of the hot spot to the greater thermal conductivity of the lower tungsten-carbide piston ($k = 100\text{W/mK}$ at 200 °C) relative to the upper stainless steel base plug ($k = 25\text{ W/mK}$ at 600 °C). The piston apparently conducts heat more efficiently downward than the steel plug does upward, thus displacing the hot spot upward from the furnace center.