A TEST FOR DETERMINING THE THERMAL SHOCK RESISTANCE OF GRAPHITES*

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Abstract

In applications such as rocket nozzles and nuclear reactors, graphites are subject to extremely high temperature gradients which may produce fracture. When selecting a graphite for such an application consideration of the thermal shock resistance is necessary. Traditionally this has been done by calculating figures of merit for the graphites under consideration. A figure of merit is based on the modulus of elasticity, tensile strength, coefficient of thermal expansion, and in some instances, Poisson's ratio and thermal conductivity or thermal diffusivity. This procedure gives only a gross approximation of the relative thermal shock resistance of graphites.

A test method has been developed which gives a direct measure of the relative thermal rupture resistance of graphites. The test is rapid enough and economical enough to be used for screening candidate graphites for a particular application.

The test consists of rapidly heating the center of a thin disk of graphite so that the center of the disk becomes quite hot before the circumference of the disk does. The thermal expansion of the hot material at the center of the disk creates a tensile stress which has a maximum value at the rim. The magnitude of the stress at the rim is dependent on the temperature gradient in the disk which in turn is dependent on how rapidly heat is introduced at the center of the disk. Thus, the amount of power which must be put into the disk to produce a crack is a measure of the relative thermal shock resistance of the graphite being tested.

The test apparatus consist of an inert-gas shielded-arc nonconsumable electrode welder as the heat source and a water-cooled copper plate on which the graphite disk is placed. The thermal rupture resistance of a

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P 99 particular graphite is determined by testing several disks, each at a different welder setting. The total power expended by the welder is measured for each specimen. All the arc variables (i.e., inert gas composition and flow rate, electrode size and gap between the electrode and specimen) are held constant so that the portion of the power which goes into heating the disk does not vary appreciably from graphite to graphite. The lowest power level at which a particular graphite will consistently fracture is a measure of that graphite's resistance to thermal shock. The graphites which do not fail at the higher power levels are the ones more resistant to thermal shock.

More than 30 graphites have been examined using this test procedure. In most instances three specimen sizes (3/4-in., 2-in., and 4-in. diameter, with thicknesses of 0.05 in., 0.10 in., and 0.20 in., respectively) were tested. The ranking was substantially the same for each specimen size.