Wolfgang, March 2, 1967

Molded Fueled Graphite Spheres for Pebble Bed Reactors

by G. Spener and H. Hrovat

Abstract

Fueled graphite spheres of 6 cm diameter will be used in the High Temperature Pebble Bed Reactor AVR in Jülich, Germany and in the Thorium High Temperature Reactor which is presently developed by an association of Euratom, the Brown Boveri/Krupp Reaktorbau G.m.b.H. and the Kernforschungsanlage Jülich e.V. (THTR).

Molded graphite spheres appear to have the best potential among several types of spherical fueled graphite elements. The spheres contain $(U,Th)O_2$-particles coated with pyrolytic carbon which are homogeneously distributed in the graphite matrix. The matrix is surrounded by an unfueled graphite shell. The same graphite material is used for matrix and shell. It consists of natural graphite powder, artificial graphite powder, small amounts of carbon black and resin binder.

The spheres are prepared from the coated particles and the graphite raw materials by two pressing operations and subsequent heat-treatment. In the first step the fueled matrix is pressed with low pressure. In the second step the matrix is surrounded with an unfueled shell. Matrix and shell are then pressed with 3 t/cm^2. Elastic rubber molds which are compressed in steel dies are used for both operations. The spheres are heat-treated at temperatures up to 2000°C. At higher temperatures too much uranium would diffuse through the pyrolytic carbon coating of the fuel particles.

The matrix of the spheres is extremely isotropic. The spheres have good mechanical strength and sustain 150 drops from 4 m height on a pebble bed without damage. The good heat conductivity of about 0.09 cal/cm sec degree C at 1000°C provides for a low temperature difference between surface and center. As a result of this the maximum operating temperature inside the fueled sphere does not exceed 1300°C at a rating of 3.4 kW per sphere.

Samples of different types of matrix graphites have been irradiated in the test reactors at Mol, Belgium and Petten, Netherlands and in the Dragon Reactor, England up to a fast neutron dose of about 10^{21} neutrons/cm^2 at temperatures between 700° and 1300°C. The shrinkage depends on the extent of graphitization of the constituents of the matrix. The lowest shrinkage of 0.2 % after $3 \cdot 10^{20}$ n/cm^2 at 1200°C showed a type with high natural graphite content of 90 %. The shrinkage is not linear between 10^{20} and 10^{21} n/cm^2, but shows some saturation effect specially at the lower irradiation temperatures. The bending strength of the irradiated specimens had increased by about 15 - 30 %.