Molded Fueled Graphite Spheres
for Pebble Bed Reactors
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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)O₂-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/cm². 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 %.