IRRADIATION EXPERIMENT WITH A LARGE GRAPHITE BLOCK

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Graphite is the main structural material for the core of a High Temperature Reactor (HTR) and in the case of the pebble bed HTR is used for the top, bottom, and side reflector as well as for the core support structure. The graphite reflector blocks are exposed to neutron irradiation at temperatures between 300 and 1000°C. Due to neutron flux and temperature gradients in the blocks internal stresses will develop which have to be assessed using calculations with input data pertaining to the irradiation of small specimens. In order to check the deformations and stresses predicted by such calculations a large block irradiation experiments was conducted under flux gradient conditions comparable to those of a reflector block. The graphite block of dimensions 30 x 20 x 14 cm was irradiated in the poolside facility of the High Flux Reactor in Petten to a maximum fluence of 2.4 x $10^{21}cm^{-2}$ EDN at the block front face which decreased exponentially in the direction of the block center. The measured front and rear face temperatures were 1050 and 900°C, respectively, which corresponded to a calculated temperature maximum in the block of 1100°C.

With a view to a possible dissectioning of the block to partially release the built-in stresses, a stress analysis was performed using a three dimensional, visco-elastic finite element code. The calculations based on the irradiation-induced changes of small specimens showed that the highest values of the tensile stresses are only present at the front face initially. They are subsequently shifted to the middle of the block edges which were orientated in a radial direction with respect to the reactor core. At the end of the irradiation, however, the maximum stresses were to be found on both vertical edges of the block rear side. The highest calculated stress value is 15.8 Nmm^{-2} which exceeds the tensile strength of the unirradiated material.

The experiment yielded two important results:

1. Exposed to the very high temperatures as well as to the steep gradient in fast neutron flux the block did not rupture. The shrinkage registered was however about three times greater than predicted from an analysis using irradiation data obtained from comparable small graphite samples. Before attempting to explain this anomaly, efforts are presently being directed towards substantiating the irradiation conditions, particularly the temperatures in the different regions of the block.
2. The unexpected large measured shrinkages on the other hand suggest that, on the basis of the adopted temperature distribution, local tensile stresses higher than three times the tensile strength do not affect the integrity of the block.