

GRAPHITE FUEL ELEMENT STRUCTURES FOR HIGH-TEMPERATURE GAS-COOLED REACTORS

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In one form of the High Temperature Gas Cooled Reactor (MTR), the core consists of a prismatic assembly of removable graphite blocks, each containing an array of axial channels in which fuel pins are located and along which the coolant flows. The paper describes several forms of fuel pin which are being considered for use in reactors of this type, including the hollow rod, tubular (interacting and non-interacting) and the teledial fuel pins.

Structural loading of the fuel pins, and the multi-channel graphite carrier block, arises mainly from differential thermal expansions and irradiation induced strains, rather than from self weight or gas pressure. The structural analysis of these components must however take into account mechanical interactions which develop between the fuel pins and the carrier block and, in the case of the interacting tubular fuel pin, between the fuel compacts and the containing graphite tubes.

The paper is devoted mainly to describing methods of structural analysis of the fuel pins and the graphite carrier blocks, although reference to methods of thermal analysis cannot be avoided because of the interdependence of the temperature distribution, stresses and deformations. For example, in the tubular fuel pin, differential dimensional changes between the fuel compacts and the containing graphite tubes has the effect of redistributing the internal gaps. Therefore the fuel pin to coolant heat fluxes at the inner and outer surfaces are changed, with a significant effect on the fuel pin temperature distribution, which must be taken into account in the structural analysis.

The methods of analysis described in the paper are time-dependent, allowing computation of the stress, strain and deformation history throughout the lifetime of the component. The methods described also permit calculation of the residual stresses which develop if the reactor is shut down at any point in time. Allowance is made for irradiation induced creep and changes of material properties.

One-dimensional methods are described, suitable for the analysis of the hollow rod and tubular fuel pins in regions distant from the pin ends and assuming axi-symmetric distributions of temperature and neutron flux. Two-dimensional methods are described for the analysis of the teledial fuel pin and the multi-channel carrier block, also for the thermal and structural analysis of the end regions of the hollow rod and tubular fuel pins. The analysis of the bowing of fuel pins, due to cross-pin gradients of temperature and neutron flux, is also described.

Results of these analyses are given, and in the case of the hollow rod and tubular fuel pins comparison is made between the results of the analysis and measurements made on fuel pins irradiated in Dragon.

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DISCUSSION

R. J. SCAVUZZO, U. S. A.

Q

In equation (1) on your slide you had the expression

$$\epsilon_t = \sigma_0 [K(\tau) - \gamma] + \text{other terms.}$$

I would expect the expansion caused by irradiation to decrease with stress. Could you comment on this equation ?

A. N. KINKEAD, U. K.

A

Equation (1) represents the mechanical response of the material to an applied stress. The term mentioned by Mr. Scavuzzo is the steady creep. The irradiation induced changes of linear dimensions are read directly into the computation from experimental data.