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Problem Set VI

Due 10/26/06

This problem illustrates a mechanism by which clad stresses can be reduced during up-power ramps by approaching full power at a slower rate.

1. Geometry (20°C)

The clad outside diameter is 11.2 mm; and the clad thickness is 0.7 mm.

2. Clad Material Properties (assumed constant)

Young's Modulus	= 76 GPa;
Poisson's Ratio	= 0.25;
Coefficient of Thermal Expansion	= 6.7 μm/m·K; and
$\dot{\varepsilon}_g$ = clad creep rate (s^{-1})	= $(1 \times 10^{-9})\sigma_g$;

where σ_g has the units MPa.

3. Operating Conditions

At hot zero power, the clad is at 280°C, the coolant pressure is 15.5 MPa, the gas pressure inside the rod is 5.4 MPa, and the clad is touching the fuel with zero contact pressure.

At hot full power the coolant and gas pressures are unchanged, the average clad temperature is 375°C, and the radial displacement of the outer surface of the fuel has increased by 35 μm.

Consider two cases:

- An up-power ramp from zero to full power in 30 minutes;
- An up-power ramp from zero to full power in 30 hours.

4. Calculational Basis

- Use a single ring to represent the clad
- Consider that the radial deflection at the fuel outer surface and the clad average temperature vary linearly with time during each up-power ramp.
- Use only elastic, thermal, and creep strains. Let the creep strains equal zero at hot zero power.
- Use zero axial force from fuel-clad contact.

5. Questions

Obtain the following quantities upon reaching full power in each up-power ramp:

- clad stress;
- clad strain; and
- radial displacement at the clad outer surface.