T72S01 Session #20 Homework: Warm Prestressing

Mentor Guide Questions:-

5.27 Describe the effect of warm pre-stressing on the subsequent fracture resistance of a structure.

5.28 Describe the phenomenon of crack arrest and when it might occur.

Numerical/Mathematical Questions:-

A ferritic steel component of a reactor core restraint assembly is subject to intense neutron irradiation in service. As a result its ductile-brittle transition temperature is elevated so that when off load it is on the lower shelf of fracture toughness. However, in normal operation at 300^{o}C it is on the upper shelf of fracture toughness. The lower shelf toughness is 30 MPa$\sqrt{m}$, whereas the upper shelf is greater than 120 MPa$\sqrt{m}$.

The material has a lower bound 0.2% proof strength at operating temperatures of 300 MPa, and rather greater than this at 20^{o}C.

The component is a square section bar, 1.5 inch thick. It is loaded in simple tension which may be taken to have unrestrained bending. It contains a crack to a depth of half its thickness, and across its full width. In normal operation at power the load is 146kN.

In normal start-up and shutdown conditions the bar is partially unloaded, but never to less than half the load experienced at full power.

(a)Confirm that the bar survives the at-power condition;

(b)Find the maximum fault load which the bar would survive off-load ignoring warm prestressing effects;

(c) Find the maximum fault load which the bar would survive off-load taking account of warm prestressing effects.

(d) If the worst shutdown fault load does not exceed the normal operating load, can a case be made for survival of the bar?