Homework for Session 32 – Qualitative Construction of Hysteresis Cycles
Last Update: 21/3/15

Mentor Guide Questions

1.14 Define "signed equivalent stress" and explain why it is important in an R5 Volume 2/3 initiation assessment.

1.15 Define the equivalent stress range and equivalent strain range used by R5 Volume 2/3.

1.16 Describe qualitatively the elastic stresses arising due to a sequence of thermal transient conditions.

1.17 Describe qualitatively the stress-strain hysteresis cycles corresponding to the loading sequence in 1.16.

1.18 Describe the effect of small cycles superimposed on large cycles.

1.19 State the simplest method in R5 for assigning a value to the dwell stress, , without constructing the hysteresis cycle.

"Numerical" Questions

1) A fuel plug unit is withdrawn from the reactor during on-load refuelling. It moves quickly from an environment at 650^oC to the fuelling machine in which the stringer is force cooled by CO_2 at ~20^oC. The feature in question is roughly cylindrical. Its outer surface is in contact with the CO_2, both in-reactor and in the fuelling machine. But there is no ready access for the CO_2 to its inner surface, either in-reactor or in the fuelling machine.

Three plug units, all previously removed from the reactor in the above manner, are to be re-used with new fuel:-

- PU1 is inserted when the reactor is shutdown and cold;
- PU2 is inserted during an on-load refuelling batch, when CO_2 temperatures are close to those at full power (~650^oC);
- PU3 is inserted with the reactor off-load, but pressurised and at intermediate temperature;

Raising a reactor to power can be assumed sufficiently gradual that it causes negligible thermal stressing of any plug units already resident in the reactor.

The thermal transient conditions experienced by PU3 on re-insertion would cause an elastic stress of *magnitude* ~$K_S S_y$ (but local heating causes compression on the OD).

The primary loading on the plug units is negligible in all conditions.

A feature being assessed is situated on the outer surface of the plug units.

(i) Sketch the qualitative nature of the stress-strain trajectories for the feature for each of the three plug units;

(ii) Which plug unit is likely to accrue the greatest creep damage in the subsequent operation at power, and which the least?

Hint: *For a steel item take note of how large the elastic stress range is likely to be for, say, a temperature change of 650 – 20 = 630°C.*

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2) A boiler component contains a stress raising feature. In steady operation this feature is subject to a localised Mises stress which, if calculated elastically, would equal $(K_S S_y)_{cold} + 0.7 \times (K_S S_y)_{hot}$, where the subscripts denote the cold shutdown condition and the hot operating condition respectively. When cold and shutdown the elastically calculated stresses would be zero (i.e., no load). When the reactor trips there is a steam over-pressure transient which would cause an increase in the elastically calculated Mises stress of $0.7 \times (K_S S_y)_{hot}$. Sketch the qualitative nature of the stress-strain hysteresis loop once the steady cyclic state has been achieved. Assume that the degree of work hardening beyond a stress of $K_S S_y$ is slight. What is the start-of-dwell stress?