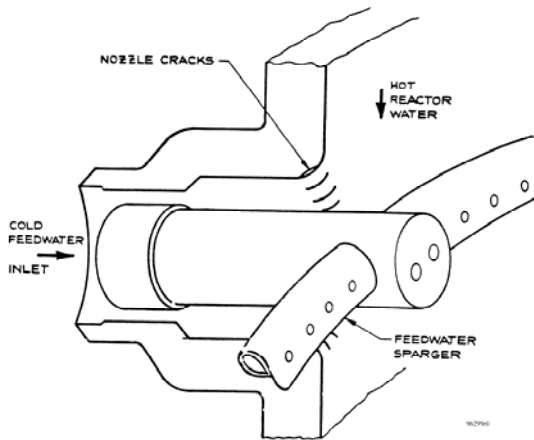


Using pc-CRACK™ for Windows to Evaluate Cracking of a Reactor Vessel Feedwater Nozzle

Fatigue cracks have initiated in Reactor Vessel feedwater nozzles as a result of cyclic thermal loading (see figure below). The applied stresses on the nozzle have a component due to feedwater temperature fluctuation and a component due to system pressurization. Hoop stresses result from thermal and pressure loading. These can be calculated by a finite element analysis, as shown in the accompanying figure.



Experimental data shows that the fatigue crack growth in water reactor environments for carbon and low-alloy steel can be described by an empirical equation as follows:

$$da/dN = C (Ke)^n \text{ (Walker Law)}$$

where:

- a = crack depth, in.
- N = number of fatigue cycles
- C = material constant, 0.0707E-9
- n = material constant, 3.726
- Ke = effective stress intensity factor range, ksi√in

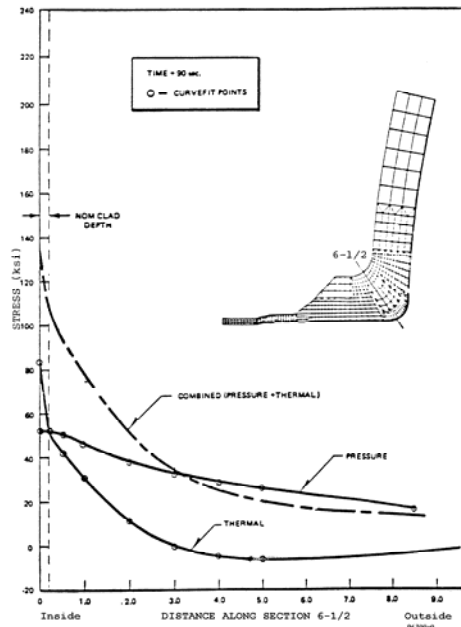
Ke is defined by:

$$Ke = (K_{max} - K_{min}) / (1-R)^m$$

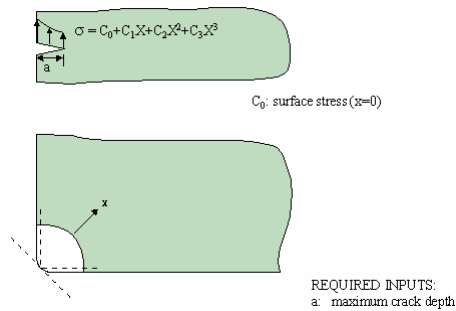
where:

$$R = K_{min}/K_{max}$$

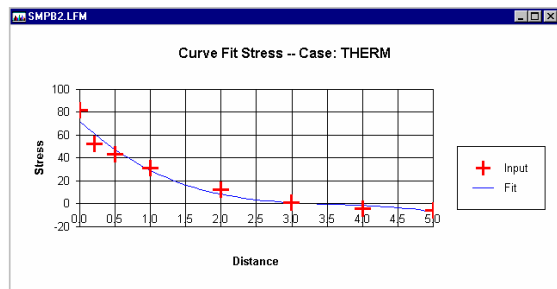
$$m = 0.5$$



pc-CRACK for Windows can be used to evaluate crack growth for this nozzle component and compare it to the critical crack depth, using the LEFM crack model "Simulated 3-D Nozzle Corner Crack".

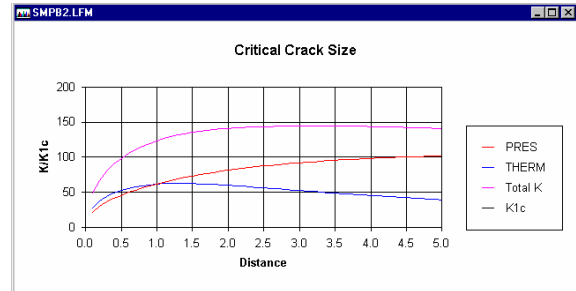


pc-CRACK for Windows provides you with the ability to import stress profile data (from commercially available finite element (FEM) programs) and the ability to curve-fit the data up to a 3rd-order polynomial. In this case, thermal stresses have been imported from the ANSYS FEM program and fitted with a 3rd-order polynomial.

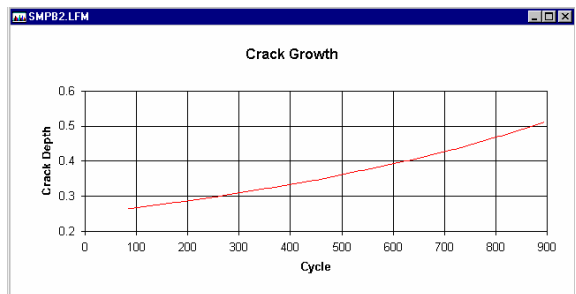


To view the **pc-CRACK for Windows** solution, retrieve the LFM file, *SPBij-1.lfm* (select “OPEN” from the “FILE” Main Menu Option). Then, activate the **FM WIZARD** option by selecting “CRITICAL CRACK SIZE...” or “CRACK GROWTH...” (under the “FM WIZARD” Main Menu Option). The FM Wizard, or Fracture Mechanics Wizard, allows you to be guided through the various steps of the LFM nozzle fracture mechanics analysis.

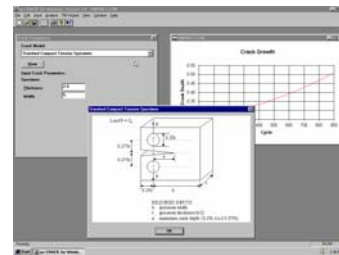
Once **pc-CRACK for Windows** completes the critical crack size analysis, results in the form of K and K_{Ic} versus crack size, will be displayed on the screen. **pc-CRACK for Windows** calculates stress intensity (K) versus crack depth in 50 discrete points of equal increments from zero to the maximum crack depth specified. Additionally, an output file which contains all the related analysis input and critical crack size results is created. The output file includes the resulting critical crack size. The output also reflects if K_{Ic} is larger than K_{total} for the full range of crack depths. Once **pc-CRACK for Windows** completes the crack growth analysis, results in the form of crack size versus cycles will be displayed on the screen.



As shown with this problem, **pc-CRACK for Windows** expands the capability of your engineering staff by providing an easy-to-use tool



that allows the user to rapidly perform highly sophisticated fracture mechanics analyses, with immediate graphics display of the results!



For more information on **pc-CRACK for Windows**, please contact:

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