Simplified Fracture Analysis in Nuclear Component Design

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1. ABSTRACT

The analysis of facture mechanics behaviour both in nuclear component design and during the life of power plants is rapidly increasing in the last years. This fact is strictly related to the evoution of numerical methods and to the capability of the last computer machines. Nevertheless, the newest and most refined numerical techniques (like Finite Element, Boundary Integral and so on) require high computer time and the most advanced physical theory (including non linear and plastic fracture mechanics) requires a very complex material property Knowledge . However, also if the use of these types of technique is carried out in special cases, they are not of practical use for an extensive analysis.

The paper shows the criteria adopted by the authors to prepare a procedure useful for extensive fracture analysis of nuclear component like Vessels or Steam Generators. The structures of interest for us are usually geometrical axisimmetric and with axisimmetric loading conditions. Also in cases that are not really axisimmetric, like for example a nozzle on a cylindrical shell, it is possible to obtain very good results using an axisimmetrical model with a Fourier load expansion (G 8/3 - 4th SMIRT).The first criterion adopted is to consider two-dimensional geometry only:
in these conditions, if applicable, the fracture mechanics analysis is obviously easier, quicker and cheaper than a tridimensional one. This approach is useful in the case of Vessels, heads, flanges and nozzles. The second criterion is the use of the classical linear, elastic fracture mechanic theory (LEFM) that is convenient not only for its semplicity but also for its strict relation with standard code (for example ASME) and with the material characterization currently available. Finally the stress concentration factor K_I is evaluated for mono and two-dimensional flow of different shape, using formulas, weight functions and polinominal influence coefficients.

The procedure is composed of a computer program chain that includes mesh generator, thermal and stress analysis, plotting functions (geometry, isoline .....) and verification functions according to ASME Code (Primary stresses, range, fatigue, fracture mechanics and so on).Every function is connected to all others with a structured and automatic data-base on disk storage. The program for Fracture Mechanics analysis (FRACT) reads, from the data base, finite element mesh and stresses and prepares a square grid with interpolated stresses. Then, using the flow shape defined by the user, the code computes the stress concentration factor KI and performes the verification according to AMSE III, Appendix G,or carries out a flow grow analysis according to ASME XI Code.