Three Dimensional Fracture Mechanics Analysis of a PWR Nozzle Under Pressure and Thermal Loading

A. Doule, F. Robisson
FRAMATOME, Division des Fabrications, B.P. No. 13, F-71380 Saint Marcel, France

A. Pellissier-Tanon
FRAMATOME, Tour Fiat, F-92084 Paris la Défense Cedex 16, France

ABSTRACT

In order to compute the fatigue crack growth and the critical size of cracks located in a PWR reactor vessel nozzle, we have to determine the stress intensity factors (SIF) of such cracks in numerous loading situations.

The geometrical forms and the natures of the stress fields make it impossible to reach closed form analytical solutions for these problems. One possible way to resolve them consists in finding a polynomial expression based on the spatial coordinates for the opening stress profile in the uncracked nozzle.

The resulting SIF is determined by employing the principle of superposition using the dimensionless influence functions computed for each term of the stress polynomial.

The influence functions depend on the position of the point analyzed along the crack front. The functions used in this study have been numerically determined by the finite element or by the boundary integral equation methods [1] [2].

This paper presents the computation of SIF for circular and non-circular crack fronts located in the longitudinal plane of the nozzle corner, normal to the hoop stress direction. The following results are given and discussed :

- Polynomial expression for isohoopstress curves obtained by a finite element analysis for pressure and thermal loading.
- SIF estimation of several flaw shapes and several depths along the crack front.
- Comparison with a semi-elliptical defect in an equivalent shell of same thickness and a similar stress field.
- Influence of the crack shape on SIF levels.