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Simulation of Crack in the Nuclear Reactor Pressure Vessel using Extended Finite Element Method Technique

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—This study presents the computing stress intensity factors (SIF) due to mechanical stress generated under tensile loading, regarding semi-elliptic surface crack initiated inside a finite plate. The analysis is further extended to study the effect of mechanical stresses on SIF for a reactor pressure vessel (RPV) having an elliptic corner surface crack at the location of the cylinder-nozzle intersection which is considered the point of highest stress concentration. The specimen considered for the finite plate having a semi-elliptic surface crack is stainless steel under tensile loading of 200 MPa and for RPV having an elliptic corner surface crack at the location of cylinder-nozzle intersection under design pressure of 17.16 MPa, the material parameters correspond to SA-533 Grade B Class-1. The propagation of the crack depends upon the material's fracture toughness if SIF under mechanical loading exceeds the material's fracture toughness, then the crack propagates leading to failure. The results obtained regarding SIF for a finite plate having a semi-elliptic surface crack considering worst case scenario is 56 MPa√ and for RPV with elliptic surface crack is 141.7 MPa√, which is below the fracture toughness of the material showing safe design. This study is done using the extended finite element method (XFEM) in open-source software (SALOME MECA) to exemplify its application and accuracy. The results are validated for both cases with a difference of less than 4% for the finite plate and 6% for RPV. The difference in results is due to limitations in computational power and mesh refinement.

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