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J-Integral Method for Assessment of Structural Integrity of a Pressure Vessel

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Abstract : The first stage of a new-generation launch vehicle of ISRO makes use of large pressure vessels made of Aluminium alloy AA2219 to store fuel and oxidizer. These vessels have many weld joints that may contain cracks or crack-like defects during their fabrication. These defects may propagate across the vessel during pressure testing or while in service under the influence of tensile stresses leading to catastrophe. Though ductile materials exhibit significant stable crack growth prior to failure, it is not generally acceptable for an aerospace component. There is a need to predict the initiation of stable crack growth. The structural integrity of the vessel from fracture considerations can be studied by constructing the Failure Assessment Diagram (FAD) that accounts for both brittle fracture and plastic collapse. Critical crack sizes of the pressure vessel may be highly conservative if it is predicted from FAD alone. If the J-R curve for material under consideration is available apriori, the critical crack sizes can be predicted to a certain degree of accuracy. In this paper, a novel approach is proposed to predict the integrity of a weld in a pressure vessel made of AA2219 material. Fracture parameter 'J-integral' at the crack front, evaluated through finite element analyses, is used in the new procedure. Based on the simulation of tension tests carried out on SCT specimens by NASA, a cut-off value of J-integral value (J?$_{ut\_o}$??) is finalised. For the pressure vessel, J-integral at the crack front is evaluated through FE simulations incorporating different surface cracks at long seam weld in a cylinder and in dome petal welds. The obtained J-integral, at vessel level, is compared with a value of J?$_{ut\_o}$??, and the integrity of vessel weld in the presence of the surface crack is firmed up. The advantage of this methodology is that if SCT test data of any metal is available, the critical crack size in hardware fabricated using that material can be predicted to a better level of accuracy.

Keywords : FAD, j-integral, fracture, surface crack
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