## Synopsis

**Thesis Title : Crack Growth Studies on Full Scale Structural Components subjected to Monotonic and Large Amplitude Cyclic Loading**

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Fracture is a problem that society has faced for as long as there have been man-made structures. Assessment of fatigue crack growth is important for the safe operation of components in nuclear power plants, microsystem technology, comminution technology, and airplane and automotive structures. The prediction of fatigue properties of structures were recognized as engineering problems in the early decades of the 20th century. The *J*-integral and Crack Tip Opening Displacement (CTOD) criteria are major breakthroughs in the field of Elastic Plastic Fracture Mechanics (EPFM). Advances in the field of fracture mechanics have helped to offset some of the potential dangers posed by increasing technological complexity.

Piping components of the primary heat transport system of Nuclear Power Plants are expected to experience dynamic-cyclic loads with high inelastic strains during an earthquake event and should have in-built safety against fracture due to improbable accidental loads. The evaluation of energy release rate and center Crack Opening Displacement (COD) for circumferential Through-Wall Cracked (TWC) pipes is an important issue in the assessment of critical crack length for unstable fracture.

In this context, studies were carried out on Nuclear Power Plant (NPP) piping components and Compact Tension [C (T)] specimens made of Type 304LN stainless steel to assess the damage due to low-cycle fatigue. *J*-integral was estimated for circumferentially TWC straight pipes subjected to monotonic and cyclic loading. Monotonic *J*-integral was estimated using the approach given by Zahoor and Kanninen, whereas cyclic *J*-integral was estimated using method proposed by Dowling and Begley. Monotonic *J*-*R* curve was evaluated and a relation between *J* and *Δa* was obtained. Similarly, cyclic *J*-*R* and *da/dN* vs. *ΔJ* curves were also obtained. A power law equation fitted between *da/dN* and *ΔJ* was utilized to get an inter-relationship between crack growth and cyclic *J*, *ΔJ*. Monotonic and cyclic *J*-*R* behavior of Type 304LN stainless steel has been investigated using C (T) specimens. Monotonic *J*-integral tests were carried out as per ASTM E 1820 - 11; whereas the cyclic *J*-integral tests were carried out at different values of maximum load amplitude (*Pmax*) and stress ratio, *R*. *J*-integral versus crack extension curves were obtained under monotonic and cyclic loading; the effect of *R* on the fracture resistance of the material has been studied. The range of the *J*-integral (□*J*) was also evaluated for the cyclic tests and the *da*/*dN* vs. □*J* plots were obtained. Numerical simulations were performed by using finite element software for the specimens subjected to monotonic loading and the *J*-*R* curves obtained were compared.

Studies resulted in understanding the *J*-*R* behavior of TWC straight pipes as well as Type 304 LN stainless steel under monotonic and cyclic loading. The equations proposed between *da/dN* and Δ*J* for TWC straight pipes and Type 304 LN stainless steel are useful in predicting the crack growth and the remaining life. A master curve based on the results of studies on TWC straight pipes was obtained. Comparison of results of C (T) specimen with the master curve indicate that failure loads determined from laboratory specimens are conservative.