IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title: Simulation and Experimental Validation of Corrosion Fatigue

Project Number	**IMURA0273**	
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Research Academy Themes:

Highlight which of the Academy's Theme(s) this project will address?

(*Feel free to nominate more than one. For more information, see www.iitbmonash.org)*

1. Advanced computational engineering, simulation and manufacture
2. Infrastructure Engineering
3. Clean Energy
4. Water
5. Nanotechnology
6. Biotechnology and Stem Cell Research

The research problem

Fracture mechanics approach to an accurate prediction of propagation characteristics of an existing crack under the synergistic action of loading and corrosion is possibly the most important data for design of components operating in corrosive environments. Traditional techniques (viz., Compact Testing (CT) or Double Cantilever Beam (DCB)) require expensive testing machine, large specimens and long testing time, making them less attractive/affordable. In recent years, Prof Raman Singh's research group Monash team, in close collaboration with Assoc Prof Raafat Ibrahim have successfully developed and validated Circumferential Notch Tensile (CNT) testing[1-4], as simple and cost-effective (20% of the cost of CT or DCB) technique to generate design data. On this topic, Prof Singh's group has collaborated with US Naval Research Lab, Oak Ridge National Lab, and Australian Defence Science and Technology Organisation (DSTO), and has received a few research grants funding support from Australian Research Council.

In the past few years, Prof SK Maiti (a specialist and educationist in fracture mechanics) and Prof Singh have very successfully collaborated to work on numerical simulation of hydrogen assisted cracking of steels. Mr. Nilesh Raykar, a current PhD student of Prof Maiti and Prof Singh, under IITB-Monash Research Academy program, has successfully developed a numerical simulation that can, for the first time, simultaneously account for the hydrogen diffusion and resulting damage[5]. The team is currently working on the generation of experimental data as well as simulation for CNT geometry.

The work summarised above is novel but it deals primarily with the static tensile mode of loading. It is well known that most failures in real life situations have a considerable contribution of cycling loading,

i.e., fatigue. The failure under cyclic loading is further complicated by the presence of corrosive environment (i.e., the phenomenon of corrosion fatigue).

Hence, there is a great value in examining corrosion fatigue phenomenon. This will involve both theoretical and experimental investigations to evaluate the contributions of each constituent of loading in the crack propagation. Specific work contents are as follows:

(a) developing simulation model for fatigue phenomenon (similar to what is being done for tensile loading in the current PhD work of Mr. Nilesh Raykar),

(b) developing similar model for combined corrosion fatigue, and

(c) Conducting fatigue and corrosion fatigue experiments after modification of the current CT and/or CNT rig.

1. S Pal, RN Ibrahim, RK Singh Raman, KISCC and Crack Growth Rate for SCC of Simulated Heat Affected Zone in Caustic Solution, ***Engineering Fracture Mechanics,*** 78 *(2011)* 13
2. RN Ibrahim, R Rihan, RK Singh Raman, Validity of a New Fracture Mechanics Technique for the Determination of KISCC and Crack Growth Rate.., ***Engineering Fracture Mechanics*** 75 (2008) 1623.
3. RK Singh Raman, R Rihan, RN Ibrahim, A Novel Approach to Determination of Threshold for KISCC using Round Tensile Specimens, ***Metallurgical & Materials Transactions A***, 37 A (2006) 2963.
4. RK Singh Raman**,** R Rihan, RN Ibrahim, Validity of a Novel Approach to Determination of Threshold for Stress Corrosion Cracking (KISCC), ***Materials Science & Engineering A,*** 452 (2007) 652.
5. NR Raykar, SK Maiti, RK Singh Raman, Modelling of Mode-I Stable Crack Growth under Hydrogen Assisted Stress Corrosion Cracking, ***Engineering Fracture Mechanics, 2011:*** doi:10.1016/j.engfracmech.2011.07.013

Project aims

Our aims are to:

(a) Simulation of the corrosion fatigue phenomenon for a material-environment system that is known to suffer corrosion fatigue, and

(b) Modification of the current Compact Tension (CT) and/or Circumferential Notch Tensile (CNT) rig to carry out corrosion fatigue experiments on the system identified at (a) above.

Expected outcomes

Simulation of fatigue is a non-trivial work. This will be further complicated by corrosion fatigue situation. However, the team of supervisors have developed considerable confidence in handling the task of this nature through the PhD work of the current student (Mr. N. Raykar).

So, the most rewarding outcome will be the successful simulation corrosion fatigue, which in itself will be novel.

Successful modification of the current Circumferential (CT) and/or Circumferential Notch Tensile (CNT) rig to carry out corrosion fatigue experiments will help to develop a relatively inexpensive way of testing under corrosion fatigue. Its success will be a great achievement in itself. It will also be attractive to several industries.