IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	Fatigue crack nucleation in aerospace alloys	
Project Number	**IMURA0327**	
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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

Fatigue is the degradation in the performance of a material as a result of exposure to alternating stresses. In many applications of engineering alloys in the aerospace sector (Aluminium, Titanium, Nickel based superalloys, etc.), the fatigue performance is the limiting property and improvements in the resistance of a material to alternating stresses would lead to significant improvements in the design of aircraft. Examples include the alternating tension and compression that is experienced by aircraft wings during take-off and landing or the alternating stresses applied to turbine blades in jet engines during start-up and shut-down. In most cases it is the limited fatigue performance that sets the inspecting schedule of a certain number of flights before planes are taken out of service for examination. Obviously, an improvement in the fatigue performance of aerospace materials would lead to refinements in aircraft design, increased safety and increased inspection intervals.

From a materials science perspective 'fatigue' consists of three stages: cyclic deformation of the material, fatigue crack nucleation and then propagation of the crack until it becomes critically sized, propagates and the component fails. The field of Fracture Mechanics has made big contributions to our understanding of fatigue crack growth but to apply fracture mechanics, the crack must already be present and herein lies the problem. We do not currently know how to predict when or where (as a function of the alloy microstructure and deformation conditions) fatigue cracks will form. If this can be understood then it opens the possibility to attempt to design new aerospace alloys specifically to resist both fatigue crack nucleation and fatigue crack growth.

Project aims

The objective of this project is to study fatigue crack nucleation in aerospace Aluminium alloys, such as those used in the wings of commercial aircraft. Specially designed samples will be fatigue tested under a range of conditions until crack nucleation can be observed (this testing will be performed at Monash University). The microstructural features influencing the crack nucleation will be identified using scanning electron microscopy and electron back scattered diffraction (at IITB) and interpreted in the framework of the applied stresses and materials response. Micro-focus X-ray will be used to characterize the state of residual stress.

Expected outcomes

The expected outcome is generation of basic understanding in an area of tremendous applied interest: the microstructural dependence of fatigue life in selected metallic materials.

How will the project address the Goals of the above Themes?

This project is aimed squarely at the manufacturing industry concerned with the production of aerospace components. The work involves components of simulation and modelling as well as experiment.

Capabilities and Degrees Required

A strong undergraduate and/or Masters degree in Metallurgical Engineering or Materials Science or Mechanical Engineering with an emphasis in metals and alloys is required for this project. An interest in both experimental and computational aspects of research is an advantage.