IITB-Monash Research Academy

An Indian-Australian research partnership

Indian Institute of Technology Bombay | MONASH University

Project Title:	Understanding Fatigue Behavior of 3D Printed Ti6Al4V Alloy	
Project Number	**IMURA0977**	
Monash Main Supervisor (Name, Email Id, Phone)	Prof. Raman Singh, Raman.Singh@monash.edu	*Full name, Email*
Monash Co-supervisor(s) (Name, Email Id, Phone)	Emeritus Professor Rhys Jones, Rhys.jones@monash.edu	
Monash Head of Dept/Centre (Name,Email)	Prof Chris Davies, chris.davies@monash.edu	*Full name, email*
Monash Department:	Department of Mechanical & Aerospace Engineering	
Monash ADRT (Name,Email)	Assoc Prof Tim Scott, Timothy.Scott@monash.edu	*Full name, email*
IITB Main Supervisor (Name, Email Id, Phone)	Prof Alankar Alankar, alankar.alankar@iitb.ac.in	*Full name, Email*
IITB Co-supervisor(s) (Name, Email Id, Phone)	N/A	*Full name, Email*
IITB Head of Dept (Name, Email, Phone)	Prof. Sreedhara Sheshadri, head.me@iitb.ac.in	*Full name, email*
IITB Department:	Mechanical Engineering	

Research Clusters:		Research Themes:	
Highlight which of the Academy's CLUSTERS this project will address? *(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*		**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	*Material Science/Engineering (including Nano, Metallurgy)*	***1***	*Advanced computational engineering, simulation and manufacture*
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*	2	*Infrastructure Engineering*
3	*Math, CFD, Modelling, Manufacturing*	3	*Clean Energy*
4	*CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*	4	*Water*
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)*	5	*Nanotechnology*
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*	6	*Biotechnology and Stem Cell Research*
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*	7	*Humanities and social sciences*
8	*HSS, Design, Management*	8	Design

The research problem

Due to an attractive set of properties in addition to high strength to weight ratio, Ti6Al4V has found extensive applications in biomedical domain. 3D printed Ti6Al4V is being used for developing patient specific implants by many commercial entities. 3D printed metals have inherent residual stresses due to primarily directional microstructure evolution. Such residual stresses play a key role in failure due to fracture and fatigue in Ti6Al4V. Fatigue in Ti6Al4V is a complicated phenomena mediated by multiphase and multiscale nature. For understanding the fatigue behaviour of 3D printed Ti6Al4V we study the interaction of residual stresses with co-deformation of dual phase microstructure of Ti6Al4V. This project will apply a combination of multiscale computational mechanics approach and data science. The test cases of Ti64 will be drawn from the conditions relevant to design of biomedical implants.

Project aims

1. Mechanical characterization of 3D printed Ti6Al4V and corresponding X-ray tomography
2. Modeling of fatigue using data science, empirical model and crystal plasticity.
3. Experimental investigation of effect of residual stress on fatigue behaviour in simulated body fluid.

Expected outcomes

1. A multiscale thermomechanical model for fatigue in Ti64
2. Understanding various models of fatigue failures in Ti64.

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

The objective of this project is to understand impact of residual stress on fatigue of 3D printed Ti6Al4V for conditions most relevant to biomedical implants. We intend to understand and model the effect of residual stress via combining the modelling and experimental efforts. This effort makes extensive use of concepts of mechanics of materials (especially plasticity) and numerical methods.

Potential RPC members from IITB and Monash

Associate Professor Tanmay Bhandakkar (expert in Elasticity, tbhanda@iitb.ac.in)
Associate Professor Wenyi Yan (expert in Mechanical Properties of Alloys, wenyi.yan@monash.edu)

Capabilities and Degrees Required

An ideal candidate should have a BTech or BE or Master in Mechanical Engineering, Aerospace Engineering, Civil Engineering or Materials Engineering with a strong inclination towards advanced mathematics, numerical methods, continuum mechanics, non-linear elasticity and fracture mechanics. Experience in at least two of the following three criteria is desired: 1. Background in mechanics of materials; 2. Expertise in numerical methods for PDEs (finite element methods); 3. Expertise in programming (Python, C, C++, Fortran). The candidate should also have an interest in fracture mechanics.

Necessary Courses

To be decided later. Courses on Continuum Mechanics, Elasticity, Numerical Methods, Finite Element Methods, PDEs will be required.
AE639: Continuum Mechanics
AE649: Finite Element Method
ME775: Crystal Plasticity

Potential Collaborators

3D printing companies, hospitals, doctors. We have not contacted yet.

Select up to **(4)** keywords from the Academy's approved keyword list **(available at http://www.iitbmonash.org/becoming-a-research-supervisor/)** relating to this project to make it easier for the students to apply.

Fatigue, Fracture Mechanics, Plasticity, Finite Element Modeling