IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	Machine learning based correlations for corrosion driven degradation	
Project Number	**IMURA1068**	
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)		
Monash Head of Dept/Centre (Name,Email)	Prof Michael Wang, Michael.Y.Wang@monash.edu	*Full name, email*
Monash Department:	**Department of Mechanical & Aerospace Engineering**	
Monash ADGR (Name,Email)	**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, 022-25767500**	*Full name, email*
IITB Department:	**Department of Mechanical Engineering**	

Research Clusters:

Highlight which of the Academy's CLUSTERS this project will address?
*(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*

1	*Material Science/Engineering (including Nano, Metallurgy)*
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*
3	*Math, CFD, Modelling, Manufacturing*
4	*CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)*
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*
8	*HSS, Design, Management*

Research 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	*Artificial Intelligence and Advanced Computational Modelling*
2	*Circular Economy*
3	*Clean Energy*
4	*Health Sciences*
5	*Smart Materials*
6	*Sustainable Societies*
7	*Infrastructure*

The research problem

Corrosion is arguably the most prominent metal degradation mode, in which the *environment* reacts with the metal leading to undesired changes in the local properties and dimensions. Local changes in dimensions often lead to unplanned stress variations causing catastrophic failure. The local changes in properties may also lead to loss of desired characteristics for protection against the environmental condition. Corrosive human body fluid-assisted failures are also a critical concern for bioimplants.

For studying corrosion, experimental studies are the workhorse wherein the environment is simulated using most prominent chemical species in the liquid or gaseous environment. The quantitative effect of corrosive reaction may be measured in terms of weight loss, corrosion current or corrosion potential. Other measures of practical importance are various mechanical properties and durability. However, it is extremely challenging to precisely replicating the environmental condition and analyze the corrosion behavior as a function of prevailing conditions and material features.

This project focuses on machine learning (ML) based prediction of corrosion cracking behavior (stress corrosion cracking and corrosion fatigue) in a variety of magnesium alloys (for bioimplant applications) and steels (for common engineering applications), by using data from literature. The primary objective is to establish correlations between chemical composition, microstructures, chemical environment and durability.

A few relevant publications are:

1. Singh Raman et al, Corrosion fatigue fracture of magnesium alloys in bioimplant applications: A review, *Engineering Fracture Mechanics,* 2015, 97.
2. Kannan, Singh Raman, In-vitro degradation and mechanical integrity of calcium-containing magnesium alloys in modified simulated body fluid, *Biomaterials,* 2008, 2306.
3. Kannan et al, Comparative studies on the corrosion properties of a Fe–Mn–Al–Si steel and an interstitial-free steel, Corrosion Science, 2008, p. 2879.
4. Javaherdashti et al., Microbiologically assisted stress corrosion cracking of carbon steel in mixed and pure cultures of sulfate reducing bacteria, International Biodeterioration & Biodegradation, 2006, p. 27.
5. Thoppil et al., Hierarchical machine learning based structure–property correlations for as–cast complex concentrated alloys, 2022, Computational Materials Science, p.111855.
6. Revi et al., Machine learning elastic constants of multi-component alloys, 2021, Computational Materials Science, p. 110671.

Project aims

1. Collection of stress-corrosion data from literature for a variety of magnesium alloys and steels.
2. Understanding the effect of chemical composition, processing and corrosion environment on the degradation of material.
3. Development of an ML based model for establishing structure-process-durability correlations in magnesium alloys and steels for SCC.

What is expected of the student when at IITB and when at Monash?

At the time of application, the student is expected to have basic understanding of metals, their mechanical behavior and corrosion. The student must also have a sound knowledge of linear algebra, statistics and probability. Good knowledge or willingness to learn any computer programming language e.g. Python, C++ is desirable. At IITB, the student will go through rigorous course work in the above areas. At the same time he/she will be expected to perform extensive literature review. The major modeling part of the project will be performed at IIT Bombay. The student will perform various fatigue tests and failure analysis at Monash University, including under the synergistic action of mechanical loading and corrosive environment.

Expected outcomes

1. A database of compositions and corresponding stress-corrosion cracking in steels and magnesium alloys.
2. Composition-Processing condition-SCC performance maps.
3. ML based predictive model for addressing SCC.

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

This project aims to understand behaviour and life of the aforementioned materials during SCC. An ML based model will be developed as part of the project. The project addresses the goal of AI related theme.

Potential RPCs from IITB and Monash

Associate Professor MJNV Prasad (expert in material processing and corrosion mjnvprasad@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 Masters in Mechanical Engineering, Aerospace Engineering, Civil Engineering or Materials Engineering with a strong inclination towards experimental methods and fracture mechanics. Experience in at least two of the following three criteria is desired: 1. Background in experimental methods, 2. Background in mechanics of materials; 3. Expertise in programming (C, C++, Fortran).

Necessary Courses

A few tentative courses are as following:
ME 616: Fracture Mechanics
MM 713 Aqueous Corrosion and its Control
CS 419 or equivalent: Introduction to Machine Learning
ME 793: Multiscale Materials Informatics, Discovery and Design.

Potential Collaborators

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.

Machine Learning, Materials Design, Structure-Property, Corrosion, Stress corrosion cracking,