STATEMENT OF PURPOSE

I am Manikandan Muruganandam, a final year graduate student in Metallurgical & Materials Engineering at IIT Kharagpur. Born and brought up in Coimbatore, a South Indian city, also known as the 'Manchester of South India,' I witnessed small and medium scale metallurgical industries served as the city's lifeline, providing livelihood to almost 50% of the population. However, the metallurgical industry has reached a saturation level as material discovery and development are often considered a constraint to the already computationally robust continuum-level systems design. Integrated Computational Materials Engineering (ICME) is the key to including material discovery and development into a computational scheme and, therefore, bridge the gap between material development and product development cycles, respectively. This motivated me to pursue the Doctor of Philosophy in Materials Engineering and study the microstructural effects on environmentally assisted cracking of aluminium alloys using a combinatorial approach.

Why this Project?

Model 7xxx alloys are widely used in structural applications owing to their high stiffness to weight ratio, fatigue behaviour and resistance to stress corrosion cracking. However, high strength aluminium alloys are susceptible to stress corrosion cracking when exposed to humid environments containing chemical species present in marine, industrial and rural atmospheres. In the coming decades, industrial components will be engineered from molecular structures. Therefore, it is necessary to understand how corrosion and associated processes occur from the molecular level to the component level. Localized corrosion by the breaking of passive film is inherently a multiscale modelling problem. It involves nucleation and propagation of a crack affected by phenomena at vastly different scales of time and space. Combining computational modelling with high-throughput methods can not only significantly increase the speed of material discovery but also provide a link to the in-service performance. If admitted to this joint PhD program of IIT Kharagpur and the University of Manchester, I will attempt to build an efficient multiscale model for stress corrosion cracking by incorporating microstructural features of an alloy and external environmental factors.

Academic background

My master's program at IIT Kharagpur allowed me to master Cellular Automata and Finite Element Analysis, which would serve as a concrete foundation for my doctoral research. In my master's project, I have simulated the microstructure evolution of dynamic recrystallization in a Nickel-base superalloy by employing cellular automata. The cellular automaton model was integrated with FEM software with the help of a novel artificial neural network. The developed model was able to simulate grain size and the fraction of recrystallized material with high accuracy. The project provided me insight into multiscale modelling and its potential impact on the manufacturing industry's future. It motivates me to pursue challenging problems such as multiscale modelling of localized corrosion in aluminium alloys during my PhD tenure.

Besides the regular coursework of my M.Tech program at IIT Kharagpur, I took the initiative to enrol in online courses to enhance my knowledge in Computational Materials Engineering and excelled in the '*Materials Data Sciences and Informatics*' and '*High Throughput Materials Development*' courses provided by the Georgia Institute of Technology through Coursera. Through these courses, I was introduced to combinatorial and high-throughput methods, which generate experimental data much faster than traditional methods. High-throughput techniques are essential in studying environmentally assisted cracking of metals because corrosion and the related process takes place at a much slower rate. So, high-throughput methods could be effective in bridging gaps in the experimental characterization of the corrosion system, particularly at the lower scales of time and space. Although multiscale models exist for glass and carbon corrosion, there are no multiscale models for metals that simulate corrosion from the atomic scale to the continuum scale. In this regard, computational modelling may be considered as a vertex of a triangle, where high-through experiments and formulation theories represent the other two vertices.

Why the University of Manchester – IIT Kharagpur joint PhD?

Being the birthplace of the industrial revolution, Manchester is originally the global leader in manufacturing and related engineering education disciplines. The University of Manchester provides one of the best doctoral programs in Materials Engineering, as the Department of Materials hosts a collective of dynamic faculty engaged in innovative research. In particular, Dr Prateek Shantraj has delivered several high impact research projects in microstructure modelling and simulation. Prof Sumantra Mandal, the lead supervisor of this project at IIT Kharagpur, had been featured among the top 2% of scientists in a recent article by a famous analyst group of Stanford University. It would be an immense pleasure to work under these researchers if given a chance.

-Manikandan