WESTERN SYDNEY
UNIVERSITY

School of Engineering

Summer Scholarship Research Program 2020

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Project 21: Metal Additive Manufacturing for tissue scaffolds

Supervisor(s): Leo Zhang - leo.zhang@westernsydney.edu.au
Principal Supervisor

Richard Yang - r.yang@westernsydney.edu.au
Second Supervisor

Project description

Bone tissue scaffolds, which act as temporary substitutes, provide essential mechanical support during healing and regeneration of bone trauma and defects. To date, tissue scaffolds fabricated by additive manufacturing (3D printing) technology have been widely used for load-bearing tissue repair in the tissue engineering community. Despite their current success, the biomechanical performance of scaffolds is one of the most important factors in bone tissue engineering. The research provides more thorough mechanical insight into the role of implant design parameters for bone scaffold replacement surgeries.

Additive manufacturing (AM) is becoming popular due to its unique ability to fabricate geometrically complex structures. As one class of metal additive manufacturing technique, powder bed fusion has attracted considerable attention in customised implants or prostheses application. It is a very effective and essential technique for the realisation of such implant or prosthetic structures.

Project Aims

This project will use the latest techniques in FEA to find the most influential geometric parameter in the implant structure and optimise the implant design by varying the dimension of the critical geometric factor. The optimal design of the implant will be manufactured by using metal-based additive manufacturing technology.

Project Methods

The application of finite element analysis has allowed for highly accurate analyses of the physical behaviour of extremely complex, organic structures, such as the human bone. In this project, an anatomically realistic model has been created from CT scan data of a healthy femur bone. After performing a bone scaffold replacement virtually on SolidWorks, the model will be simulated using finite element analysis in an attempt to replicate a physiological loading condition on a femur.

Opportunity for Skill Development

Problem-solving and critical thinking skills: This project will develop student's ability to define problems clearly, develop testable hypotheses, find the appropriate solutions to problems.

Computer-aided engineering skills: Student will learn to use finite element analysis software. The student will use the finite element method to solve problems while understanding the fundamentals and theory of finite element analysis and design optimisation.

Communication skills: student will improve this skill through the meeting with supervisors. Students will present information in a clear and organised manner. Write the report in a scientifically appropriate style.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

N/A

Project 22: Effect of atmospheric boundary layer flow on the performance of wind turbines

Supervisor(s): Ming Zhao - m.zhao@westernsydney.edu.au
Principal Supervisor

Leo Zhang - leo.zhang@westernsydney.edu.au
Second Supervisor

Project description

The wind velocity is generally non-uniform near the ground because of the atmospheric boundary layer (ABL) flow. Most of the studies on wind turbine assumed that the air of the flow of the wind are uniform. The effects of ABL on the performance wind turbine is have not been paid attention to. In addition, the non-uniform distribution of wind velocity in a boundary layer will also cause extra load on the wind turbine, which may affect the structural safety. In this project, the impacts of the sheared wind velocity distribution in an ABL on the performance and safety of wind turbines will be analysed using computer simulations. The engineering software ANSYS will be used as the tool to conduct the study and student will also learn the Blade Element Method (BEM) for analysing turbines.

Project Aims

- Finding out reduction or increase of the energy harvesting of wind turbines by the sheared flow in boundary layer flow.
- Identify the risk of sheared flow on wind turbine safety, by calculating the increase of wind load.
- Provide recommendation on efficiency modification by sheared flow.

Project Methods

The project will compare the Engineering Software Solution of wind turbine energy harvesting with the solution of traditional Blade Element Method (BEM) and as a result the BEM will be modified to account for the boundary layer effects.

Opportunity for Skill Development

Engineering Software Application, knowledge of sustainability, communication skills, engineering analysis skills.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

Programming skills, report writing skills, Engineering Mechanics, Fluid Mechanics and Fluid Engineering

Project 23: Additive Manufacturing of Nano-composites

Supervisor(s): Richard Yang - r.yang@westernsydney.edu.au
Principal Supervisor

Leo Zhang - leo.zhang@westernsydney.edu.au
Second Supervisor

Project description

Additive manufacturing (AM) is a novel manufacturing technology due to its nature of sustainability and becoming more and more popular recently. Additive manufacturing is a category of fabrication techniques that synthesise objects using CAD models as three-dimensional blueprints. As a new advanced manufacturing technology, further researches are urgently needed to get expected mechanical properties of 3D printed materials. Currently Nano-Composites is one of the most popular 3D printing material for AM and will be research material in this proposed project.

Project Aims

In this project it aims to further investigate the mechanical properties of 3D printed Nano-Composites materials to manufacture high-quality material for engineering application.

Project Methods

In this project, the research will be conducted theoretically and experimentally. In the theoretical analysis, the fundamental analysis of 3D printed Nano-Composites materials will be conducted by using the MSC Digimat Software in a multiscale modelling sense to get the comprehensive understanding on AM of 3D printed Nano-Composites materials. In the experimental work, the Nano-Composite material will be printed out for validation at the end of the project.

Opportunity for Skill Development

- Problem-solving and critical thinking skills: This project will develop student's ability to define problems clearly, develop testable hypotheses, find the appropriate solutions to problems.
- Hands-on skills: This project will enhance student's hands-on ability to work on AM printer available at Advanced Manufacturing Precinct at Penrith campus.
- Computer-aided engineering skills: Student will learn to use finite element analysis software. The student will use the finite element method to solve problems while understanding the fundamentals and theory of finite element analysis and design optimisation.
- Communication skills: student will improve this skill through the meeting with supervisors. Students will present information in a clear and organised manner. Write the report in a scientifically appropriate style.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

N/A

Project 24: Design for Additive Manufacturing and its Application in Metals

Supervisor(s): Richard Yang - r.yang@westernsydney.edu.au
Principal Supervisor

Leo Zhang - leo.zhang@westernsydney.edu.au
Second Supervisor

Project description

Additive manufacturing (AM) is a novel manufacturing technology due to its nature of sustainability and becoming more and more popular recently. Additive manufacturing is a category of fabrication techniques that synthesise objects using CAD models as three-dimensional blueprints. As a new advanced manufacturing technology, further researches are urgently needed to explore new design philosophy and principles on Design for Additive Manufacturing to get expected highly quality AM materials and products. Currently stainless steel is one of the most popular 3D printing material for AM and will be research material in this proposed project.

Project Aims

In this project it aims to further investigate the new design philosophy and principles on Design for Additive Manufacturing and apply these new principles to manufacture high-quality product using stainless steels.

Project Methods

In this project, the research will be conducted theoretically and experimentally. In the theoretical analysis, the fundamental analysis of stainless steels will be conducted by using the MSC Simufact software to get the comprehensive understanding on AM for a typical mechanical parts and then based on the results, the Design for AM will be implemented to obtain a high quality product using AM. In the experimental work, the mechanical part will be printed out for validation at the end of the project.

Opportunity for Skill Development

- Problem-solving and critical thinking skills: This project will develop student's ability to define problems clearly, develop testable hypotheses, find the appropriate solutions to problems.
- Hands-on skills: This project will enhance student's hands-on ability to work on AM printer available at Advanced Manufacturing Precinct at Penrith campus.
- Computer-aided engineering skills: Student will learn to use finite element analysis software. The student will use the finite element method to solve problems while understanding the fundamentals and theory of finite element analysis and design optimisation.
- Communication skills: student will improve this skill through the meeting with supervisors. Students will present information in a clear and organised manner. Write the report in a scientifically appropriate style.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

N/A

Project 25: Investigation of damage growth behaviour of bonded composite joints/repairs

Supervisor(s): Sarah Zhang - sarah.zhang@westernsydney.edu.au
Principal Supervisor

Leo Zhang - leo.zhang@westernsydney.edu.au
Second Supervisor

Project description

Composite materials and structures have been applied in many engineering structures especially in aeronautical and aerospace structures due to their light weight, high strength and excellent fatigue resistance. Bonding joint is a widely used method to join composites and in composite repairing, and It is essential to develop good bonding technology so as achieve the structural integrity. However, debonding and delamination have been the typical failure mode for the bonded composite joints which have damaged the structures and affected the performance of the joints. It is thus essential to investigate the damage growth behaviour of bonded composite joints and to understand the failure mechanism. This project aims to investigate the damage growth behaviour of the bonded composite joints/repairs via conducting an intensive literature review on the experimental technology and numerical modelling methods.

Project Aims

- Investigate the experimental technologies and methods used to detect the damage growth of the bonded composite joints/repairs;
- Investigate the numerical methods used to model the damage growth of the bonded composite joints/repairs

Project Methods

This project is a literature review based project. The student will need to conduct an intensive and comprehensive literature review on the experimental technologies and methods used to detect the damage growth of the bonded composite joints/repairs and also the numerical methods used to model the damage growth of the bonded composite joints/repairs. The student will need to compare and analyse the methods and report the investigation.

Opportunity for Skill Development

- Skills of scholarly research and critical thinking and analysis.
- Skills of doing literature review
- Skills of technical writing
- Knowledge on numerical methods such as finite element analysis

Students are required to have the following skills/meet the following pre-requisite(s) to apply

- Student in the area of Mechanical Engineering
- Knowledge on composites is desired.
- The candidate must have a very good academic record with a Weight Average Mark of 80 and above.
- The candidate must have good reading and writing skills.
- The candidate must be able to work on the project full time during the project period.

Project 26: Methods for improving steel corrosion resistance of Magnesium Oxychloride Cement

Supervisor(s): Sarah Zhang - sarah.zhang@westernsydney.edu.au
Principal Supervisor

Ee Loon Tan - e.tan@westernsydney.edu.au
Second Supervisor

Project description

Ordinary Portland cement (OPC) is one of the most important ingredients to make concrete, which is the most common and widely used construction and building material. However, the production of OPC accounts for 5-10% of all global greenhouse emissions. Recently A/Prof. Zhang and her team have developed an environment friendly and green cement named as MOC (magnesium Oxychloride cement) by using the by-products from industries, and solved the notorious issue of poor water resistance of MOC, which has restrained the wide application of MOC. This will enhance the performance and durability of the MOC products which have been widely used indoor and will open opportunity for outdoor application. The project was supported by ARC Research Hub on NanoComm Construction Material and a local industry. The research has been published in the Conversation in Nov. 2019 and the research outcome was reported in 7 medias including ABC Radio National. The research has generated wide public interest. The development of the new water resistance MOC is currently being used to further develop the MOC products of the partner industry, who supported the application for the Innovation Connection fund.

Another bottle neck for wide application of MOC to replace OPC is the poor corrosion resistant to steel. Based on the developed MOC formula for water resistance by A/Prof. Sarah Zhang and her team, this project will be the first step for a new project on development of corrosion resistant MOC. This project will investigate the methods used to improve the corrosion resistance of MOC to steel by conducting an intensive literature review and propose a suitable method to improve the corrosion resistance for the newly developed MOC. With solving both corrosion resistance and water resistance, the two hurdles for MOC research and application, the new MOC could be a game changer in the construction sector and full or partial replacement of OPC will lead to significant social, environmental and economic befits.

Project Aims

This project aims to

- Investigate the methods used to improve the corrosion resistance of MOC to steel; and
- Propose a suitable method to improve the corrosion resistance for the newly developed MOC.

Project Methods

This project is a literature review based project. The student will need to conduct an intensive and comprehensive literature review on the methods reported in the literatures to obtain the methods used to improve the corrosion resistance of MOC to steel. The student will then analyse the available methods and propose a suitable method for the recently developed water resistant MOC to achieve corrosion resistance to steel.

Opportunity for Skill Development

- Skills of scholarly research and critical thinking and analysis.
- Skills of doing literature review
- Skills of technical writing
- Knowledge on sustainability
- Knowledge on sustainable construction and green construction materials.
- Knowledge on MOC.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

- Student in the area of Civil Engineering/Mechanical Engineering/Science with chemistry background, who has an interest in sustainability and engineering materials.
- The candidate must have a very good academic record with a Weight Average Mark of 80 and above.
- The candidate must have good reading and writing skills.
- The candidate must be able to work on the project full time during the project period.