QUB - Mechanical and Aerospace Engineering PhD Project 2019-2020

Title: Interface formation in injection overmoulding of composite structures for aerospace and automotive applications

Project background:

Composite injection overmoulding or hybrid injection moulding is a recently developed manufacturing technique which enables fabrication of parts combining the strength and stiffness of continuous fibre reinforced composites with the complexity and high production rate of injection moulded components. Overmoulding can significantly minimise the typically high manufacturing cost of parts based on fibre reinforced polymer composites, and at the same time enhance consistency and dimensional accuracy of the resulting products. This process is based on the injection of a thermoplastic resin (which may include reinforcing fillers) over a polymer composite laminate, facilitating the production of fine geometric details not easily amenable through other manufacturing routes. The possibility of selective reinforcement within components, to meet specific service requirements, is another advantage of this technique and is increasingly being explored for the manufacture of aerospace and automotive structures, and medical devices. Various aspects of the associated processing parameters and material selection requirements, however, remain largely unexplored. One key feature, determining the integrity of an overmoulded component, is the interfacial bonding between the injected phase and the composite laminate. Results of a recent academic/industry collaboration revealed that several factors could affect the quality of the interfacial bonds and hence the structural performance and service life of the final products. These mainly include thermodynamic compatibility of the phases, processing conditions, as well as thermal and rheological characteristics of the polymer materials.

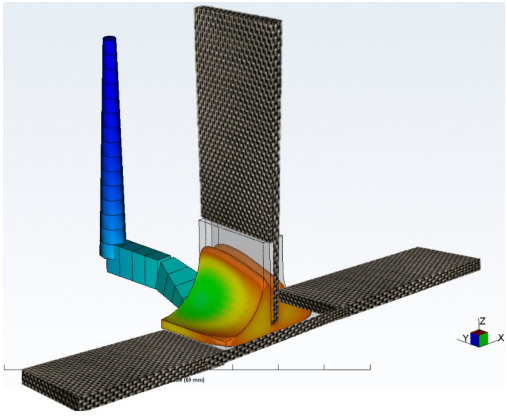

Fig. 1-Flow simulation for a composite overmoulding case

Aims and Objectives:

The aim of this research is to establish analytical as well as numerical models enabling us to gain further insights into the formation of interfacial bonds between polymer phases during manufacture of the overmoulded composite parts, as well as failure of the final structures under loading. The PhD candidate will have the advantage of exploiting a relatively wide range of the test results and data obtained during the course of a previous comprehensive study where the bond strength of several overmoulded specimens based on various types of engineering and high-performance polymer composites was measured. The key objectives of the project include:

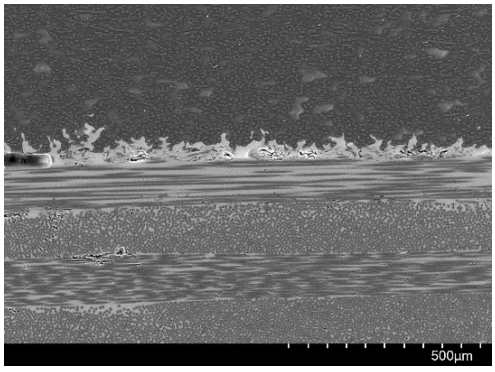

Fig. 2-Interface region in a CFRP overmouled specimen

- Simulation of the interface formation during the overmoulding phase using CFD packages
- Developing FE based platforms for stress analysis and failure prediction of the overmoulded specimens using the available experimental data
- Investigating the effects of key processing variables including injection pressure, and temperature of the phases as well as thermal and rheological properties of the polymers on the model-based results, in comparison with experimental data.
- Manufacture and testing overmoulded specimens (when necessary) in collaboration with industrial partners.

Successful candidate will have the option of engaging with industry partners of the Northern Ireland Advanced Composite Engineering (NIACE) centre involved in related projects, through participation in meetings and company visits.

Key skills required for the post:
Knowledge of computational methods (structures and preferably, also fluids).

Key transferable skills that will be developed during the PhD:
Polymer composite processing, injection moulding, numerical simulation, stress analysis

Lead supervisor:	Dr. Ali Aravand (m.aravand@qub.ac.uk)
Other supervisor(s):	Prof. Brian G. Falzon
Guaranteed stipend:	£14,925.

PhD students in the School have the opportunity to apply to be demonstrators on undergraduate modules. Compensation for this can amount to in excess of £2,400 per year.

Queens University Belfast is a diverse and international institution which is strongly committed to equality and diversity, and to selection on merit. Currently women are under-represented in research positions in the School and accordingly applications from women are particularly welcome.