PhD project outline: EPSRC DTG Centre in Complex Systems and Processes

Property Prediction of Composite Components Prior to Production

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This is an exciting opportunity for a postgraduate student to join a vibrant inter-disciplinary team and to work in the modern area of Uncertainty Quantification.

Fibre reinforced composites are increasingly used in the transport industry to decrease the structural weight of a vehicle and thus increase its fuel efficiency. The importance of the UK composite sector is reflected in the current growth rate of 17% pa for high performance composite components and the expected gross value of £2 billion in 2015 [1]. However, due to the large number of production steps and the necessary saturation of the fibre preform with a resin matrix, a significant amount of waste is produced, which may range between 2% and 20% of the production volume [2]. A major cause of rejecting parts is variability in the reinforcement, such as varying yarn spacing and yarn path waviness, which can significantly influence subsequent properties. For example, these variabilities can affect resin flow and may cause dry spots or reduce mechanical properties. This PhD project will enable the successful candidate to work at the forefront of material science, combining engineering standards, applied mathematics and statistics, with a potential of making an impact on the way of manufacturing composite parts in the future.

This proposed doctoral study aims to demonstrate that properties of light-weight fibre reinforced plastics can be predicted in real time before a part is actually manufactured. Data gained from images taken of each layer of a composite during the stacking process are used to determine local geometries and variabilities, within and in-between individual layers [3]. For example, based on the measured textile geometries it will be possible to predict the resin flow within a preform during a liquid composite moulding (LCM) process considering individual variabilities before injection. These specific flow predictions will allow adjustments of the process parameters during the impregnation process to ensure full saturation of the entire preform with a liquid resin matrix. This will be especially useful when a number of inlet and outlet ports are present such as in the case of complex or large parts. The formation of dry spots will be avoided, which will reduce immediate wastage. For these predictions, faster solutions than currently available are necessary. To find such solutions, appropriate advanced statistical techniques and stochastic modelling for quantifying uncertainties in composites production will be developed in the course of the PhD project.

In addition, the developed techniques will also allow virtual testing of a finished component with its specific inherent reinforcement variability. This will make it feasible to customise predictions for every fabricated component. In combination with continuous health monitoring of a structure, it may be possible to estimate the influence of loading conditions, load cycles and damage evaluation. This will also make it possible to predict an individual life expectancy of a part in service. These data can then be used to determine customised inspection intervals for each component.

We require an enthusiastic graduate with a 1st class degree in Mathematics or Engineering, preferably of the MMath/MSc level, with good programming skills and willing to work as a part of an interdisciplinary team. A candidate with a solid background in statistics will have an advantage.

References

[1] CompositesUK. www.compositesuk.co.uk/Information/FAQs/UKMarketValues.aspx.
[2] A. C. Long, *Design and Manufacture of Textile Composites*: Woodhead Publ, 2005.
[3] F. Gommer, L. P. Brown, and R. Brooks, “Quantification of meso-scale variability and geometrical reconstruction of a textile”, *submitted to Compos Part A-Appl S*, 2015.