A4I Analysis for Innovators

Measuring how much materials shrink during manufacture

NPL measurements improve model used to ensure that composite aircraft structures and wind turbine blades meet design specifications.

LMAT offers software and consulting to improve composite products, such as those used to form the structures of wind turbine blades or aeroplane wings.

Residual stresses during the curing process of thermoset-based composites often mean the final part deviates from the design specification, requiring costly additional machining to deliver the desired shape.

LMAT solves this problem with a software package which uses a modelling technique based on Finite Element Analysis to simulate how composite materials will distort following curing.

This information can then be used to design moulds with geometries that compensate for the predicted distortion, ensuring the product comes out as per its intended shape.

Challenge

The model relies on knowing values for a number of input parameters that contribute to residual stress, such as coefficient of thermal expansion, cure gradients and interaction of moulds with the composite.

LMAT is confident of most of its inputs, but needed to measure reliable values for the shrinkage of the materials as a result of curing. They worked with NPL through the A4I programme to develop reliable measurements that they could input into their model, helping them provide more accurately designed moulds for their customers.

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Innovate UK

Solution

NPL worked with LMAT to develop a modified PVT cell to measure shrinkage of the composite. PVT is a technique which allows control of pressure, volume and temperature conditions.

The instrument was adapted from one previously used by NPL for characterising behaviour of thermoplastic materials used in injection moulded parts. The instrument was redesigned by NPL to take measurements to characterise shrinkage of thermoset resin systems, and manufactured by a contractor commissioned by LMAT.

NPL tested the cell on two materials provided by LMAT, one which cures at room temperature and one which cures at high temperature. The instrument is a cell, into which the composite material is placed, with a plunger located on top. As the material shrinks or expands during the curing process, the plunger is displaced in a way that follows the movement of the material, providing measurement of shrinkage.

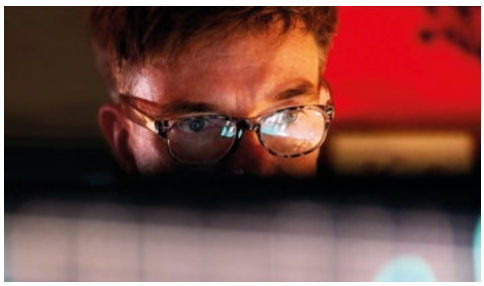
Impact

As a result of the project, LMAT has access to tools for measuring cure shrinkage. Some refining is still continuing with NPL to improve accuracy further, and a route has been identified to reach the required level of precision.

This will allow LMAT to improve its material characterisation process, leading to better calculations of cure shrinkage properties that feed into their simulations, therefore improving the accuracy of the entire simulation.

> It is expected that this will provide an important competitive advantage for LMAT, and improve customers' productivity by reducing the need to rework or scrap parts.

Based on the project learnings, LMAT has also commissioned a new test rig which can be run on-site, which will be suitable for measuring most materials they encounter. With further refining, the PVT cell could also become a product which LMAT could manufacture and sell to its software customers to enable them to bring bespoke material characterisation in-house.



"This was a successful and worthwhile project, helping us obtain measurements that will improve our simulations, in a fast and cost-effective way. NPL were able to identify the right tools and techniques, drawing on wide ranging expertise from similar projects, to find a suitable solution to our challenge. We are confident that with some further refining, we will have a simple route to acquiring the accurate measurements of cure shrinkage that we need."

Alan McMillan
Senior Engineer at LMAT

LMAT

A4I

A4I is a programme that gives UK businesses, of any size, access to cutting-edge R&D expertise and facilities to help solve problems that they have been unable to tackle using standard techniques. The focus is on solving issues affecting product cost, reliability or lifetime and production problems.

NPL nel flow measurement services NMI

Science & Technology Facilities Council

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