An Experimental Investigation of Residual Stress in Rapidly Cured Composites

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Carbon fibre reinforced plastics are becoming more and more popular in the aerospace and automotive industries due to their high specific strength and stiffness. However, one major drawback of more traditional composite manufacturing techniques is that they have very long processing times. This is primarily due to the need to slowly increase and decrease the processing temperature to avoid residual stress formation and warpage after cure. In recent years, rapidly curing resins systems with cure times of 1-10 minutes have been developed to reduce the processing time required to manufacture composite parts. However, the effect of shorter processing times on residual stress formation is still not well understood and if these manufacturing techniques are to be adopted for structural applications this gap in knowledge must be addressed. Therefore, this research aims to investigate ways in which to evaluate residual stress in fast curing composites and to determine the effect that residual stress has on the mechanical performance of the finial composite part. In this work, the applicability of the use of embedded optical fibres with Fibre Bragg Gratings (FBGs) in fast-curing composite systems for the measurement of residual strain is investigated.

Advances in embedded sensors technologies have proven very promising for the more widespread adoption of residual stress monitoring in composites [1][2]. Embedding FBG's into a laminate before cure allows for an insight into the internal strain state of the composite laminate during cure and while analysing the structural performance during subsequent testing. In this work, residual stress fields within various laminates are manipulated by altering curing temperature and laminate thickness. To ensure that there is sufficiently good bonding between the embedded optical fibre and resin matrix for representative strain measurements to be made, an analysis of the interface is conducted. This is done over a variety of laminates with varying levels of residual stress to determine that effect of that residual stress on the interface quality. The internal strain state of laminates with varying levels of residual stress is monitored during the curing process, allowing for an analysis of the mechanisms that contribute to the final residual stress state of the laminates tested. Transverse flexural testing is then used to investigate the effect of varying levels of residual stress on the matrix dominated bending response of the laminate.

With a greater understanding of the formation of residual stress and the effect of that stress on mechanical performance in rapidly cured composites, it is hoped that this work will help drive the wider adoption of rapid curing composite technology in industry.

References

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