Derivation of temperature dependent material properties of polymer foam core materials using optical extensometry

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Summary

A methodology for determining the Young's modulus and Poisson's ratio of polymer foams is presented. The approach is based on a non contact measurement technique so that the behaviour of the complaint foam is modified by the attachment of gauges or extensometers. Firstly experiments are conducted at room temperature and then at elevated temperatures in a thermal chamber. Readings are taken through an optical window using a standard digital camera. Digital image correlation is used to obtain the strains.

1. Background

Polymer foam cored sandwich structures are being used increasingly for a variety of applications including wind turbine blades, boat hulls and ship structures as well as for structural applications in the transportation and aerospace sectors. Polymer foams (usually polyvinylchloride, PVC or Polyethylene, PET) are commonly used. Sandwich structures are often subjected to aggressive service conditions that may include elevated temperatures. The material properties of foam cored sandwich structures depend on the temperature field imposed particularly as the polymer foam core materials is sensitive to elevated temperatures. Significant degradation of the mechanical properties may occur well within the operating range of temperatures. For example, PVC foams (Divinycell® and Airex®) lose all stiffness and strength at about 80-100^{o}C, while PMI foams (Polymethacrylimide, eg Rohacell®) lose the heat distortion resistance at about 200^{o}C. Moreover, significant degradation of the properties of the foam occurs at much lower temperatures than the temperatures where a complete loss of stiffness and strength is experienced. The thermal degradation of polymer foam cored sandwich structures is generally poorly understood. However, there is a growing concern that the simultaneous action of mechanical loads and elevated temperatures may compromise the structural integrity under certain circumstances, e.g. [1]. At the same time the manufacturers of polymer foam core materials, including PVC, PET, PMI and other polymer foam types, offer limited and incomplete information about the temperature dependence of the core

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properties alone and without any consideration of the effects of interacting mechanical and thermal loads. The starting point in mapping the thermal degradation behaviour of polymer foam sandwich structures is to ascertain the mechanical properties of the foam over a range of temperatures. Therefore in the paper a methodology is defined that enable Young's modulus and Poisson's ratio to be established. The paper contains a detailed description of experiments on PVC foam and a comparison with results from other sources.

2 Experimental work and results

The test specimens were manufactured from Divinycell H100 and H200 cross-linked PVC foam and were of prismatic form with a cross section of 25 mm x 25 mm. They were loaded in uniaxial tension via specially designed end clamps in a test machine. For the tests at elevated temperatures, a controlled chamber with an optical glass window was installed around the specimens. The specimens were heated from room temperature to 70^{o} C and a thermocouple was used to continuously monitor the surface temperature of the test specimens. A video extensometer (Imetrum) was used to collect the deformation data both at elevated and room temperatures using a DIC approach. A typical plot of Young's modulus against temperature for H200 foam is shown in Figure 1.

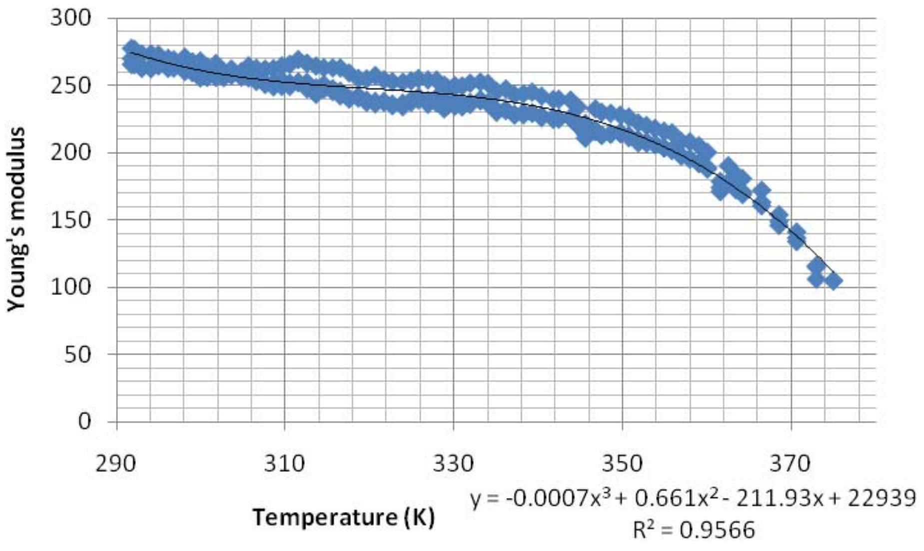

Fig.1 Variation of Young's modulus with respect to temperature

3 Conclusions

The work shows that precise property data can be obtained from foam materials using a DIC video extensometry technique. An experimental methodology is defined that is validated against known property data and the uncertainties in the derived values established.

References

1. Frostig, Y. and Thomsen, O.T., 2008, *Non-linear Thermal Response of Sandwich Panels with a Flexible Core and Temperature Dependent Mechanical Properties*. Composites Part B: Engineering, Vol. 39, Issue 1, pp. 165-184.