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ANALYTICAL AND NUMERICAL PREDICTION ON FLOW STRESS OF FIBRE METAL LAMINATE BASED ON ALUMINIUM ALLOY AND SELF-REINFORCED POLYPROPYLENE

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Uniaxial tensile tests have been carried out to accurately evaluate the in-plain mechanical properties of fibre metal laminates (FMLs). The FMLs in this paper comprised of a layer of self-reinforced polypropylene (SRPP) sandwiched between two layers of aluminium alloy 5052-H34.

In this study, nonlinear tensile and fracture behaviour of FMLs under in-plane loading conditions has been investigated with numerical simulations and theoretical analysis. The numerical simulation based on finite element modelling using the ABAQUS/Explicit and the theoretical constitutive model based on the volume fraction approach using the rule of mixture and the modified classical lamination theory, which incorporates the elastic-plastic behaviour of the aluminium alloy and SRPP, are used to predict the in-plain mechanical properties such as stress-strain response and deformation behaviour of the FMLs. In addition, the pre-stretching process is used to reduce the thermal residual stresses before the uniaxial tensile tests of the FMLs.

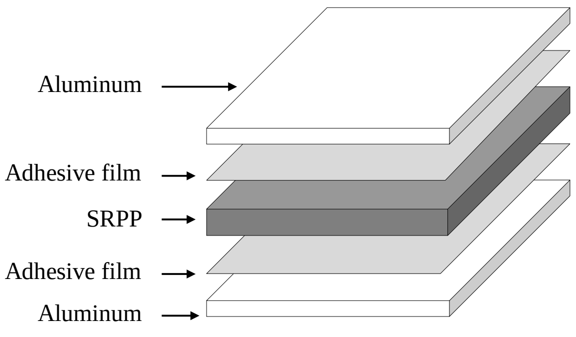

Fig.1. Layup structure of the fibre metal laminates

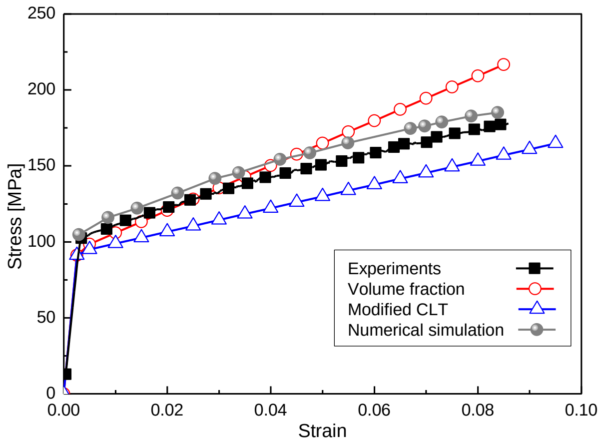

Fig.2. Comparison of stress-strain curve of the FMLs

The theoretical modelling of the FMLs was performed to determine he Young's modulus and predict the in-plain mechanical properties of the FMLs. The mechanical properties of hybrid laminates can be predicted by the volume fraction approach using the rule of mixture and based on the classical lamination theory. In the plastic behaviour region of the FMLs, it can be confirmed that there is the more similar tendency using the results based on the classical lamination theory than using the volume fraction approach by the rule of mixture.

In addition, using the tensile test results of the constituent materials of the FMLs, the numerical analysis was performed. The specimen of the FMLs was modelled as a single layer solid element to evaluate the uniaxial stresses in the aluminium alloy and the SRPP layers, since this finite element analysis is focused on the tensile behaviour, not the de-bonding or the delamination. The finite element analysis results are in good agreement with the experimental results. However, there is some degree of discrepancy between the experimental and the theoretical calculations, since the adhesive strength are not considered in the theoretical model.

Through comparing the numerical simulations and the theoretical analysis with the experimental results, it is concluded that the adopted numerical simulation model and the theoretical approach can describe with sufficient accuracy of the actual tensile stress-strain curve.

REFERENCES

[1] L.B. Vogelesang and A. Vlot, Development of fibre metal laminates for advanced aerospace structure, J. Mater. Process. Tech., Vol. **103**, pp. 1–5, 2000.

[2] A. Sexton, W. Cantwell and S. Kalyanasundaram. Stretch forming studies on a fibre metal laminate based on a self-reinforcing polypropylene composite, Compos. Struct., Vol. **94**, pp. 431–437, 2011.

[3] J. Xue, W. Wang, Y. Takao and T. Matsubara, Reduction of thermal residual stress in carbon fiber aluminum laminates using a thermal expansion clamp, Compos. Part A-Appl. S., Vol. **42**, pp. 986–992, 2011.