8th ECCOMAS Thematic Conference on the Mechanical Response of Composites: COMPOSITES 2021

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THE INFLUENCE OF THE CURING RESIDUAL THERMAL STRESSES AND POST-STRETCHING PROCESS ON GLARE LAMINATE

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Fiber Metal Laminates (FML) require of manufacturing processes that originate residual thermal stresses. These appear when heating the FML for curing the resin and due to the different thermal expansion coefficients of the involved materials.

Glass Laminate Aluminium Reinforced Epoxy (GLARE) is a laminate within the FML family which consists in a balanced combination of aluminium sheets and composite glass-fibre/epoxy-resin layers. This FML is widely used in the aeronautical sector as it provides a better structural strength and fatigue resistance along with a better impact and corrosion resistance than aluminium alloys.

In this paper, the manufacturing residual thermal stresses of multiple GLARE configurations are analysed. It is also studied the response of these laminates when subjected to an after curing post-stretching process.

The resin curing process generates high temperatures that expand differently the layers within the laminate. During this process the mechanical bonding between the composite and the metal takes place. The temperature at which this occurs is known as the stress-free temperature [1]. Assuming that all layers deform equally during the cool-down process, due to the fact that the coefficients of thermal expansion are different for each material and directions this means that the plies develop thermally induced residual stresses. The procedure presented in this paper obtains the residual thermal stresses for each material within layers by means of Serial Parallel mixing theory [2]. The behaviour of the unidirectional Glass Fibre Reinforced Polymer (GFRP) is defined by a matrix damage model used along with an elastic fibre, aluminium is simulated with a plasticity model.

Finally, taking into account the calculated residual stresses, which are also compared with experimental data [1], the effect of different post-stretching processes are analysed. The purpose of the post-stretching is to modify the stress balance within the GLARE material in order to improve the laminate mechanical properties. This is achieved through the plastic behaviour of the aluminium. Generally, at the end of the curing, aluminium layers remain under tensile stress but if a permanent deformation is applied, this tensile load can be turned into a compression. As consequence, the mechanical behaviour of GLARE material is improved when subjected to cyclic loads, improving its fatigue performance.

References

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