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Flax fibre metal laminates (FLARE): A bio-based FML alternative combining impact resistance and vibration damping

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Fibre metal laminates (FML) were originally developed as a hybrid material, to create synergy between the impact resistance of metals and excellent fatigue and corrosion resistance of fibre reinforced polymers, and to overcome the shortcomings of monolithic materials. Yet, the scope of the FML concept is predominantly limited to GLAss REinforced laminates (GLARE) for aerospace structures [1].
However, with the rising concerns about climate change, and the issues of recycling glass fibre composites, a new generation of FMLs with a reduced carbon footprint should be envisaged. This can be achieved by using bio-based fibre reinforced composite layers, particularly flax fibre instead of glass fibre composite, rendering FMLs with lower embodied energy, in which aluminium layers can be easily recycled by incineration with energy recuperation of the flax composite.

Flax fibres demonstrate promising specific mechanical properties compared to glass fibres, particularly regarding tensile stiffness and bending stiffness and strength. This means that flax fibres can outperform glass fibres in stiffness-based designs, and in applications in which the loading mode is predominantly in bending. This includes applications in the transportation and construction sectors as well as secondary structures for civil aircraft, such as automotive panels, flooring, and bridge decks.
Additionally, flax fibre composites demonstrate high damping capabilities due to the unique hierarchical structure of these fibres. This makes them particularly suitable for applications where vibrational and acoustic damping is of interest which includes many of the above given examples. However, they also have disadvantages such as high moisture absorption that can restrict their use [2]. The FML concept would overcome these limitations and thus allow the introduction of these materials in primary structures.

In this study, the combination of flax fibre reinforced epoxy with thin aluminium layers is realised as a partially biobased alternative to current FMLs, aiming to obtain primarily good vibration damping properties and improved impact resistance. The impact behaviour of the flax fibre reinforced aluminium (FLARE) will be evaluated by low velocity impact and quasi-static indentation tests to identify the role of each material constituent. The results will be compared with a predictive model based on the work of F. Morinière et al. [3]. For the damping properties, to cover a wide range of frequencies and to compare methods, the vibration absorption capacities will be measured by dynamic mechanical analysis and vibration beam tests. The results will be compared to the model predictions from the metal volume fraction method.

Finally, this study will give a first overview of the properties of FLARE and will verify the validity of the predictive tools developed for conventional FMLs, which help in the design phase to optimise the structure according to specific requirements.

Fig.1: Cross-section of first FLARE

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