Understanding and optimization of durability and performance reproducibility of powerRibs structures

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1. Introduction

The powerRibs technology consists of flax fibres yarns displayed in a grid-like structure. When placed on a sheet structure such as CFRP, CFRP or even aluminium, they locally increase the thickness, leading to an improved bending stiffness, while keeping a low density.

Two different types of powerRibs exist: the 5020 type (unit cell length: 28 mm) and the 5019 type (unit cell length: 14 mm).

As a natural material, flax also shows some weaknesses such as water sensibility, thermal degradation at high processing temperatures and some variability of its mechanical properties.

2. Goals of the project

- Development of a reproducible production process for aluminium and powerRibs composites.
- Optimization of their mechanical properties (linear rigidity, force at yield and maximum force).
- Understanding of how they behave during hygrothermal (60°C, >95% of relative humidity) and thermal (60°C) ageing.

3. Materials, processing and testing method

**Materials:** Thin aluminium plates, powerRibs 5020, epoxy resin (Araldite/Aradur 5052), PA/PP vacuum bag, flow channel (coiled tube), bleeder (foil), PVC tubes

**Process:** VARTM (Vacuum-assisted resin transfer moulding) with thermoformed vacuum bag

**Testing method:** 3-point bending, powerRibs are under compression

**Varied parameters:** Thermoforming step, vacuum bag (flexible, made of latex), heated powerRibs, resin (low viscosity, L-GL2) and old batch of powerRibs

4. Performance reproducibility

With the VARTM process used, samples with standard deviations between 2.5% and 6.7% on their mechanical properties were obtained.

This process is highly reproducible and will be used for further testing of powerRibs composites.

5. Performance optimization

- The use of a flexible vacuum bag made of latex increases the linear rigidity. The impregnation quality and the amount of resin are also higher.
- The heating of the powerRibs makes them stiffer due to the loss of water, which normally acts as a plasticizer for flax. This stiffening increases the force at yield and the linear rigidity.
- Due to a better impregnation and to thicker powerRibs, the maximum force is improved with the latex bag. The heating step is damaging the aluminium-epoxy interface, leading to a drop of the maximum force.

6. Durability: hygrothermal ageing

- The linear rigidity is slightly reduced: the swelling of the powerRibs (increase of the linear rigidity) is counterbalanced by local damages to the aluminium-epoxy interface (decrease of the linear rigidity). These damages reduce the force at yield and the maximum force. Due to a processing problem, the linear rigidity after 15 days of ageing is particularly low.

7. Durability: thermal ageing

- The linear rigidity, the force at yield and the maximum force are improved thanks to a small loss of water inside the powerRibs, which increases their stiffness. The small drop of the force at yield after 15 days of ageing may be due to a modification of the hemicellulose and lignin inside the flax fibres. The maximum force shows a similar behaviour.

8. Conclusion and future work

- A simple and highly reproducible production process for aluminium and powerRibs composites has been developed.
- The mechanical properties of powerRibs composites can be improved by using a flexible vacuum bag (up to 20% of increase of the linear rigidity) and by heating the powerRibs (up to 10% of increase of the linear rigidity). These 2 parameters can be used at the same time.
- Linear rigidity is slightly reduced during hygrothermal ageing. Thermal ageing increases the linear rigidity for a short-term treatment.
- The epoxy-aluminium and epoxy-powerRibs interfaces have to be improved to increase both mechanical properties and durability.

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