PhD Grants from the China Scholarship Council: Co-operation Program with the UTs and INSAs (France), Program 2027

Thesis subject :

Investigation of advanced hybrid composites with improved vibration and shocks damping capacity

Keywords :

vibration damping, composites, materials characterizations, finite elements simulation

Description :

The dynamic behavior of composites made of thermoset matrix reinforced traditional fibers are thoroughly studied. Clearly, carbon fibers present high stiffness that may influence negatively the damping properties of CFRC materials. Consequently, these are suitable for industrial applications requiring stiffness but they present a poor damping performance where vibration and shock absorbing potential is expected.

For sports equipment such as racing bike frames, ski, skateboards and tennis racquets for example, the poor damping properties of CFRC can result in lower comfort for the user, which can lead to more fatigue of muscles and ultimately lower performance of the athletes.

For high performance applications, stiffness could be insufficient for their safe design so that it should be combined with damping performances.

Currently, new matrices and reinforcements offer increasing interest and they are being developed in many applications, in particular in the manufacturing of automotive parts (door panels and dashboards), thanks to their lightweighting potential [1, 4].

In particular, thermoplastics matrices (polypropylene, LDPE, …) for example are replacing thermosets (epoxy) and move composites into the automotive thanks to their processing short cycle time that allows new high-speed manufacturing technology in vehicle parts production. Similarly, bio-sourced reinforcement such as flax fibers are being developed for lightweight requirements in automotive. Some research papers showed that flax fibers present good damping properties better than traditional reinforcement but their low stiffness still limiting the use of composites reinforced flax fibers on components requiring low stiffness such as vehicle interior cover parts.

This thesis proposal aims to investigate the stiffness and the dynamic properties of hybrid composites reinforced carbon and flax fibers allowing human centred design [1-3] of sports equipment that present high performance of vibration and shocks damping, thanks to the high stiffness of carbon fibres as well as the full vibration damping potential of flax fibers.

Especially, the study is related to vibrations and shocks damping and lightweighting of sports equipment, such as those mentioned above, so to reduce fatigue of muscles and to allow athletic performances.

Two approaches will be investigated:

(i) an experimental approach that concerns:

- study of the influence of the content of flax fibers and stacking orientation on damping and stiffness properties of the hybrid composite,
- the influence of thermoplastics versus thermosets matrices on damping and stiffness properties of the hybrid composite [2],
- mechanical characterisation (bending, tensile, torsion, etc.), dynamic characterization (low velocity impact, flexural vibrations, etc.) following normalized ergonomic tests requirements. Flexural vibration test will be carried out on an experimental device provided with a vibrating hammer and accelerometers.

(ii) a numerical approach related to the modelling of the dynamic behavior of the hybrid composite reinforced flax-carbon fibers. The model will define the optimized vibration dampening properties so to help processing the optimised composite structure for efficient vibration damping. Numerical simulation will be performed using Abaqus software. The model will be validated by the comparison with the experimental results.

Expected background of the PhD candidate:

Master's degree in Mechanics, composites

Supervision of the research works:

Supervisor: Morad Mahdjoub [1], *associate Professor,*
Co-supervisors:

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References

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