Manufacturing Optimisation For A Non-Linear Compliant Hydrofoil

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Introduction

Hydrofoils are wing-like structures used in sailing boats to lift the hull and maintain it out of water, thereby reducing the friction and increasing the speed.

For catamarans, hydrofoils are widely used but their efficiency depends on their shape and the speed of the boat. For example, C-foils are efficient for low speed, while L-foils are better for high speed. Therefore, a third shape, which is a compromise is often used, but the foiling is quite unstable.

Objectives

- Develop a self-adapting hydrofoil providing a significant reversible passive morphing, to be efficient at all speeds.
- Use superelastic Nitinol wires to induce the non-linear compliant behaviour.

Nitinol characterization

DSC

Goal: Determine characteristic temperatures of martensitic transformation.

Nitinol characterization

Tensile tests

Goal: Determine mechanical properties of the Nitinol wires (average over 4 samples).

- E=40 GPa
- Plateau begins at a strain of 1.56%

Pull-Out

Goal: Compare the interfacial shear stress for different surface treatment, embedded length and orientations of the Nitinol wires.

- Only knots have a significant influence.
- Surface treatments induce only a little increase.
- Lower adhesion for 0° plies.

Manufacturing of the beam

- Make knots at extremities of wires (mechanical anchorage).
- Positioning on a tape.
- Prepare prepreg plies.

4 Points bending test

- Core-free length: 14 cm.
- Loading span: 18 cm.
- Displacement rate 2 mm/min.
- 3 loads until about 9%, forth until failure.

4 Points bending test

Results:

- Martensitic transformation begins at a moment between 152 and 141 MPa (decreases with number of loads).
- Angle made by the beam switch from 5,6° to 23,4° during martensitic transformation.

Conclusion

- Working principle validated: Nitinol wires provide desired behaviour.
- Outstanding interfacial characteristics between Nitinol wire and composite.
- Good results when Nitinol wires have little knots at extremities.

Outlook

- Further develop model decreasing the number of hypotheses.
- Refine calculations to take in account more parameters to analyse results of bending tests.
- Make a beam fulfilling real sailing conditions for a A-Class catamaran (plateau at 500 Nm, 478 Nitinol wires).

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