MATERIAL SELECTION FOR FUNCTIONALIZED FIBER-REINFORCED COMPOSITE STRUCTURES

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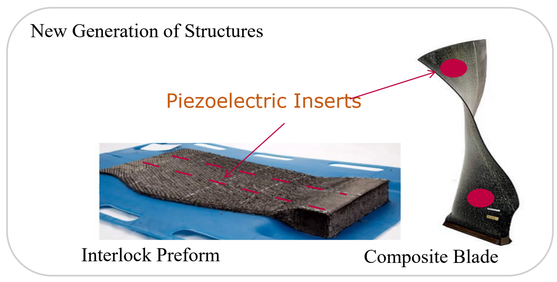
ABSTRACT

- The paper investigates **material selection** for functionalized structures and active materials, particularly piezoelectric materials, for integration in design and manufacturing phases.
- Study proposes **PVDF** (Polyvinylidene fluoride) as the active element and **pre-impregnated unidirectional flax fiber** as the base material for creating **smart composite structures** capable of fracture detection and monitoring.
- Selection process considers **insulation capacity**, **curing temperature**, and **production process** of the smart composite in choosing the host fiber-reinforced composite material.
- Testing includes creating symmetrical laminated composites and conducting vibration tests with magnetic manipulation on the smart materials.
- Future work suggestions: exploring diverse **fabrication methodologies**, investigating piezoelectric sensor **placement configurations**' signal response, and utilizing advanced **finite element analysis** to validate interlaminar stress impact.

OBJECTIVES

• To select appropriate materials for functionalized structures, particularly piezoelectric materials, for potential integration during the design and manufacturing phases.

• To embed piezo-based sensors into a composite material structure during fabrication instead of attaching external sensors.

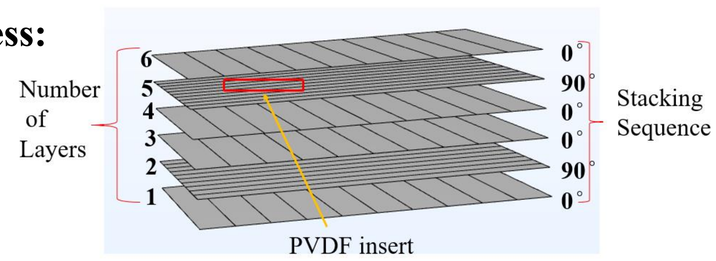


• To create new aeronautical structures capable of detecting and monitoring fractures.

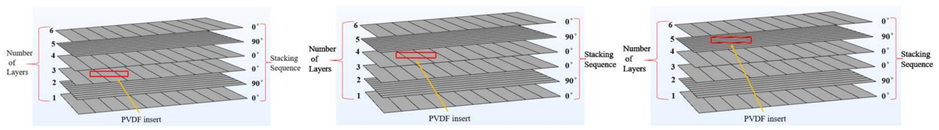
• To investigate the functional properties of the resulting smart materials through vibration tests with magnetic manipulation.

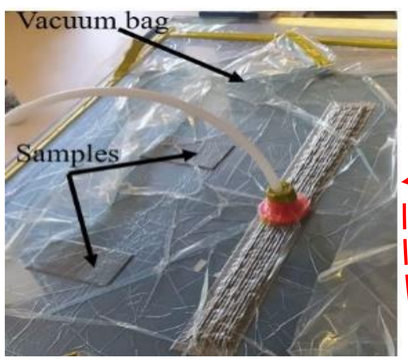
METHODS

- **Sample Fabrication Process:**

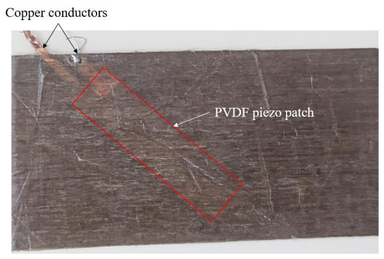


- Sample's lamination scheme.

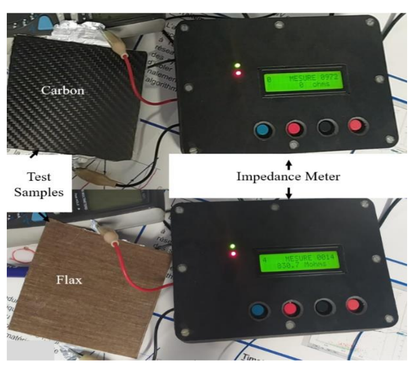




- Consolidation molding process.



- Smart composite structure



- Sample's impedance/conductivity test.

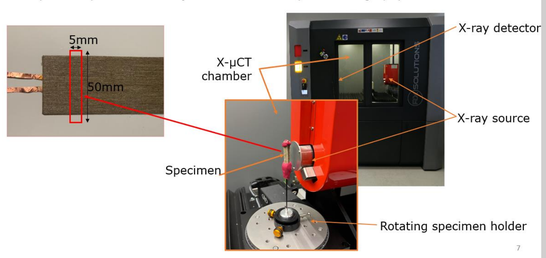
Composite's Fiber Type	Electrical Continuity	Resistance
Carbon	Yes	0 Ω
Flax	No	830.7 MΩ

- Electrical conductivity test results

- **Sample Experimental Tests :**

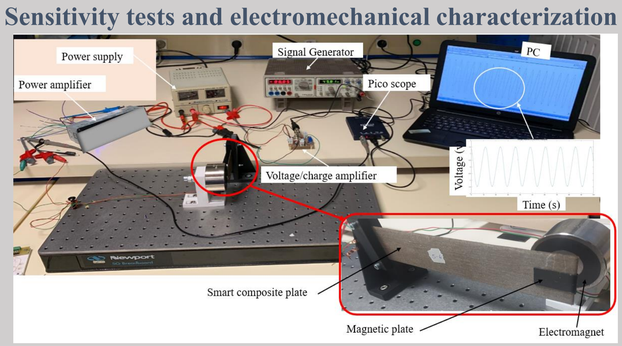
Test for structural integrity

➢ To assess the impact of the embedded PVDF in the structure and the wire adhesion status, a 5mm by 50mm pieces were subjected to micro computed tomography.



- X-ray micro computed tomography

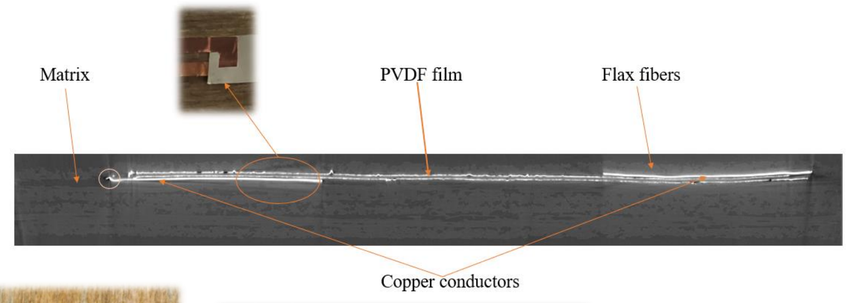
Sensitivity tests and electromechanical characterization



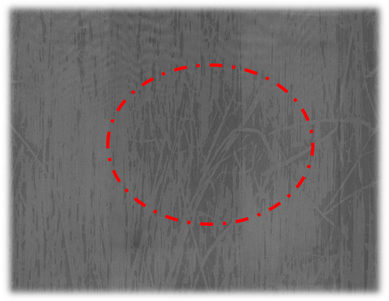
- Vibration tests setup

RESULTS

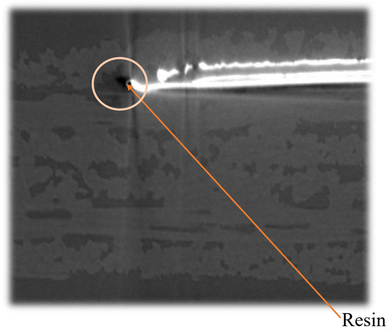
- **Integration's Impact on the Structural Integrity**



• UD - FlaxPreg – with variational density of fibers

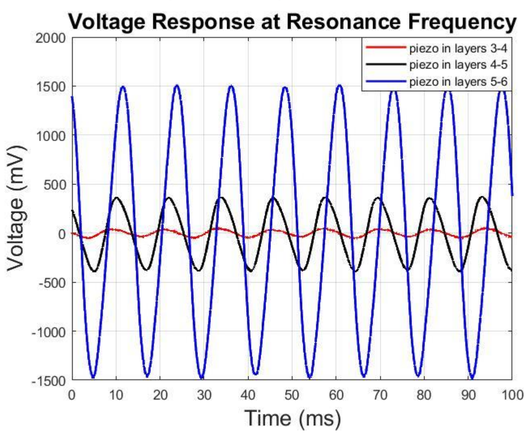


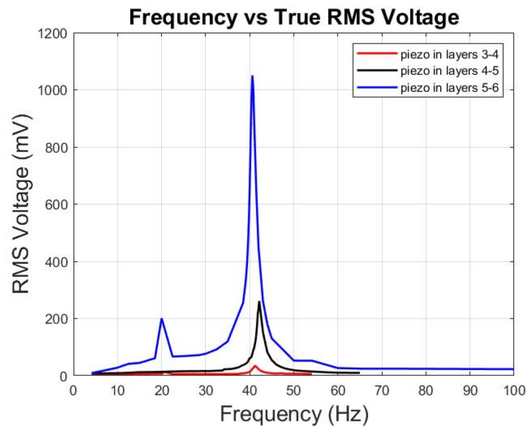
• Defects sustained from the raw material



• Defects due to embedding

- **Sensitivity Analysis**





Composite Number	Number of Layers Stacking sequence $[0/90/0]_s$	Position of Piezo Layer	Pk-Pk Voltage (mV)	RMS Voltage (mV)	Resonance Frequency (Hz)
Sample 1	6	Layers 3-4	108.93	34.67	41.21
Sample 2	6	Layers 4-5	770.30	261.6	42.15
Sample 3	6	Layers 5-6	3017.60	1048	40.60

• The sensitivity test results from dynamic loading of the smart composite laminates. The peak to peak and the true RMS voltages were measured at resonance

CONCLUSIONS

- The selection of appropriate constituent materials plays a critical role in the context of smart composite structures.
- PVDF has proven to be highly beneficial in reducing thickness variation and preventing fiber cutting, making it a suitable material for embedded sensors.
- Dynamic vibration tests have confirmed the feasibility of implementing PVDF in aeronautical structures, establishing its reliability for applications requiring embedded sensors.
- The study's results demonstrate the potential of using pre-impregnated unidirectional flax fiber as the base material for creating new aeronautical structures capable of detecting and monitoring fractures.
- The study's findings provide a foundation for future research on the development of smart composite materials with enhanced performance and reliability.

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