A Hybrid Experimental-Numerical Framework to Improve the Repair Quality of Wind Turbine Blades by Cold Spray

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Research Overview

- The repair process using cold spray technology is the main focus of this project, which investigates the deposition of thermoplastic coatings on fiber reinforced polymer composites. This project uses multiscale finite element analysis (FEA) to study the bonding mechanism.
- Through this cutting-edge technology, mechanical properties of damaged composites are significantly recovered.
- Cold spray technology is an efficient method for repairing damaged composites due to its ability to produce thick coatings with strong adhesion and stiffness.

Materials and Methods

Materials

Base Materials: i) Glass fiber reinforced epoxy (GFRP)
(Materials of the wind turbine blade)
ii) Carbon fiber reinforced epoxy (CFRP)

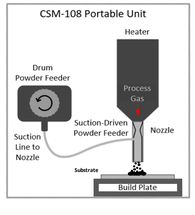
Micro Particle Materials for Cold Spray:
i) Thermoplastic Polymer (Nylon 6)

Velocity Window for Successful Deposition by Cold Spray

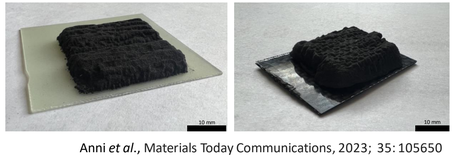
Impact Velocity (m/s)	350	359	382	392	401	409
Successful Deposition	✗	✗	✗	✗	✓	✓

Critical Impact velocity: **400 m/s**

Cold Spray Setup:



- Cold spray deposition of polymeric particles on CFRP and GFRP substrates at 409 m/s



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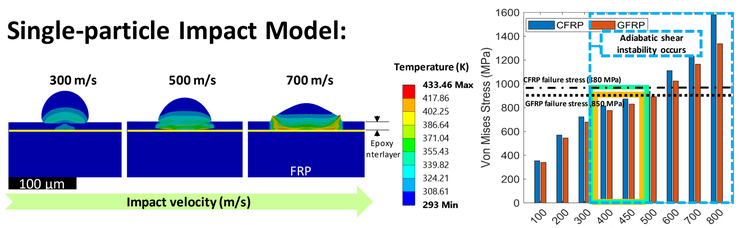
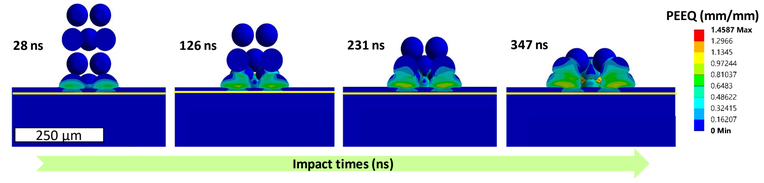
Numerical Framework

Adiabatic Shear Instability & Von Mises Stresses: Temperature contour maps and Von Mises stresses developed in substrates for the single particle impact model at different impact velocities:

Single-particle Impact Model:



Deposition Morphology of Multi-particle Impact Model:

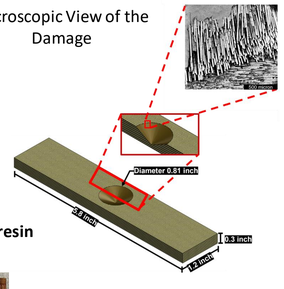


Experimental Work (Damage Repair)

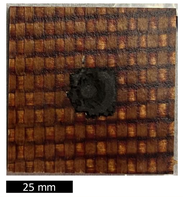
Damaged Turbine Blade Materials Repaired with Cold Spray:

- Damage prepared on the sample by conventional drilling process

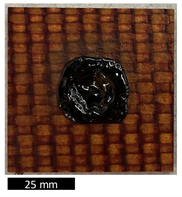
Microscopic View of the Damage



Repaired With Nylon 6 (thermoplastic powder)



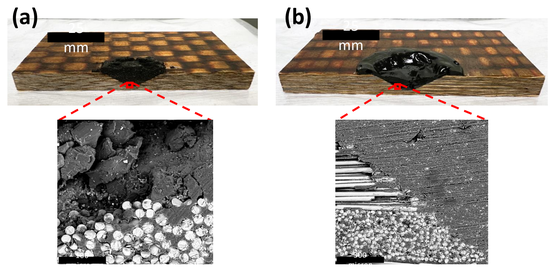
Repaired With Polyester resin (thermoset powder)



Results and Discussions

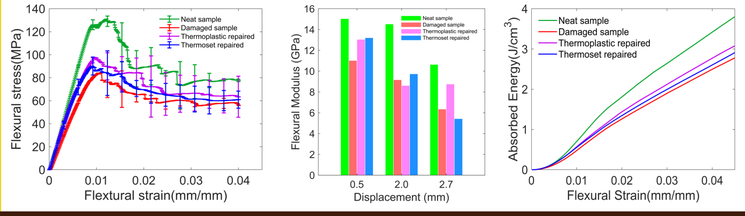
Microstructural Observation of Repaired Damage:

Cross sectional image of cold spray repaired damaged GFRP composite with polyester epoxy resin thermoset powders (a), and nylon 6 thermoplastic powder (b)



Mechanical Response:

The experimental findings of quasi-static three-point bend tests on the neat, damaged and repaired samples with thermoplastic and thermoset polymer.



Summary

- Cold spray is a promising technique for onsite repair of damaged wind turbine blades.
- Cold spraying of thermoplastic polymer repairs damaged composites with greater bending resistance compared to thermoset polymer spray.

Acknowledgements

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