MULTIFUNCTIONAL SHAPE MEMORY ALLOY TUFTED COMPOSITES

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Objectives and outline

- 1. Manufacturing of SMA tufted composites
- 2. Characterization:
 - I. Fracture toughness
 - II. Microscopic observations on the specimen
- 3. Incorporation of SMA functionalities:
 - . Crack closure
 - II. SMA resistance measurement
 - III. Defect detection by thermography
- 4. Conclusion and future work



1. Manufacturing of SMA tufted composites









2.i Fracture toughness (Experiment)









- » Cohesive zone model
 - Composite
 - Tuft





» Extraction of traction-separation law of the tufts







Т

 $\delta\sigma/\delta T$

Stress versus temperature gradient for loading



GPa

%

MPa

MPa

MPa

MPa

°C

MPa/°C

45

12





» ASTM D5528-01

Table 1

Elastic properties of the composite material. E and G are the elastic and shear modulus; ν is the Poisson's ratio. The subscripts 1, 2, 3 are the in-plane, transverse and out-of-plane directions in a ply-based coordinate system of fibres, respectively.

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Property	Value	Units
E ₁₁	60,000	MPa
E22	60,000	MPa
E33	9,500	MPa
$v_{12} = v_{13}$	0.3	MPa
V ₂₃	0.3	MPa
$G_{12} = G_{13}$	3,900	MPa
G ₂₃	2,800	MPa

Table 2

Cohesive material input properties for the composite.

Property	Definition	Value	Units
K ₁₁	Penalty stiffness	$1 imes 10^5$	MPa
K ₂₂	Penalty stiffness	$1 imes 10^5$	MPa
K33	Penalty stiffness	1×10^5	MPa
τ_{33}	Transverse strength	50	MPa
$\tau_{13} = \tau_{23}$	Shear strength	40	MPa
G_{Ic}	Mode I fracture toughness	0.5	kJ/mm ²
$G_{IIc} = G_{IIIc}$	Mode II & III fracture toughness	0.8	kJ/mm ²



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2.ii Microscopic observations on the specimen









3.i Crack closure





3.ii SMA resistance measurement











- » FLIR A6780 MWIR
- » 3MP resolution
- \gg 3.0 5.0 µm spectral range



» Undamaged specimen





» Specimen with delamination









Heating step



Cooling step



» Image processing by PCA



3. Conclusion and future work



- » SMA as out of plane reinforcement
 - Improvement in delamination resistance
 - Useful as heat generator for delamination detection using thermography
 - Exhibits shape memory properties when heated to close delamination
 - · Shows potential as a 'strain sensor'
- » Future work
 - Performance evaluation on a structural component, e.g. T-joints
 - Quantification of the SMA 'clamping' force





Crosshead Displacement (mm)