Minimising Forming Defects in the Diaphragm Forming Process by Reducing Interply slip Resistance

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Composite Forming

- High lay-up speed
- Simple material deposition process
- Low cost for large-sized preforms
- Only suitable for simple geometries

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Composite Forming

High quality forming

Low quality forming

Forming complex shapes

Out-of-plane shear + In-plane shear

Sjölander, Composites Part A, 81, 2016, 41-51

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Forming Quality Improvement

Conventional method

- **Forming temperature**
- **Forming speed**
- **Resin tackiness**
- **Interply shear stress**
- **High energy consumption**
- **Long process time**

Interply lubrication method

- Minimising forming defects in the diaphragm forming process by reducing interply slip resistance.
Forming Quality Improvement

**Conventional method**

- **Forming temperature**
- **Resin tackiness**
- **High energy consumption**
- **Forming speed**
- **Interply shear stress**
- **Long process time**
- **Viscoelastic effect**

- **Particle toughener**
- **Non-woven veils**

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Experimental Methods

**Interply slip test**

- **Force**
- **Fixed ply**
- **Lubricant**
- **Pressure**
- **Mid ply**

**Diaphragm forming**

- **Single diaphragm forming rig**
- **Recess region**

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Interply Slip Test

- **Material:**
  CF/epoxy prepreg (IM7/8552)
- **Lubrication material:**
  polyester veils
- **Ply direction:**
  0° against 0°
- **Debulking simulation:**
  15 min., 1atm, 25°C
- **Test:**
  1mm/min without compaction

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Diaphragm Forming Test

Stacking sequence: 
\([-45^\circ/90^\circ/40^\circ/0^\circ]\)_s

60°C forming
Without lubricant

30°C forming
With veils lubricant

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Conclusion

**Interply lubrication method**
- Can significantly reduce the interply slip resistance
- Can achieve high-quality forming even at low temperature
  - High energy efficiency, high production rate
- Has the potential to improve forming quality of complex geometry composites

**Future work**
- Investigation on the effect of interply lubricant on structural performance
- Application to the drape forming of the preform manufactured by automated lay-up processes
Acknowledgement

Thank you for your attention