Development of hybrid compounds for compression moulding for structural composites

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Electric vehicle challenges

- Deploying an electric vehicle fleet with a minimal carbon footprint requires introducing lightweight low-cost recyclable composites with outstanding mechanical performance.
- Requirements include: impact loads, tensile loads, scalable manufacture, thermal resistance, etc.

Fig. 1. Crash test of RIMAC concept 2

Hybrid short fibre

Proof of concept: An interply hybrid composite with short fibre core and outer uni-directional (UD) plies.

Method: Short fibre injection moulding PEEK/carbon fibre composite was combined with UD PEEK/carbon fibre composite through a 2-step compression moulding process.

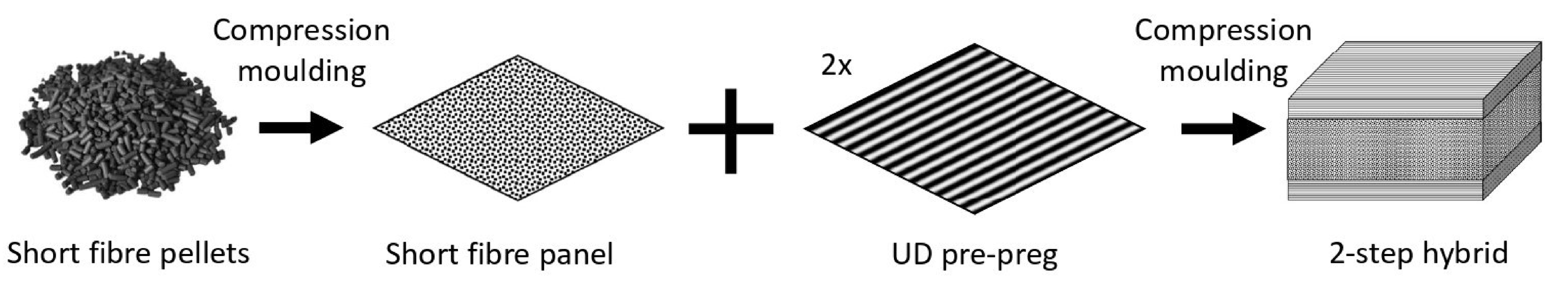

Fig. 2. 2-step manufacturing process used to produce hybrid composite

Results:

- Large increase in tensile stiffness (131%), strength (165%) and flexural stiffness (330%) when comparing the short fibre to hybrid composite

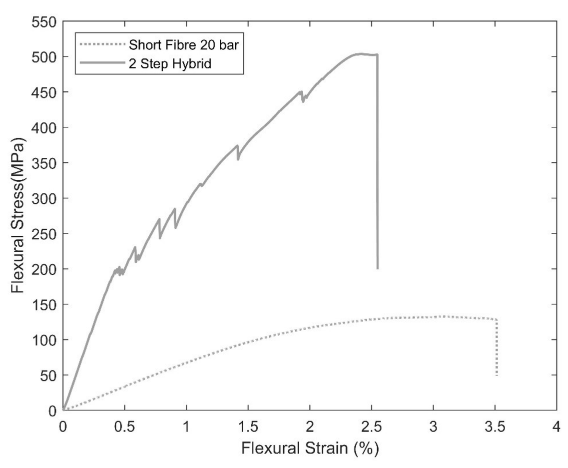

Fig. 2. Stress-strain comparison of flexural performance of short fibre and hybrid composites

- FEA determine the influence of the stochastic microstructure on the mechanical properties. The model predicted the heterogeneous strain fields.

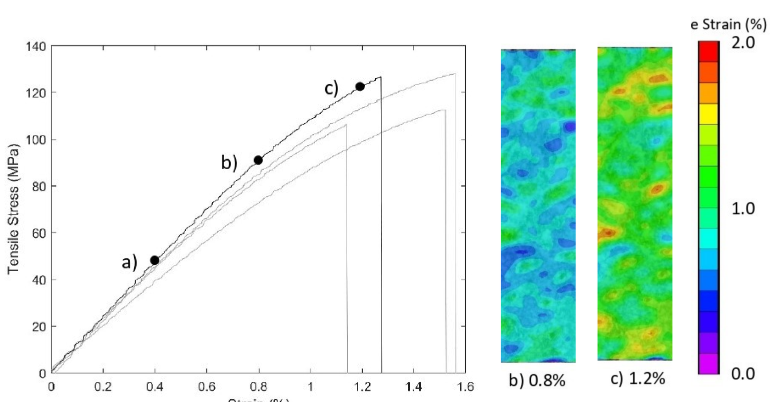

Fig. 3. Experimental tensile stress-strain with DIC contour plots

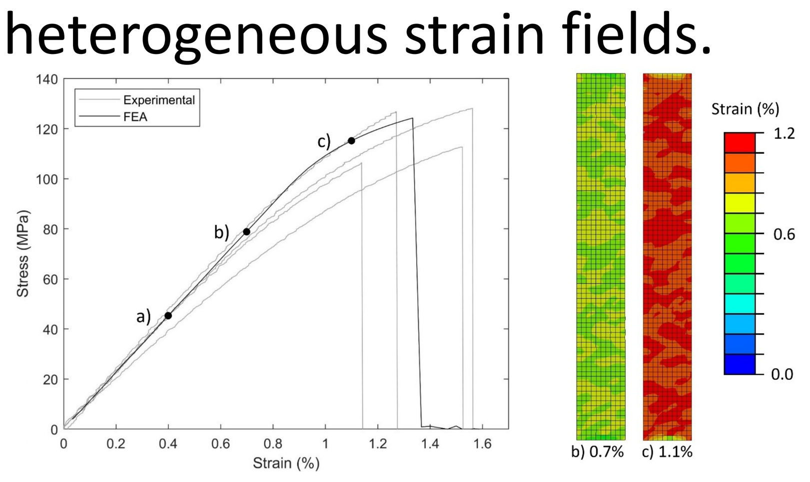

Fig. 4. FEA tensile stress-strain prediction stochastic contour plots

- Gaussian distributions computed from 75 simulations predicted the experimental scattering.

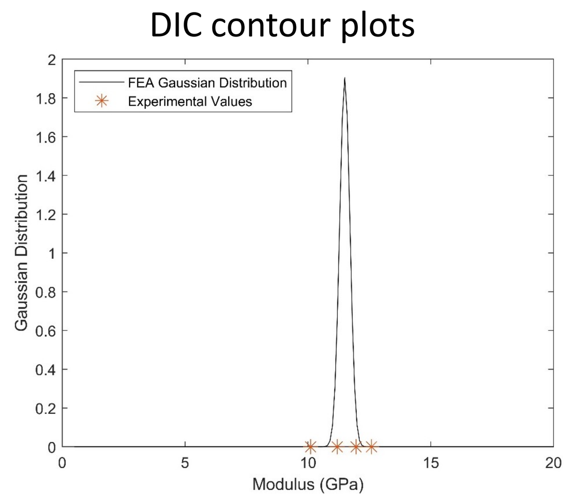

Fig. 5 Gaussian distribution of FEA predicted composite tensile modulus of the short fibre material

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References:
[1] IDI Composites (2023). [online] https://www.idicomposites.com/smc-bmc-overview.php [accessed 21 Sep 2023].

Drawbacks of Short fibre composites

- Discontinuous fibre composites are a suitable candidate for structural components, but further research is needed to develop:
  - Large scale manufacturing methods
  - Improved mechanical properties
- **The hybridisation** of different materials can improve structural performance at a relatively low cost by combining different fibre formats or architectures.

Hybrid Sheet Moulding Compound

Proof of concept: Interply Carbon/Glass SMCs with 60% fibre volume fraction and randomly distributed fibres of 25 mm length.

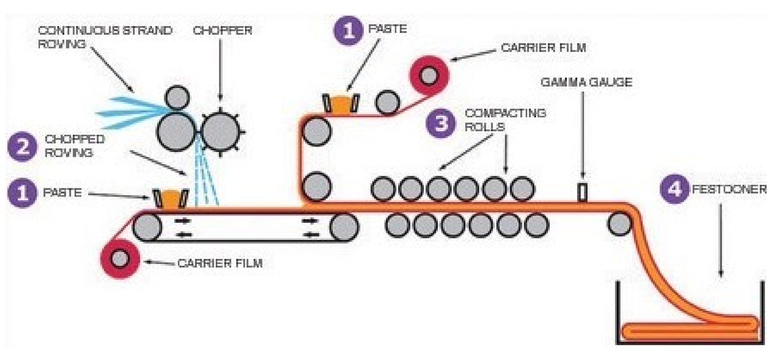

Fig. 6. SMC manufacturing process [1]

Results:

- In tension, the carbon showed the highest properties with the glass lowest and the hybrid an intermediate level.

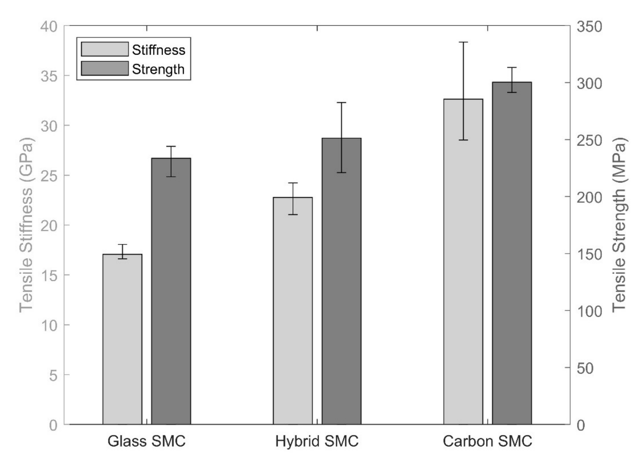

Fig. 7. Tensile properties of SMC materials

- Carbon laminate presented the highest energy absorption capacity when subjected to low-velocity impact.
- The glass SMC showed the best impact tolerance with the smallest drop in Compression After Impact Force.

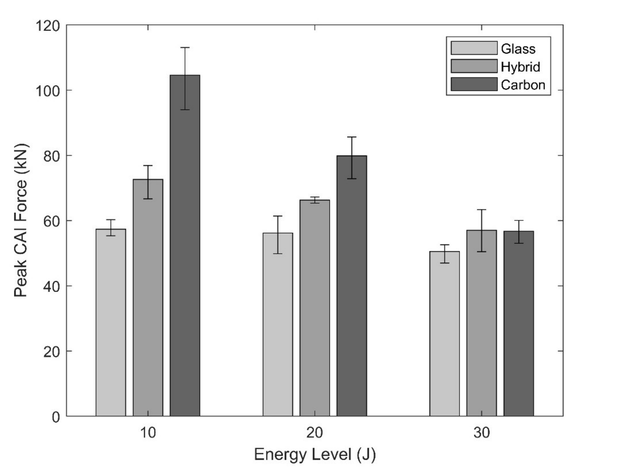

Fig. 8. Peak CAI force measure after each impact energy level

- All samples showed clear cracks propagation from the impact area during CAI tests.
- Glass fibres have higher strain to failure resulting in improved impact performance.
- Outer glass layers protect carbon fibres in the hybrid.

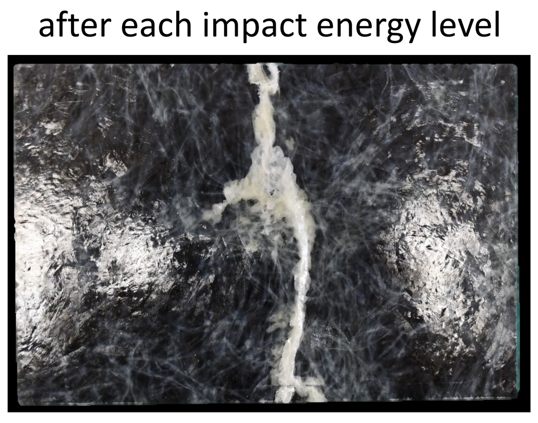

Fig. 9. Hybrid material forcing CAI testing

Conclusions

- Hybridisation strategies can be implemented at an industrial level to produce composite structures with superior mechanical performance and a reduced cost. Modelling approaches can quantify the uncertainty in mechanical performance due to stochastic microstructure

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