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Impact Behaviour of Composite Structures Filled with Shear Thickening Fluid

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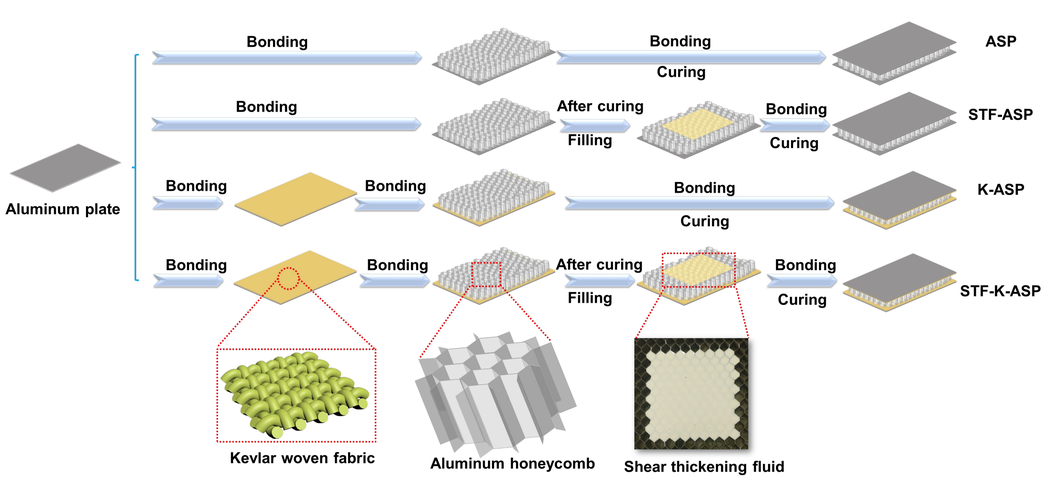
Introduction

- A sandwich panel with a honeycomb core has been widely used as a structural component in the aerospace, automobile and marine industries due to its excellent flexural strength/stiffness and ease of manufacture. However, a sandwich panel has proven to be particularly vulnerable to low-velocity impact.
- Shear thickening fluid (STF) is a non-Newtonian fluid. STF exhibits solid-like behaviour under impact with a rapid increase in both the impact force and energy absorption. Hence, STF has attracted growing interests from both academia and industry.
- This study aims to develop a high impact-resistant hybrid aluminium sandwich panel (ASP) with aluminium/Kevlar fabric facings and an aluminium honeycomb core filled with an STF.

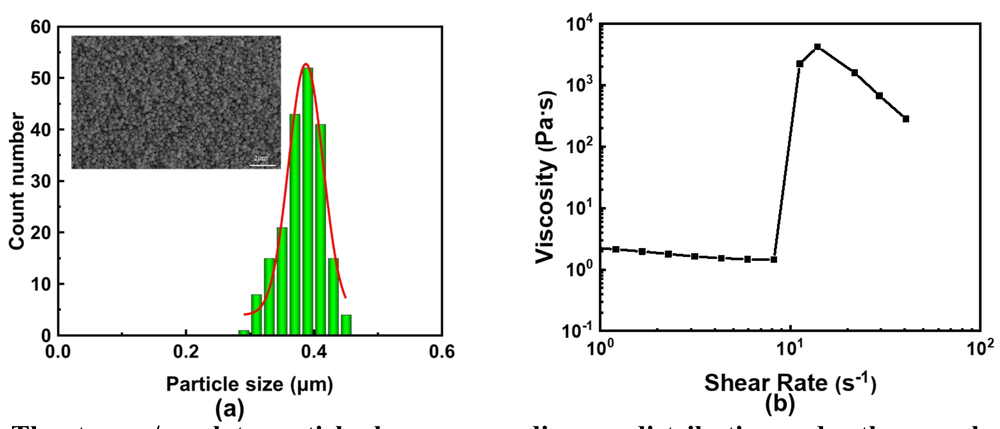
Results & Discussion

Fabrication of ASPs



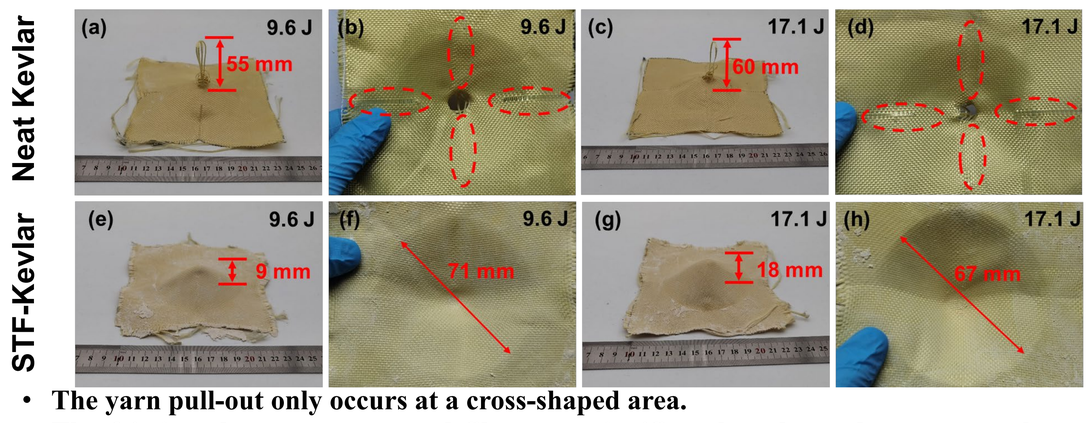
Schematic preparation processes of four ASPs

Microstructure and rheological behaviour of STF



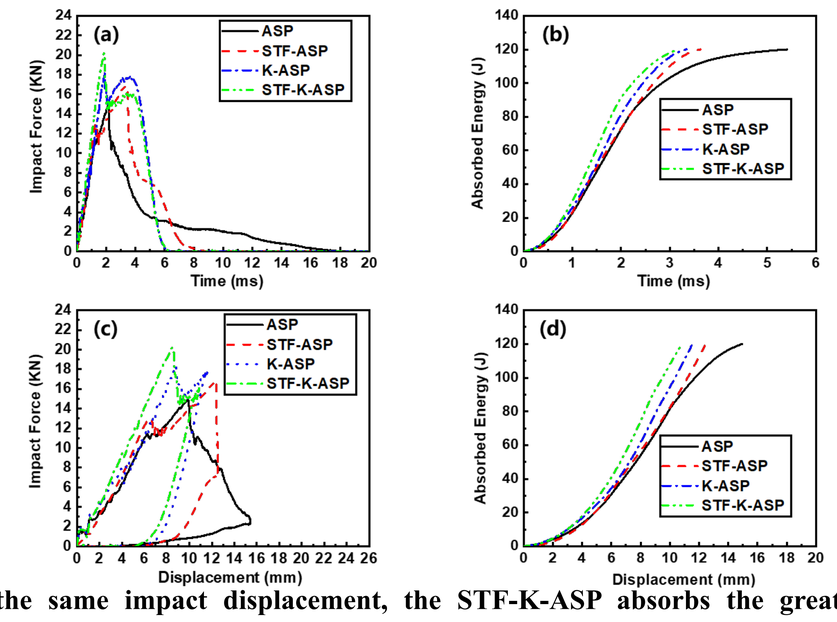
- The styrene/acrylate particles have a monodisperse distribution and rather rough surfaces.
- The viscosity of the STF rapidly increases above a critical shear rate.

Low-velocity impact behaviour of STF-Kevlar fabrics



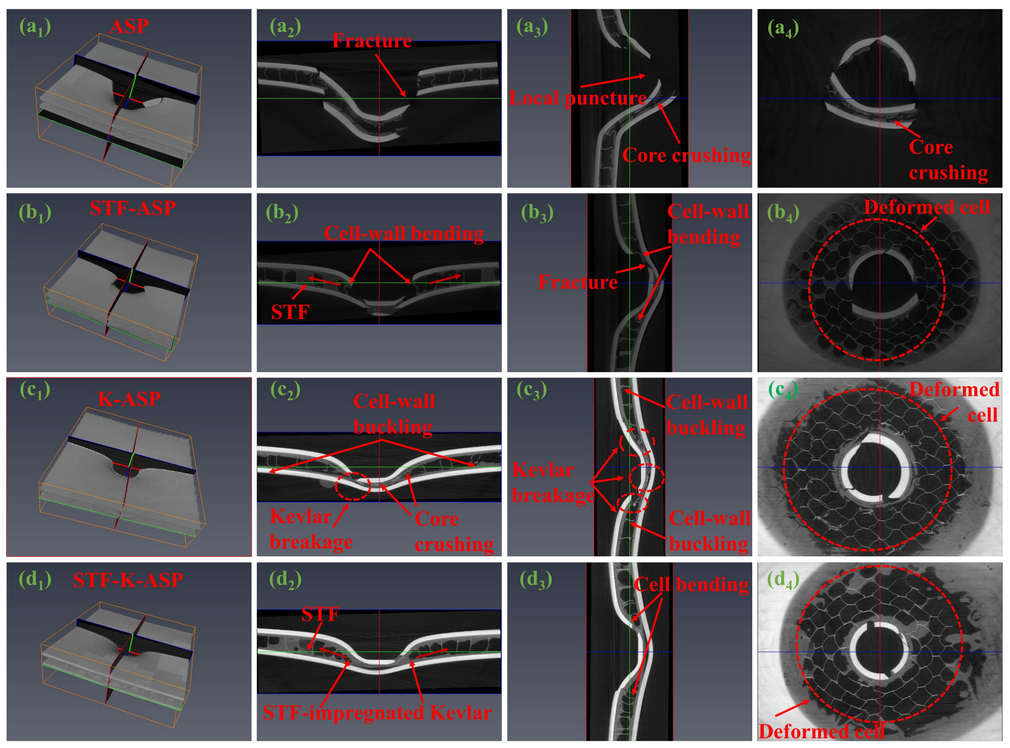
- The yarn pull-out only occurs at a cross-shaped area.
- The frictions between yarns and fibres are significantly enhanced to prevent the relative slipping.

Low-velocity impact behaviour of hybrid ASP



- With the same impact displacement, the STF-K-ASP absorbs the greatest impact energy.
- The addition of the STF and Kevlar fabrics greatly improves the impact resistance of ASP and decreases the maximum impact displacement.

Damage characterisation



- The impregnation of STF increases the rigidity of the Kevlar fabric. Therefore, the STF-K-ASP has the highest supporting stiffness.
- The STF-K-ASP has the highest impact resistance and the failure pattern alters, from local puncture of ASP to global energy absorption.

Conclusion

- The impregnation of STF restricted the mobility of Kevlar yarns and fibres as well as increased the rigidity of the Kevlar fabrics under impact, and the yarn pull-out failure of the Kevlar fabrics was effectively prevented with the addition of STF.
- The dominant failure mode of pure ASPs under impact was local puncture, whereas global energy absorption was achieved after the addition of Kevlar fabrics and STF.
- Micro-CT results revealed that the high impact resistance of hybrid ASP was attributed to the synergistic effect of three factors: STF's high energy absorption, the increased in-plane stiffness of Kevlar fabrics caused by STF impregnation and the confinement of aluminium cells on STF.