Energy Dissipation Mechanism and Ballistic Characteristic Optimization in Foam Sandwich Panels Against Spherical Projectile Impact

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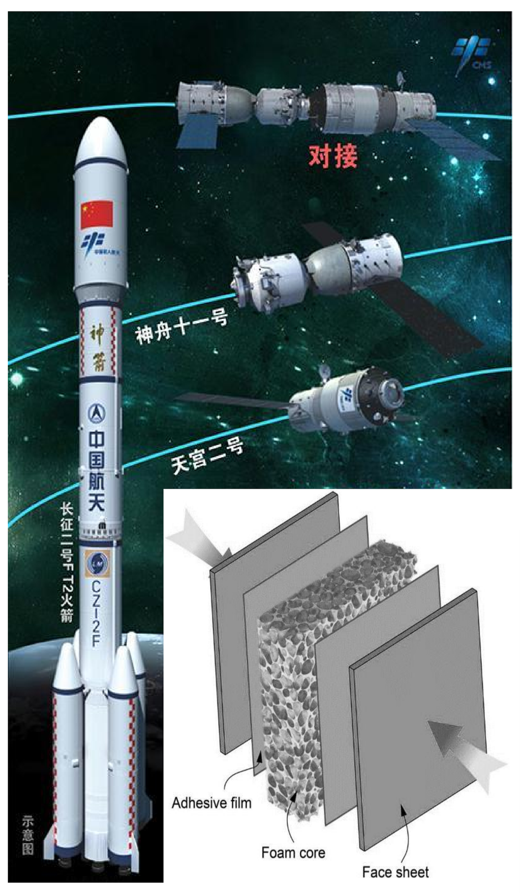
Introduction

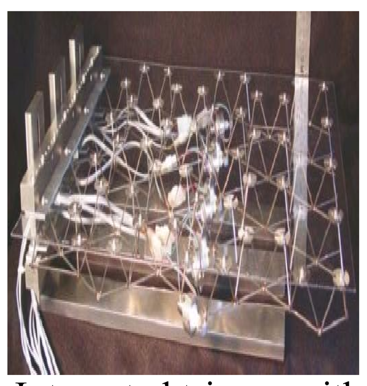
As lightweight, designable composite structures, the sandwich panels had excellent mechanical properties and energy dissipation, and thus could be used as a protective structure or sacrificial shield in aeronautics, marine and automotive industries, etc. With further study of sandwich panels, it was observed that the face sheet and core layer had different effects on the impact behavior and energy dissipation, which would greatly affect the protective performance of sandwich panels. This indicated that the sandwich panel had more design choices.

➢ *application*



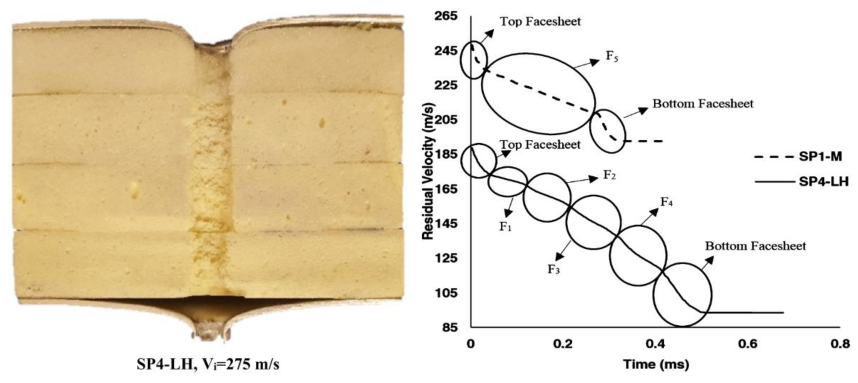
Sandwich structure using in aerospace

Navigation with sandwich structure

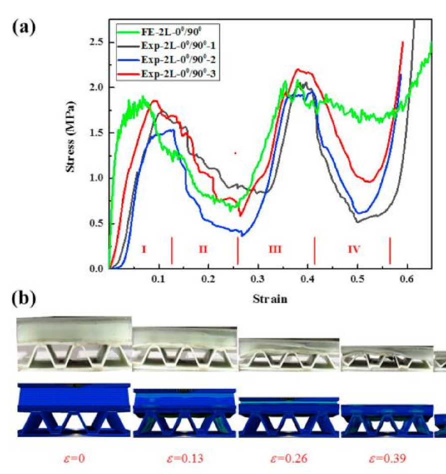


Integrated trigger with sandwich structure

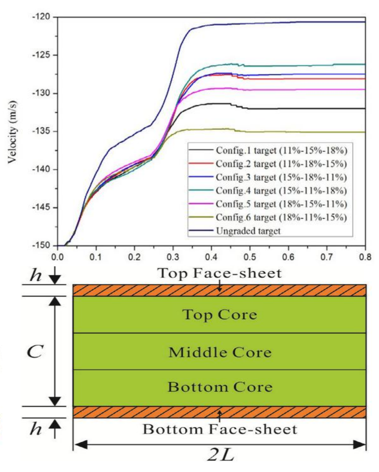
➢ *previous studies*



M. Abbasi et al., Aerosp Sci Technol (2020)



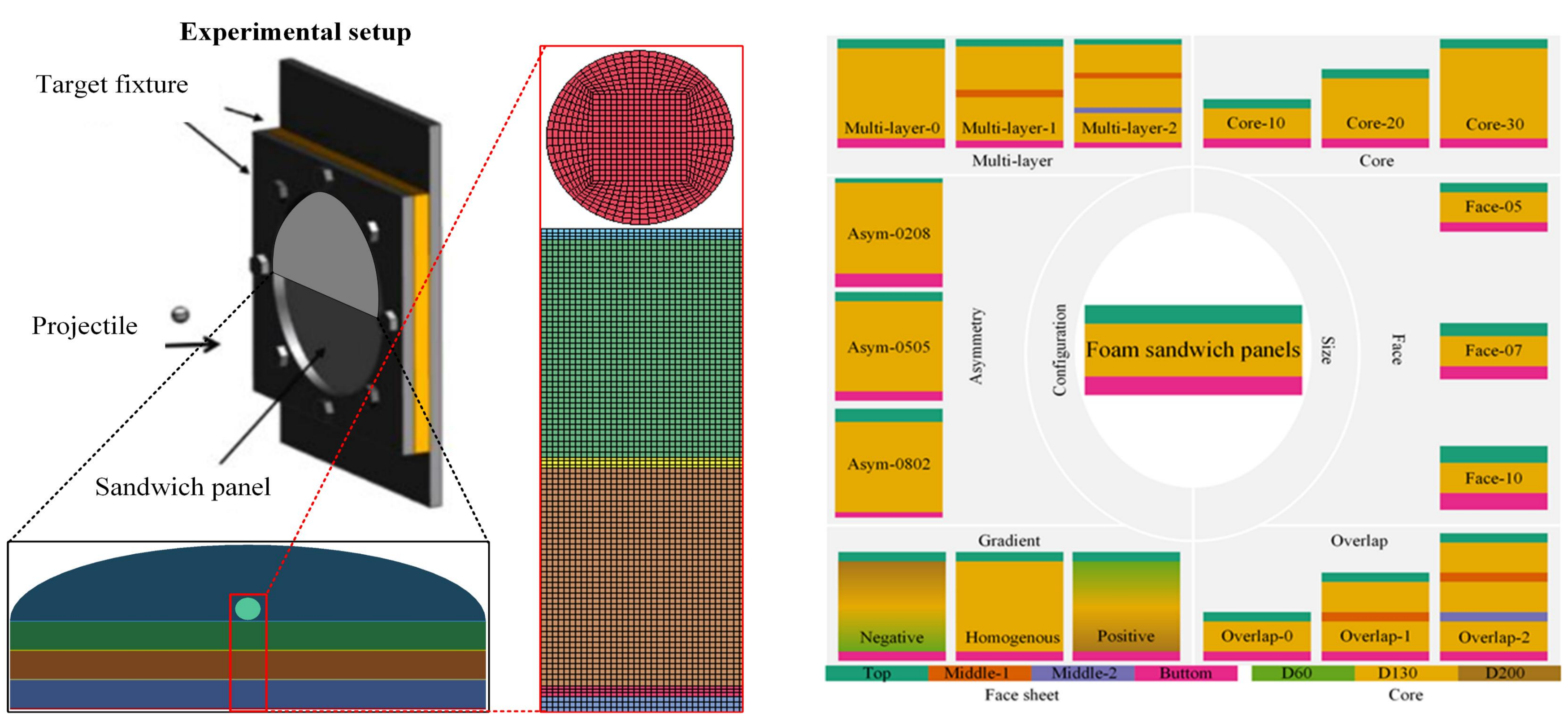
L. Chen et al., Compos Part B-Eng (2020)



L. Jing et al., Compos struct (2020)

Simulation model

The foam sandwich panel (FSP) were modeled using the explicit non-linear finite element method

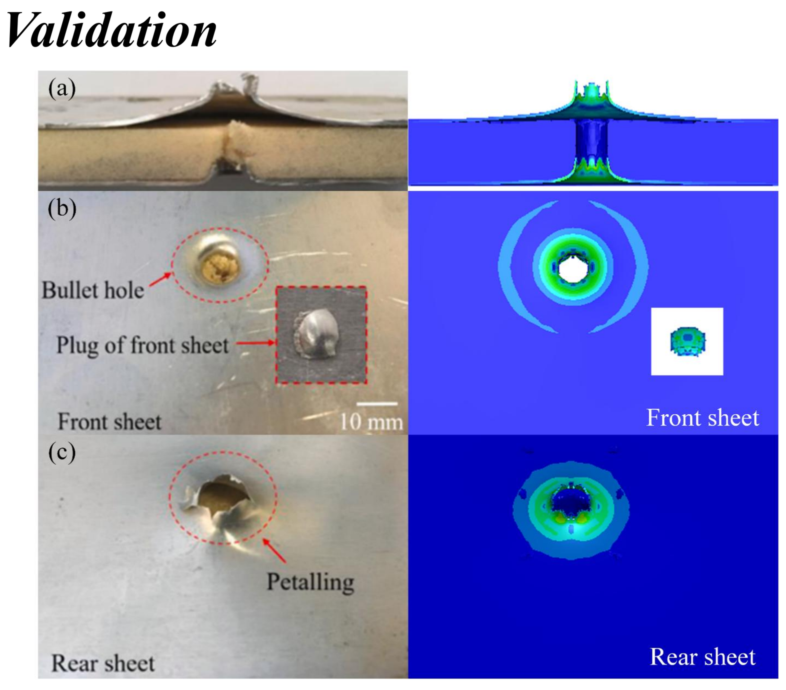


Finite element model　Interior meshed regions　Schematic diagram

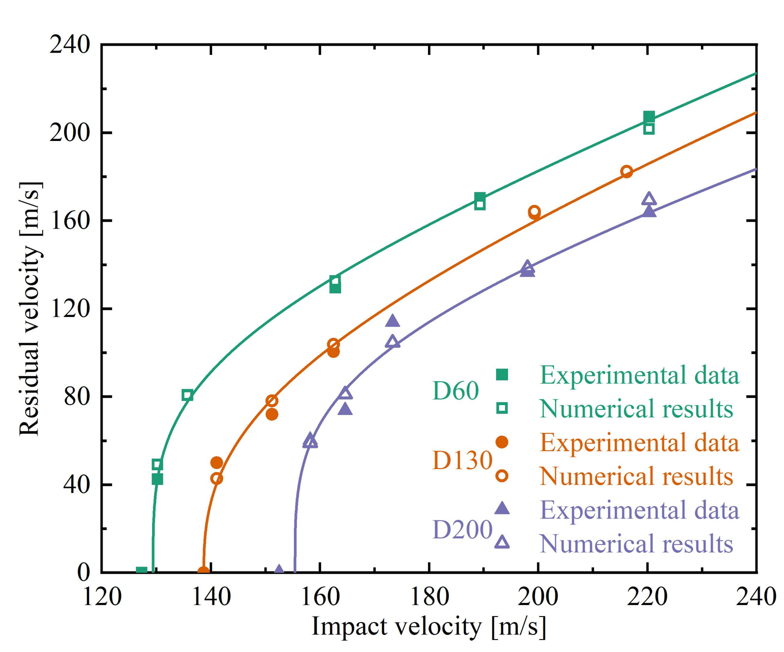
➢*Simulation*

- ✓ **Tiebreak algorithm** between face sheet and core;
- ✓ **Eroding algorithm** between panel and projectile;
- ✓ **C3D8R** for face sheets, core, and projectile;
- ✓ Element size:0.15 mm(refined at center)-2 mm
- ✓ Impact velocity:**100m/s-1100m/s**

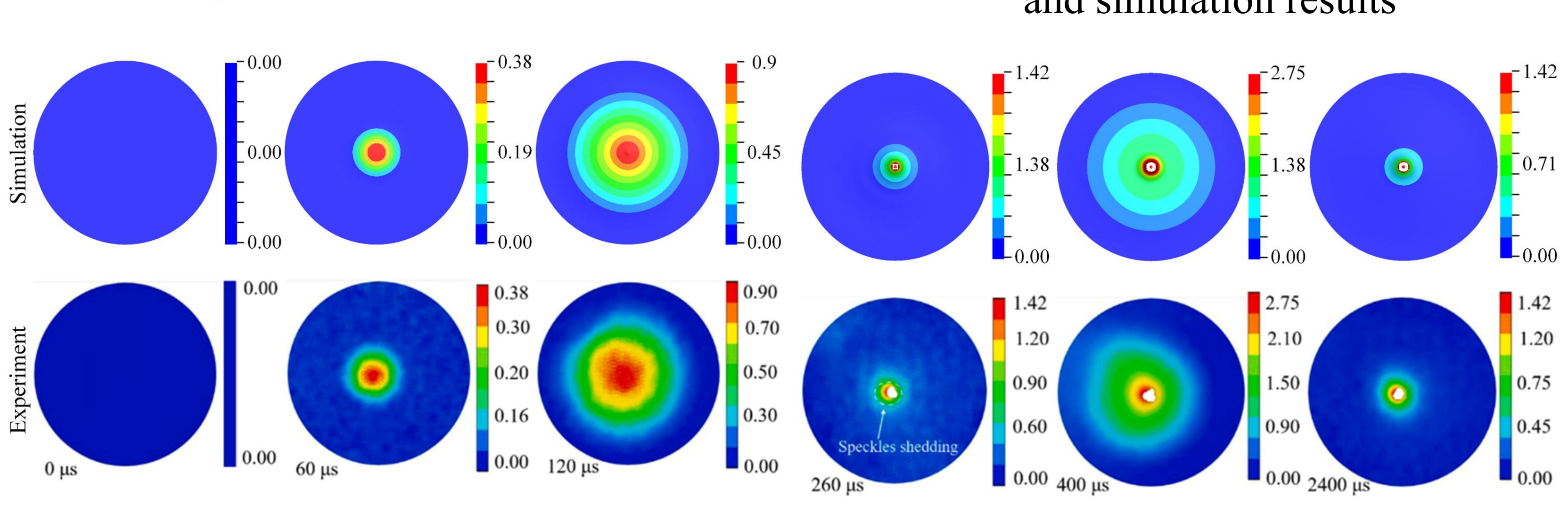
➢*Validation*



Comparison of failure mode

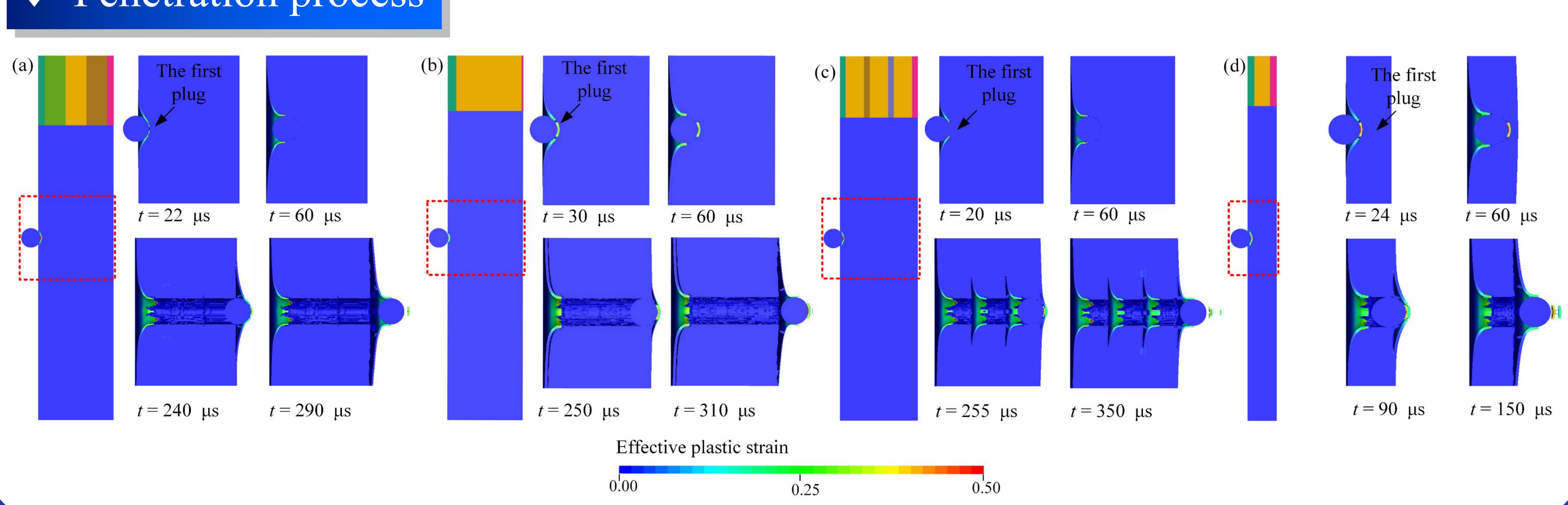


Comparison of experiment and simulation results

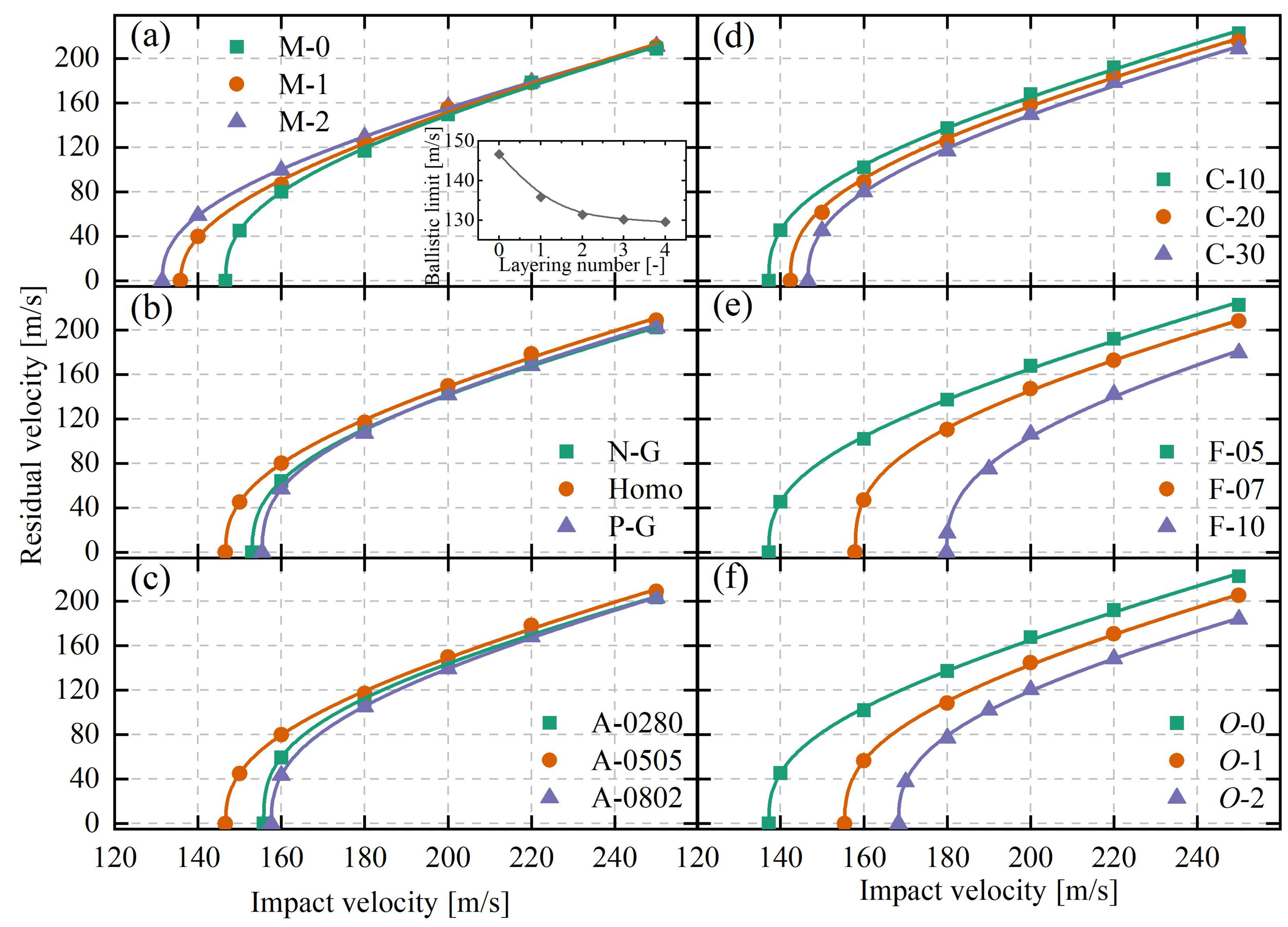


Dynamic response of rear face sheet of sandwich panels

Penetration process

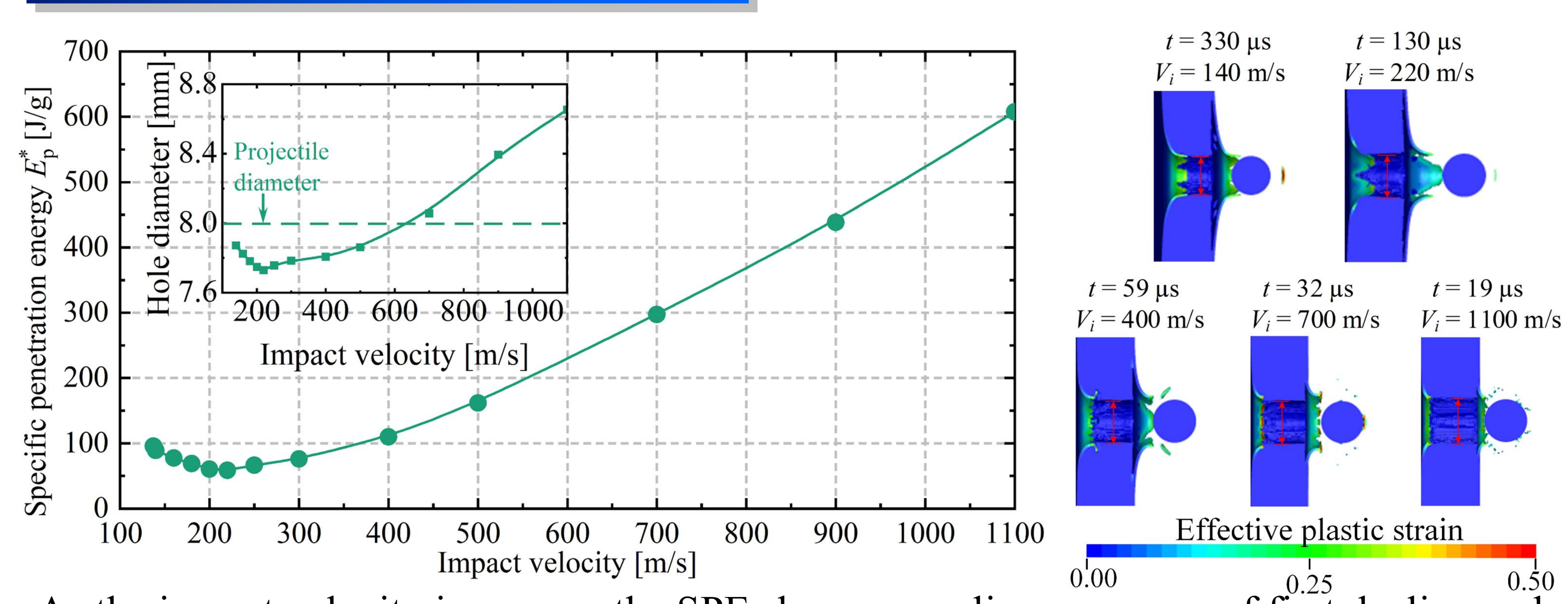


Ballistic resistance of foam sandwich panels



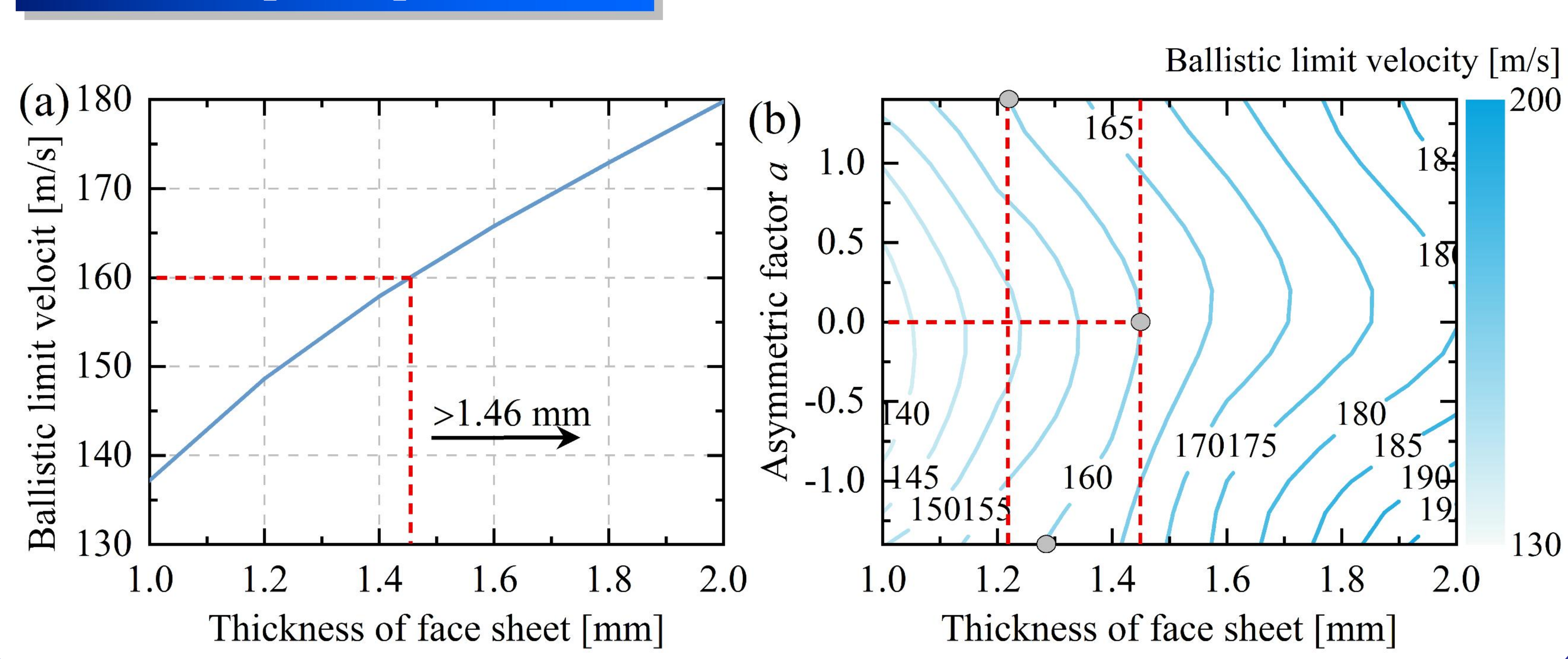
Based on the above observations, the face sheet optimizations (asymmetric face sheet) perform better than the core (gradient core) in the structural configuration in terms of ballistic performance and multi-layer design should be avoided. The increase of the t_f shows the best ballistic limit increment.

Specific penetration energy



As the impact velocity increases, the SPE shows a nonlinear process of first decline and then rises monotonically, and appears a minimum value at the impact velocity is around 220 m/s. The variation of damage modes and the hole diameter of the FSP with impact velocity confirms the variation of SPE.

Anti-impact optimization



Conclusions

- ➢ The FSP system exhibits a significant configuration dependence, whose ballistic performance ranking is: asymmetric face sheet>gradient core>multi-layer.
- ➢ The face sheet's thickness and distribution are decisive factors in the ballistic characteristic and energy dissipation of the FSP. With increasing t_f, the BLV and SPE of the FSP are significantly enhanced due to the synchronous enhancement mechanism of energy dissipation. In the same total thickness of face sheets, the ballistic performance of the FSP can be optimized by tuning the asymmetric factor.
- ➢ More layers, a stiffer foam core behind the front face sheet, and a thinner front face sheet will result in a more concentrated perforation behavior of the FSP around the impact site. The deformation pattern in face sheets is insensitive to both t_c and n_o.
- ➢ With the increase in impact velocity, the SPE of the FSP shows a nonlinear process characterized by an initial decrease followed by a continuous rise, and appears a minimum value at the impact velocity is around 220 m/s.

Acknowledgments

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