GPU-accelerated numerical modeling of hypervelocity impacts on CFRP using SPH

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Abstract

CFRPs (Carbon fiber reinforced plastics), as a kind of fiber-reinforced plastic, present various advantages over traditional materials regarding the specific strength, stiffness, and corrosion resistance. For this reason, CFRPs are widely used in the space industry, like satellites and space stations, which are easily subjected to the HVIs (hypervelocity impacts) threatened by space debris. In order to mitigate the damage of HVIs and protect the spatial structures, it is necessary to predict the HVI process on CFRPs. Smoothed particle hydrodynamics (SPH) method, as a mesh-free particle-based method, has been widely applied for modeling HVI problems due to its special advantages when modeling problems with large deformations [1]. Also, SPH is attractive for parallel computing, benefiting from its particle-based nature [2]. Considering such advantages, we present a GPU-accelerated HVI model for composite CFRPs structures based on the SPH method in this talk. Firstly, a metallic penetration problem is studied as a test example to validate the numerical model. The simulation results agreed well with the published data, and nearly 350 times of speed-up (GPU vs CPU) has been achieved. Then, the process of a bullet penetrating a CFRP laminate has been investigated and the corresponding physical behaviors, such as the orthotropic property, shock response, and delamination have been well captured as well. Finally, the HVI problem of the Whipple bumper shield, one of the typical shields for spatial structures, has been investigated considering the secondary debris cloud and the damage effects. Our studies have shown that the GPU-accelerated SPH model allows us to investigate three-dimensional HVI problems with complex composite structures accurately and efficiently.

Keywords: Hypervelocity impact (HVI); Carbon fiber reinforced plastics (CFRPs); Smoothed particle hydrodynamics (SPH); GPU parallelization.

References

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