Low-velocity impact response of composite sandwich panel with Al foam core

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Abstract:

The composite sandwich structure with metal foam core is being widely used in aerospace, automotive and construction en2gineering fields due to its excellent properties, such as low density, sound absorption, noise reduction, good impact resistance, multifunction, etc.

The composite sandwich structures are often subjected to low velocity impact in practical applications. It is very important to investigate the mechanical properties of composite sandwich structures under low velocity impact. In this paper, the theoretical analysis, numerical simulation and experimental study on the low velocity impact of composite sandwich panel with aluminum foam core is carried out from five aspects: core thickness, impact energy, stacking sequence, impact speed and punch size. A kind of commercially available closed-cell Al foam is adopted. The skin used in this article consists of S2-glass/epoxy prepreg with high specific strength and stiffness. The fiber areal weight was 254 g/m^2 and the nominal resin content was 54 wt%. The upper and lower skins consist of five plies each with different stacking sequence [45/-45/0/-45/45]. The face sheets were bonded to the core with epoxy resin adhesive. Impact tests were conducted using an instrumented impact testing system, which consists of a drop tower equipped with an impactor and a variable crosshead weight arrangement, a high speed data acquisition system, and a load transducer mounted in the impactor. The specific research contents are as follows.

Firstly, the low velocity impact properties of glass fiber reinforced composite sandwich panel with aluminum foam core are studied. The effects of different core thickness and impact energy on the failure mode, energy absorption capacity, energy absorption efficiency and maximum contact load of composite sandwich panels were studied by means of drop hammer impact test.

Secondly, the finite element analysis model is established, and the finite element model is proved to have mesh convergence. The validity of the finite element model is

verified by comparing the contact force displacement response curve, the absorbed energy and the failure mode to the experiments.

Finally, the finite element model is used to simulate the low velocity impact performance of sandwich panels with different impact velocity, different layers of the composite material and different punch sizes.

Some important research results are obtained by the theoretical analysis, numerical simulation and experimental.

The deformation and failure of the sandwich panels are roughly confined to the area underneath the indenter and the material outside the contact area seems to be intact. The maximum contact force, energy absorption efficiency and bending stiffness of sandwich plate increases with the increase of the thickness of the core. The elastic stiffness of sandwich plate is decided by the bending stiffness and contact stiffness under the low-velocity impact.

The contact force of sandwich panel increases gradually with the increase of impact energy. After the punch energy is enough to penetrate the sandwich plate, the impact energy will continue to increase, and the peak of the contact force of the sandwich plate will tend to a certain stable value. At this point, the contact force peak of the sandwich plate has nothing to do with the size of the impact energy.

The bearing capacity and energy absorption capacity of sandwich panel increases with the increase of the indenter radius, but the initial elastic stiffness of sandwich plate is not change. Good agreement was observed between experimental and FEM results over the wide range of core thickness investigated in the study. FEM can be used to predict the impact response of the same sandwich structure under impact with different levels. Failure modes of sandwich panels have the delamination of face sheet, fiber break and delamination of face/core, etc.

Keywords： Low-velocity impact; Composite sandwich plate; Damage evolution criterion; Energy absorption efficiency; Failure mode