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Cellular Geometrical Refinement Studies on Fold Core Composites for Enhanced Impact Resistance

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Abstract

Fold core structures wide-ranging of composite resources have increased attention in the aerospace manufacturing as optimistic sandwich core structure. In this study the performance of a sandwich structure with a folded core made of aluminium is placed in between Glass Fibre Reinforced plastic face sheet under transverse low velocity impact.Study of Impact analysis on the fold core model using LS-DYNA.I n this study response of metal fragments is implemented using simulation of metal target. Transverse low velocity impact analysis is performed for aluminium fold core composite structure. The parameter of projectile and target is considered, which includes diameter, mass, velocity of projectile and thickness, boundary condition of target which will influence the impact process of metal ball. The refining of cellular geometry has done for implementation of impact resistance of fold core composite structure.

Keywords: Aluminium Foldcore, Ls-Dyna, Low velocity, Metal fragments

1. Introduction

Weight decreasing is one of the important design considerations of present engineering and transport structures for aerospace and automotive applications. In this circumstance, the sandwich design standard is playing a key part, as it permits for considerable higher weight-specific bending stiffness related to a uniform structure. A sandwich structure characteristically comprises of two thin and stiff skins, divided by a lightweight cellular core. The main drive of the core is to improve the bending stiffness by splitting the skins, to transmit transverse shear loads and to endure compressive loads normal to the sandwich superficial. In circumstance of transversal impact loads, the core has to provision the skins from local bending and it has to avoid main destruction and dissemination by great energy absorption ability.
However, honeycomb sandwich structures when it comes to the aircraft applications undergo from drawbacks like humidity inclusion in the closed cells which will lead to the increase in structural weight and lessening of mechanical properties and exclusive sporadic manufacturing process. In order to overcome these disabilities in modern years, alternative sandwich core structure have been urbanized by folding to three dimensional open zigzag structures of composite prepreg sheets, which are referred to as Fold core structures. The basic principal

of these Fold core structure is that of flat sheet of a material is folded to a three dimensional structure in an origami like manner without stretching the material.

1.1 Materials used in present study

In our study in order to analyze the diversity between the conventional carbon fibre reinforced plastic (CFRP) and aramid which is used as a core material in the later part of the studies we have come up with the modern aluminium core and glass fibre reinforced plastic as a face sheet which enables us in providing light weight and high strength for withstanding loads.

1.2 Aluminium Core

The aircraft capable of flying at high speeds and high altitudes would have been difficult without the use high strength aluminium alloys in major airframe components such as fuselage and wings. Aluminium is used in greater quantities in the majority of aircraft. Aluminium accounts for 60-80% of the airframe weight of most modern aircraft, helicopters, and space vehicles.

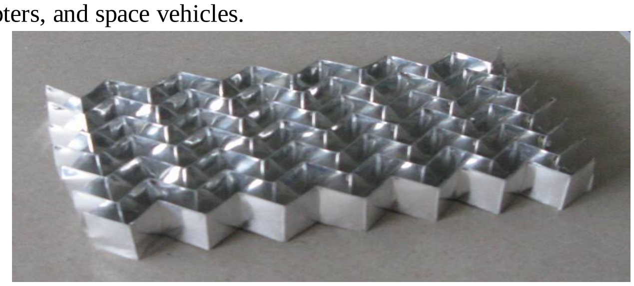


Fig 1: Fold core Structures made from Aluminium

1.3 Fiber-Reinforced Polymer Composite

For Fibre Reinforced Polymers ,the matrix materials must meet some requirements in order to be suitable for the fibre reinforced plastic. The bonding and saturation of matrix material with fibre reinforced plastic must be within suitable period of curing. The chemical bonding of the matrix adhesive should be maximum with fibre reinforced plastic. The matrix should able to cover the reinforcement to prevent from notches and cut which would leads to the reduction of the strength and transmission of loads to the fibres.

2. Literature Review

***Kiran chelluru* [1],** " Finite element simulations of Ballistic impact on metal and composite plates" (2004) the thesis submitted to Department of Mechanical engineering And the faculty graduate school of Wichita University has concluded that, the parameters such as projectile velocity, projectile mass , projectile geometry boundary conditions, target thickness, target yield strength and target failure and friction between the target and projectile has to be considered for ballistic impact simulations.

***S. Heimbs, T. Mehrens, P. Middendorf, M. Maier, A. Schumacher* [2]** , "Numerical Determination of the Nonlinear Effective Mechanical Properties of Folded Core Structures for Aircraft Sandwich Panels" (2007), has explained impact simulations with such kinds of cellular structures necessitate information of the standardised properties, subsequently a detailed cell wall modelling approach is unpractical for large sandwich structures. One way to determine these nonlinear effective mechanical properties is extensive experimental testing under compressive, tensile and shear loading.

***S. Heimbs, P. Middendorf, C. Hampf, F. Hahnel, K. Wolf* [3],** "Experimental and Numerical Analysis of Composite Folded Sandwich Core Structures Under Compression ", (2008) in this review the performance of such a sandwich assembly with a fold core made of carbon fibre-reinforced plastic under low velocity impact is studied experimentally and numerically.

3. Modelling and Simulation

The development of the model done on a parametric basis reducing the pre-processing work and offering an efficient way of investigating different folded core geometries. Design of the fold core structure has been done using CATIA V5 Software. By using hyper mesh, meshing has done with the size of 10 for wall geometry and core geometry. Using Ls-Dyna material has been assigned for core using piece wise linear plasticity and wall using by elastic properties. Aluminium is core material and Glass Fibre reinforced Plastic is Face sheets with wall thickness of 0.8 mm and core of 1.0 mm. Contact between core and wall, is surface to surface contact with termination time of 1.8sec.The Model has constrained the outer node of the core geometry in X,Y,Z directions there will not be any rotational moment. Transversal low velocity analysis has been done using model of metal ball with diameter of 10 mm at different velocities. The Impactor was modelled as a spherical rigid body.

In order to separately validate the folded core model, simulations of the compression tests were performed before impact and after impact in ANSYS. In this study the influence of geometry of cellular was also investigated and found out to be significant. Furthermore, the impact resistance was over predicted in the FE-model, which could be explained by energy absorption of the fold core geometry. Such and other imperfections, which normally occur in all cellular structures, influence the mechanical behavior and have to be accounted for in a meso-scale FE-model. The model was calibrated accordingly.

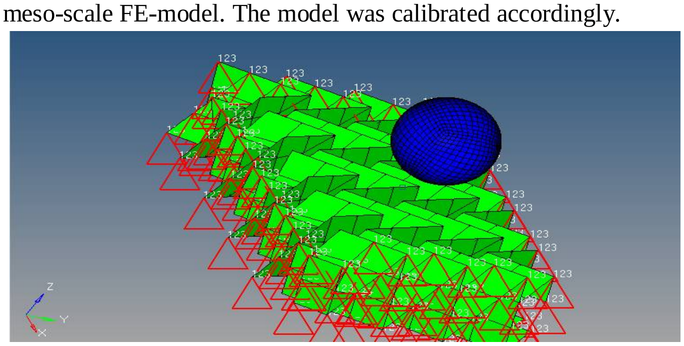
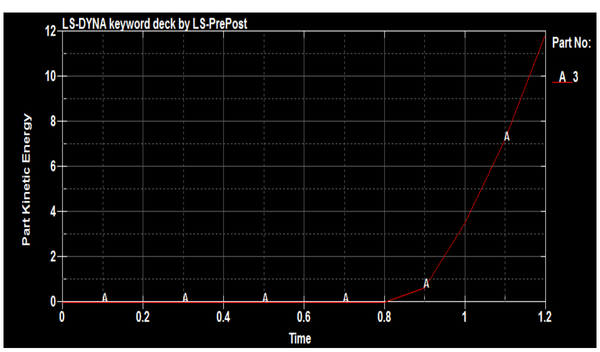
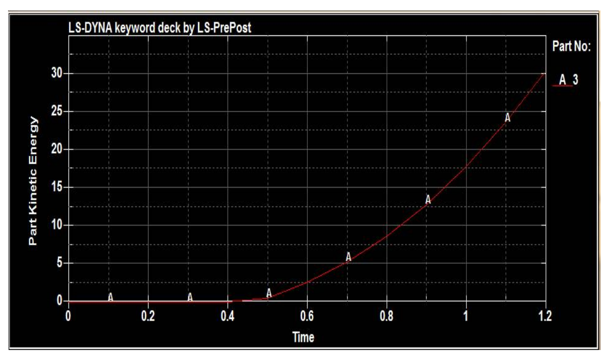


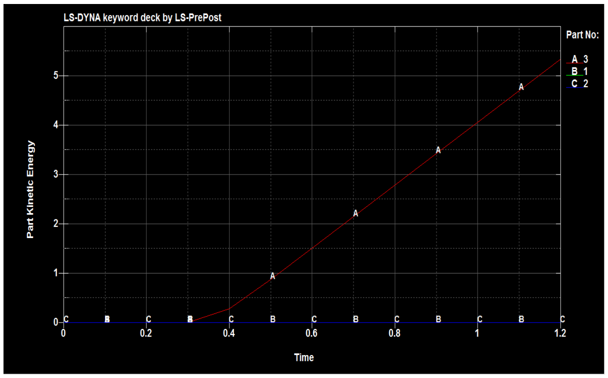
Fig. 2 The representative FE model of the core under projectile impact

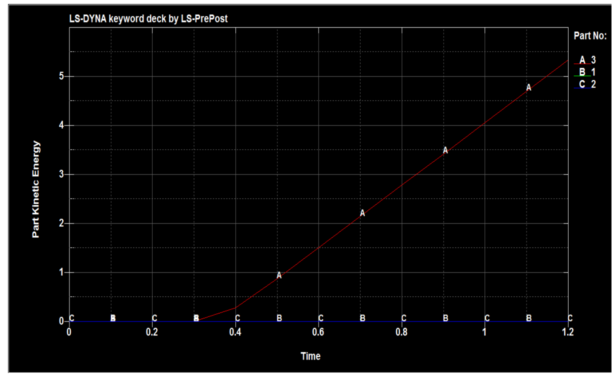
Simulation has been done for the different cellular geometries of fold core sandwich structures with GFRP face sheets with a Steel ball (dia10 mm impacting at velocity of 60m/s.) Kinetic Energy in 10^{-3} J and Time in Microseconds





(**A) Triangular(45° included) geometry** **(B)Triangular(45° included with 3mm curve**)





(C) Triangular (60degree inclded angle) with 3mm **D) Rectangle (90°included angle geometry)**

A-Folded core B- Front face-sheet C-Back face-sheet

Fig. 3 Energy absorption Vs Time plot of core for the different geometries

Simulation has been done for the different cellular geometries of foldcore sandwich structures without GFRP face sheets with a Steel ball (dia 10 mm impacting at velocity of 85m/s.)

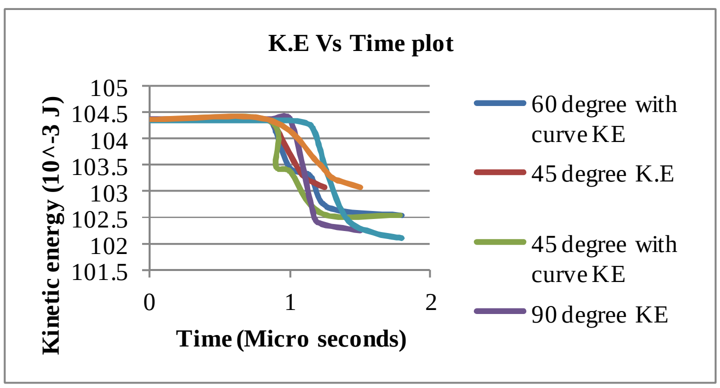


Fig.3 Kinetic Energy Vs Time plot of Metal ball

4. Validation

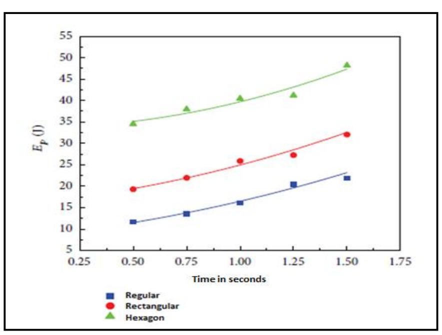


Figure 4: Energy absorption by core [5]

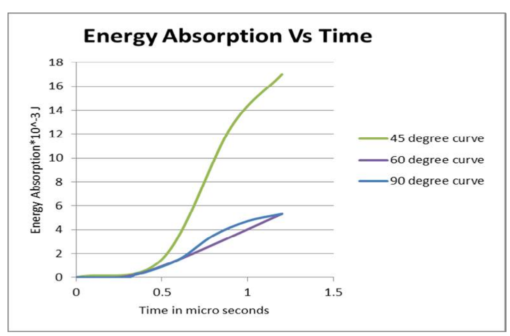


Figure 5: Energy absorption by core

Fig 5 shows the energy absorption for aluminium core for 45 degree, 60 degree, and 90 degree, which represents the increase in energy absorption by core with increase in time Comparison of fig 5 with fig 4 we can validate that the energy absorption for the core structure depends on the cellular geometry of the folded core. Here Triangular (45° included with 3mm curve) foldcore sandwich structure showing the better energy absorption of the impact of the ball.

5. Conclusion

- In present study, triangular unit cell of angle 45° with 3mm outward from midpoint curve and cell length of 23mm geometry is showing good energy absorption due to the material density and curve restricting the load transmission to the adjacent cell of the core.
- As increase in relative density and thickness of fold core and face sheets the residual velocity will decrease.
- Nonlinearity due to the residual velocity of the core with increased thickness, with respect to the impact velocity and core relative density.

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