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FEM Analysis of Aluminum and Nomex based Honeycomb Composite Structure

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***Abstract*: Honeycomb structures wide usage in Aero Structure due to its higher strength to weight ratio. The strength is mainly derived from height of core structure. Hexagonal shape is provided to reduce the weight with higher torsional strength. The high strength materials with low cost and lesser weight is present day requirement with high speed jet engines which will reduce the weight of the structures. Practical prototype built up and destructive testing is costlier process to select the best material. So present day research is moving towards numerical simulation and eliminating the costlier setup and time consuming practical setups. Due to the advances in computer based numerical simulations, this virtual testing is made simple and any number of designs can be tested for its performance in short time, which eases the designer work to select best material and mechanism. Now a days, in every field computer based Finite element analysis find wide usage to reduce the cost of design process. Two materials find wide usage in Aero structure design for higher strength with lower weight. In the present work, these two materials (Aluminium and Nomex) are checked for its structural strength under impact test conditions. Initially the core and skin of the sandwich panel is prepared and meshed as per dimensions specified in the problem. Mid surfaces are extracted and shell meshing is carried out in the problem. Using Explicit algorithms, the problem is executed with 70 kg mass under impact loading. Shell meshing is used for both skin and hexagonal core. The results are captured for acceleration, velocity, displacement, plastic strain und vonmises stresses.**

***Keywords*: Aluminium Nomex and Ls-dyna software**

1. Introduction

Structural crashworthiness is a multidisciplinary area concerning the study of the behavior of components of different materials and structures when subjected to quasi- static or dynamic compressive loads. Its applications range from low velocity vehicular collisions to high velocity impact loads. Truck under ride is when a passenger vehicle crashes into and penetrates beneath, or "under rides" the taller rear of a large truck or trailer. The top of the car is crushed or ripped off, and the occupants suffer severe with injuries. Rear guards on trucks and trailers were initially required in 1953, and are known as ICC bumpers (Interstate Commerce Commission), but such rear bumper devices are typically defective, too high above the road, too narrow across the truck's rear, and too weak to prevent the under ride hazard. To minimize the number of deaths and serious injuries associated with under ride collisions, in the United States, NHTSA issued a safety standard to require safer guards as per their roadway regulations still truck guards are not strong enough to absorb impact forces, and may well be defectively designed and ineffective. As per work carried out by NHTSA, without compromising with the proved out designs of rear truck under ride, some amount design optimization has been looked in to the existing design to suit the Indian perspective. Truck under ride is preventable. The prevention of the truck-under ride hazard is accomplished with guard devices designed into or attached to the rear or side of large trucks or trailers. When a passenger vehicle makes contact with a guard of sufficient strength, that guard prevents the vehicle from under riding, thereby safely maintaining the occupants' survival space. About 40-percent of all rear under ride fatalities involve the rear corners of the truck or trailer. Therefore, an effective guard should have additional vertical support members at the corners to help prevent the main horizontal bar from breaking away and failing.

Vehicular collisions are among the most serious issues that engineers in particular and society in general is facing today. These vehicular collisions are not only dangerous to the occupants of the vehicle but also to the impacted structures such as buildings,pillar supporting bridges, etc. Therefore, it is important to evolve collision protecting solutions which maximize the protection without compromising the structural integrity. Thus the emphasis on the design and development of Impact Energy Absorbers (IEAs), which dissipate kinetic energy from unwanted collision in a controlled manner, has increased in recent times. In the case of vehicular collisions, the need is to interpose a structure between the impacting bodies which can dissipate the kinetic energy by undergoing large plastic deformation in a predictable manner hence to bring the vehicle to stop in a controlled way. Such impact energy absorbers can also be used as protective claddings in structures and buildings of public importance against any sort of external threat or damage.

2. Scope of present investigation

The scope of present work is concerned with the evaluation of energy absorbing characteristics of certain materials such as Aluminium and Nomex, which are extensively used in automobiles and high-speed aircraft structures. Higher strength with lesser weight is required to withstand the competition in

the market. There is a lot of research is going on with different materials for better strength to weight ratio. The honeycomb structure uses the old concept of bending stress distribution across the geometry. Generally, the top fibers are subjected to higher stress and zero stress at the neutral axis. This way of distribution of stress nature is the main concept of honeycomb structure design. In addition, the energy absorption capacity is an important parameter in the honeycomb structure. The impact strength checks the two important materials namely aluminium and nomex is carried out using Ls-dyna software.
The following are the different stages of the present work.

- Initially geometrical modelling of honeycomb structures using catia-v5software.
- The modelled structure is meshed using hyper mesh software.
- The meshed component is ported to Ls-Dyna atmosphere.
- The simulations are carried out in Ls-Dyna atmosphere to find the nature of impact behavior.
- The results are presented and finally it is concluded from the result that the nomex material is proved to be better than aluminium in all aspects.

3. Design methodology

Drop weight impact test simulation of Aluminium based sandwich structure and Nomex based sandwich structure has been carried out to check impact strength is the main definition of the project. The main objectives includes Geometrical modelling of the honey comb structures Finite element model development of honey comb structures Crash simulation and character study of different materials under impact Requirement: Due to the advances in automobile and high speed aircraft structures, the requirement of high strength materials with lesser weight is required to with stand the competition in the market. There is lot of research going with composite for better strength to weight ratio. Honeycomb structures use the old concept of bending stress distribution across the geometry. Generally, the top fibers are subjected to higher stresses and zero stress at the neutral section. This way of distribution of stress nature is the man concept of honeycomb structure design. Along with this, energy absorption capacity is also an important parameter in the honeycomb structures. So commonly used composite materials are Here it is shown how to style a subsection and sub sub-section also

4. Methodology

- Geometrical modelling of the honey comb structures
- Meshing of the geometry with different materials
- Ls-Dyna simulation to find the nature of impact behavior
- Results presentation
- Pre-processing
- Imported the 3D model in Para solid exchange format Hyper mesh then exported to ANSYS
- Assigned the necessary material properties
- Chosen 20 node solid 95 as the element
- Assigned appropriate element edge divisions to lines and meshed themodel
- Checked the mesh fordegeneracy’s
- Solution
- The problem based type of analysis, solver type will beselected.
- Postprocessor
- View the results and plot the necessary graphs and draw conclusions based on the resultsobtained.

5. Results and discussions

The impact simulation using Ls-Dyna software has been discussed in this chapter. As mentioned the primary candidate materials chosen for impact testing are aluminium and Nomex based sand wich based materials. An impact simulation for 0.2 milliseconds is considered for the impact of the standard weight specimen. Mass of the circular specimen is 70 kg. Here it is shown how to style a subsection and sub sub-section also

6. Conclusion

Impact simulation is carried out on Aluminium and Nomex based Honeycomb structures to evaluate its absorption capacity and strength when subjected to suddenly applied load. The summarized results are as follows.

- Initially the geometry is honeycomb structure using cad modelling and dimensions are represented. The top and bottom skin along the hexagonal core structure is built
- The geometry is imported to hyper mesh in ‘step’ file format and mid surface is extracted for shell meshing. The geometry is split to ease the quad meshing. Trimming is used for obtaining regular surfaces on honeycomb structure. The shell mesh is checked for aspect ratio, warpage, skew angle and Jacobian.
- Shell meshing is carried for skin and core sections. Shell element is the best element suitable for modelling thingeometries.
- Contact definitions are created between the mass and the meshed honeycomb structure. Explicit contacts are defined between rigid mass structure and deformable shell structure.
- Impact simulation is carried out by standard mass value of 70 kg using Ls-Dyna, 3D crash simulation software. Total time of 10milli seconds is considered for analysis. Results are obtained at different time intervals.
- The simulation results shows higher stress development near the zone of impact and lesser stresses at other locations. The results at skin and core structure are represented for vonmises stress for Nomex material. The results show increasing internal

energy with the impact time with the drop of kinetic energy.

- When compared to the Aluminium the Nomex material shows superior properties with lesser plastic strain and stress, Also Nomex material has lesser deformation compared to the aluminium structure where displacements are more. Higher plastic strain is undesirable for aero structure where continuous fatigue load leads to eventual failure of crack propagation. So Nomex material will give good life for the aero- structures compared to the aluminiumstructures.

7. Future scope

- The problem can be further extended with optimization of the geometrical properties
- Thermal environment can be considered for Honeycomb structure
- The shape of the Hexagonal sided honey comb structure can be optimized for dimensions
- The effect of delamination and debonding can be analysed
- Topology optimization can be considered
- Spectrum analysis can be carried out to find the applicability of the materials for space applications.

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