Numerical and Experimental Analysis of Energy Absorption of Aluminium Honey Comb Filled Pipe for Car Bumper Application – A Review

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Abstract— In general car bumper is considered as the front most and rear most part designed to withstand damage to vehicle's safety systems. During frontal crash, the bumper beam is the main component which undergoes damage and transfers remaining energy to other parts of the car. Thus, there is a need to further improve the design of bumper beam to ensure the safety of automobile confirming minimum accelerations are transferred to the occupants. In this work an attempt is made to further improve the material of the bumper beam to enhance the passive safety of the occupants. This is proposed to achieve by using aluminium honey-comb panel as a filler material between bumper beam and support region. Primarily the behavior of the hollow rectangular aluminium tubes will be determined using Ansys. The honey comb panel will be embedded into the hollow rectangular aluminium tube which will be arranged along the bumper space so that tubes can withstand major portion of the impact energy. Enough space between the tubes will be provided to permit displacement to tubes during crush. The influence of aluminium honey comb panels will be analyzed.

Key words: Car Bumper, Aluminium Honeycomb Panel, Water Jet Machining, Aluminium Honeycomb Filled Tubes, Drop Weight Impact Test

I. INTRODUCTION

Bumper is the one of the most important component of an automobile and its basic necessity is to absorb the impact energy at the time of low speed collision to protect the occupants and also to reduce damage to the other parts in the car. Even in low speed collision poor bumper design may damage the parts of the car. Bumpers are also meant for the safety of pedestrians under low velocity collisions. To improve the structural energy absorption many methods has been tried. One of the best method is filling the tubular structures with light weight material such as aluminium honeycomb. Aluminium honeycomb is a thin walled multi-cellular structure with high strength to weight ratio. In past the bumpers were only made of rigid material this may increase the weight and fuel consumption of the car. To overcome all these problems honeycomb structure can be used in place of rigid materials, this can reduce the material used. Honeycomb structure can increase the energy absorption during collision and it also reduces the impact created on the occupants during collision. Comparing to other materials Aluminium honeycomb structure is good in energy absorption.

II. ALUMINIUM HONEYCOMB STRUCTURE

Honeycomb structures were obtained by a series and systematic arrangement of thin edged hexagonal cells. These structures are called as honeycomb structures due it resemblance with honeybee nests. Because of its geometry these honeycombs minimizes the material use and this reduces the both weight and cost. In axial direction, these honeycombs show high shear & compression properties with less density.[1-2]

III. WATER JET MACHINING

Water jet machining is based on mechanical energy. It is a non- traditional machining process used for cutting the non metallic materials and it is machine soft. High velocity of water jet is used to cut a soft work piece smoothly. Here a high velocity of water jet is allowed to pass on the given work piece. In this process kinetic energy is converted into pressure energy. This produces a stress on the work piece. When this produced stress is high unwanted particles on the work piece are removed automatically. [16]. Aluminium honey comb was machined using this method.

IV. RESEARCH ON ALUMINIUM HONEYCOMB AND ITS PROPERTIES

BS Roudsari et al. [3] in this paper they have made a study on three types of bumper materials such as basic bumper design with steel, with attachment of foam and with attachment of honeycomb and they have described that carbon fibres gives high strength to weight in ratio in comparison with steel and dissipates energy, The basic design with front part as a foam absorbs the energy and ensures the pedestrian safety, The honeycomb structure having strength absorbs more energy thereby ensures passenger safety. So honeycomb and foam are far better than the other.

Maheshkumar. V .dange et al.[4] in this paper they have made a study on material and structure of bumper and they have said that In order to design the front bumper beam, two major factors are considered. Materials having high yield strength and high modulus of elasticity are used to keep the internal absorbed energy of the bumper beam high. In second place, plastic deformation of the bumper beam should be avoided as much as possible in low-speed mode. Maximum deformation of bumper beam is kept within the acceptable limit. The maximum stress of the bumper is also below the yield stress of the material. From the study it is clear that if bumper is safe with passenger then it is definitely safe without passenger.

Siji chen et al.[5] in this paper they have made a number of experimental and theoretical studies to investigate various single cell structures, such a circular, square and hat shaped tubes subjected to static and dynamic loads. A very simple yet very practical and theoretical model was developed to evaluate the average crush force and energy

absorption of a metal tube under axial compression. At last they have concluded that the crashworthiness of the tube with curved surfaces is better than that of their counterparts with flat surface corners has been verified by many studies.

Xuan Zhao et al. [6] has done a study to increase the energy absorption by changing the material of bumper. The original materials of the bumper, crash box, and front rail were replaced with aluminum alloy 6060, TRIP800, and DP800, respectively. The result showed that the energy absorption increased by 10.1%, the peak collision force and the crumple distance decreased by 11.1% and 12.6%, respectively, and the total mass decreased by 11.1%.

Jianguang Fang et al. [7] has done a study and research by making the structural change in the bumper material. The structure is changed to enhance the energy absorption capacity. The corners are filled with circular element. The structure can be effectively optimized by employing the multi-objective particle swarm optimization (MOPSO) algorithm and radial basis function (RBF) surrogate model. The study outcome facilitates the design of multi-cell structures with better crashworthiness.

Chunsheng Songa et al. [8] has made a research by changing the material of bumper to energy absorption. Aluminum honeycomb-filled Carbon Fiber Reinforced Plastic (CFRP) thin-walled square beams is used. Strength to weight ratio is high. Combining aluminium 3003 with CFRP gives isotropic material property. The results show that the energy absorption and specific energy absorption of filled composite tubes can significantly increase by 104.3% and 26.8% respectively compared with those of CFRP hollow beams. This study elaborates the potential of CFRP beams filled with aluminum honeycomb to be used as energy absorbers.

Jayadeep s.bagi et al [9] has made bumper design enhancement through crash analysis. Here , structural change is employed by increasing the thickness of car bumper to 5mm.Increasing the thickness , load carrying capacity of bumper has increases due to stiffness. In this research, a front bumper beam made of three different thicknesses: 4mm, 4.5mm and 5mm are studied by impact analysis to determine the deflection and plastic strain induced in the bumper beam. The mentioned characteristics are compared to each other to find best choice of Bumper thickness.

L. Romera et al.[10] has used glass fiber reinforced plastic to increase energy absorption. Surrogate based optimization is used here. The three objective functions are — mass, absorbed energy and peak load. The peak load is reduced by 37% on a specimen with similar mass and absorbed energy, and the specific energy absorbed is increased by 39.5%. The results obtained show great improvements on all objective functions compared to the original design. The peak load is reduced by 37% on a specimen with similar mass and absorbed energy, and the specific energy absorbed is increased by 39.5% for a specimen with a same peak load to the one from the initial model.

Zhie bhaio,fang et al.[11] has optimized crashworthiness design for functionally graded foam filled bumper to decrease the crumple distance. The structure can be effectively optimized by employing the multi-objective particle swarm optimization (MOPSO) algorithm and radial basis function (RBF) surrogate model. The present study with better crashworthiness will faceplate.

Kiani, Imitiaz et al.[12] has made light weight material in the place of bumper to enhance the energy absorbing capacity. Magnesium material is used to enhance the design. A front bumper beam made of three different thicknesses: 4mm, 4.5mm and 5mm are studied to induce the plastic strain capabilities' mentioned characteristics are compared to each other to find best choice of Bumper thickness.

Guohua Zhu et al.[13] has made development process in new bumper beam for passenger car. This beam absorbs kinetic energy in slow speed. Efficiency of this product will also developed. This is made to obtain the multiple objective parameter. The results suggests that variable cross section is superior to uniform cross section .Because of light weight this is recommended as replacement of conventional car bumper.

M. Altina et al.[14] has made analysis on bumper beam subjected to offset impact load which increases the biodegradable and recyclable material which also reduces the pollution in the environment. The goal is to optimize the aluminium under quasi static loading. This increase the energy absorption and standard energy absorption by 6%. To obtain higher energy absorption this must be in low weight. This will not give any additional weight.

Farshid Kholoosi & Seyed Ali Galehdari et al[15] has made optimization and analysis of a helmet made with graded honey comb under load. The behavior was also compared with the ESP foam filled bumper. This gives extra safety to the passengers. Based on the results obtained this gives longer safety and energy absorption duration, which transfers force to the user.

Bradley D et al. [17] has made research Crash test rating and likelihood of major thoracoabdominal injury in motor vehicle crashes: The new car assessment program side-impact crash test.Theside-impact testseekstore replicate a crash where the car is struck on the driver's side door at an intersection and attempts to predict the likelihood of major (Abbreviated Injury Scale [AIS] score Q 3) thoracic or upper abdominal organ injury (referred to herein as ''major thoracic abdominalinjury''). theefficacy of NCAP side-impact star ratings in predicting the presence of major thoracoabdominal injury following side-impact crashes in the National Automotive Sampling System (NASS) Crashworthiness Data System (CDS) data set.

F A Berg et al. [18] has made research on Motorcycle crash tests. To research on this, it is important to check all criterias and bring possible measures into action. Here the safety of vehicle is also more important .focusing on the motorcycle impacts against steel guard rails and concrete barriers many research and crash test have been conducted. Some more tests dealing with the protection potential of motorcycle clothing have been accomplished. The article gives the knowledge about the real world accident studies, and full crash tests carried out by DEKRA Accident Research & crash test center.

M. U. Khan et al. [19] has review is to identify all research information related to analysis of the OOP airbag deployment, covering all theoretical, numerical and experimental work in this field, from the first few initial

mathematical models to all current research projects. The method also has known deficiencies like correct unfolding airbag procedures, good contact algorithms during the unfolding process and unwanted leakage. These are certain areas that need to be improved to aide in the overall accuracy of the method, leading to a greatly enhanced fluid structure coupling numerical simulation techniques which can be utilized for OOP loads cases and a range of other possible situations.

K. Ludwinek et al. [20]has made researchanalysis of Physical Quantities during Crash Test at Low Speed.The crash tests are carried out in a trolly with different seat belts at low speed.During the experimental investigations, the waveforms of forces in the 3-point hip and shoulder parts of the belt in the range of crash speed 15.54 - 17.48 km/h were determined.The results showed that despite the low speeds, the values of forces between the dummy and the 3-point belts reach significant values of up to 5 kN with the dynamic increase rate of 30 kN/s.

ZhiguoZhang et al. [21] has made experimental study and research on the Crash Test's Safety in NCAP of electrical Vehicle.With the development of electrical vehicle, the technique of electrical vehicle's passive safety is very worth researching. This paper is key-point is the safety of electrical vehicle in crash test compared with gasoline vehicle. First, the crash standard of electrical vehicle is analyzed. The key we have to pay attention is suggested in our regulation. The matters needing attention in the crash test are suggested too.

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