JOURNAL OF AERONAUTICAL MATERIALS
ISSN: 1005-5053

Vol. 43, Issue-01, 2023
pp. 46-52

EXPERIMENTAL INVESTIGATION OF ENERGY ABSORBER MATERIALS FOR LOW AND MEDIUM VELOCITY IMPACT

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Abstract-With the new inventions in technology, automotive sector has been growing rapidly. The objective of this work is to experimental investigation of shock and energy absorbing capacity of an energy observer component for low and medium velocity impact of frontal collision on shock absorbing bumper for M1 category of vehicle. Energy absorbing bumper which absorb the impact energy under collision is designed and developed.The sample specimen of absorbers is prepared for half cylinder and double cylinder arrangement. The Impact testing is done for same loading. It is found that double cylinder arrangement is better impact resistive material under different impact speeds. The half cylinder failed under the speed of 40 Kmph while the double cylinder continues to resist with gradual increase in deformation for 50 Kmph.

Keywords: Energy Absorbing Techniques, Composites Materials, Experimental Investigation

1. Introduction

To protect the car occupants, the car structure should absorb most of the energy caused by collisions, prevent intrusion and the compartment should not deform. To achieve these conditions, both longitudinal should work together in the same time to absorb enough energy and to keep passengers safe. If one or both longitudinal are not loaded axially, this will decrease the absorbed energy and bending occurs. This gives two discrepancies: The maximum energy has to be absorbed by one or both longitudinal, and that in partial overlap or oblique collisions, the energy absorbed by longitudinal will not reach that of full overlap as in direct impact [3].

Analysis of lower leg fractures in pedestrians and bicyclists after collisions with passenger cars[1]. Han [2] conducted the Effects of vehicle impact velocity, vehicle front- end shapes on pedestrian injury risk to in collisions with passenger vehicles with various frontal shapes. Li [3] described the influence of passenger car front shape on pedestrian injury risk observed from German in-depth accident data. These findings suggest that passenger car bumpers should support the lower leg with a low and at lower bumper. Wang [4] discussed the effects of vehicle front design variables and impact speed on lower extremity injury in pedestrian collisions using in depth accident data. To identify the correlations of pedestrian AIS2+ lower extremity injury risk with the vehicle front design variables and impact speed by using real-world accident data. Moradi [5] evaluated the kinematics and injury potential to different sizes of pedestrians impacted by a utility vehicle with a frontal guard. The vehicle front geometry profile and stiffness, as well as impact speed are important factors governing pedestrian kinematics. FUJII [6] explained the method for determining the impact force in crash testing. In this method, a mass is made to collide with the object being tested and the instantaneous value of the impact force is measured as the inertial force acting on the mass. The relative combined standard uncertainty in determining the impact force in a three-point bending test is estimated to be 0.5 10 2 (0.5%) of the maximum value of the impact force. H. Naderpour et.al. [7] presented a new model for calculating impact force and energy dissipation based on the CR-factor and impact velocity. To calculate the impact damping ratio based on the coefficient of restitution and steady-state response of a single degree of freedom system, due to external force, a new equation of motion is suggested.. Zhou [8] studied the Cumulative Impact Forces of stainless steel reinforced concrete pier. The results show that the formula of the collision force proposed in this paper is able to better reflect the actual force of the cumulative impact of the pier. Kireev [9] presented energy-regenerative shock absorber mathematical model. One of the factors enhancing transport efficiency is to introduce the suspension system based on the energy-regenerative shock absorber which converts mechanical losses in the suspension into electric energy by means of the electromechanical converter. Dhamone [10] described the advance robotics technology on crash analysis of automobile bumper by varying suitable input parameter in order to control energy absorption for improve passenger car safety aspect. Different impact attenuation systems in the vehicle were studied with emphasis on the bumper modelling, material consideration, automatic machine handling, Robotics sensor for Bumper can achieve the desirable properties such as low weight, high fatigue strength, accessories in automation, improvement in quality of products.

The objectives of this paper are formation of experimental model for impact mechanism in case of automobile and development of Energy absorber component.

2. Modellingof Energy Absorber

2.1 Double Cylinder Arrangement

Fig.1. Double Cylinder Energy Absorber

Double Cylinder Energy Absorber as shown in Figure1. The double cylinder model with various compression stages is used as energy absorber. The number of stages depends on the no. of cylinders used. Due to geometric constraints and to make energy absorber less stiff, the two stage compression is used. It is simple in construction and in case of damage it can be replaced at a low cost.

2.2 Half Cylinder Arrangement

Figure 2. Double Half Cylinder Model of Energy Absorption

Figure 2 shows double half cylinder model of energy absorption. To increase the compression stages and energy absorbing capacity, a design is considered with double half cylinder model with 4 stage compression. It consists of two cylinders which are cut into half and welded against each other forming double half portion of cylinder. This method is effective in cost, where as it absorbs more energy as that of the double cylinder model.

2.3 Material Selection

Material selection is based on following parameters.

Strength Related to Weight - Strength-to-weight ratio is a material's strength in relation to how much it weighs.

Corrosion Resistance - Composites resist damage from the weather and from harsh chemicals that can eat away at other materials.

Durable - Structures made of composites have a long life and need little maintenance.

Part Consolidation - A one piece made of composite materials can replace an entire assembly of metal parts. Reducing the number of parts in a machine or a structure saves time and cuts down on the maintenance needed over the lifespan of the item.

Material properties for composite materials as given in Table 1.

Table 1 Material Properties for Composite Materials

Material and Properties	S-Glass	Carbon
Tensile Strength (MPa)	4587	1100
Yield Strength (MPa)	3250	900
Young's Modulus(MPa)	8.69e5	0.5e3
Poisson's Ratio	0.28	0.25
Density (kg/m^3)	2480	1600
Energy Absorption (J/Kg)	49	99

3. Experimental Investigation

The Concept of Material and Optimization of Half Cylinder and Double Cylinder has been solved using the simulation. The results of simulation are completely based on the theoretical modules which are implemented in the software. Hence, to implement the concept in real time example, it is necessary to verify the results obtained in simulation with the experimental performance of the study. This process is called as experimental validation.

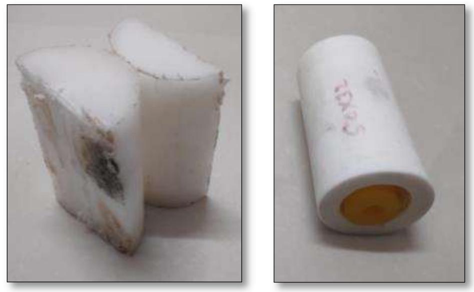

Figure 3. (a)Half Cylinder (b) Double Cylinder energy absorber

Figure 3 shows half and double cylinder energy absorber. The motto of experimental investigation is to define the impact strength of modified energy absorber. Hence for the same the sample of energy absorber of half cylinder and double cylinder are manufactured.

The Experimental analysis is carried on drop weight impact testing machine. A drop weight impact test (Fig. 4) determines a material's resistance to sudden external force.

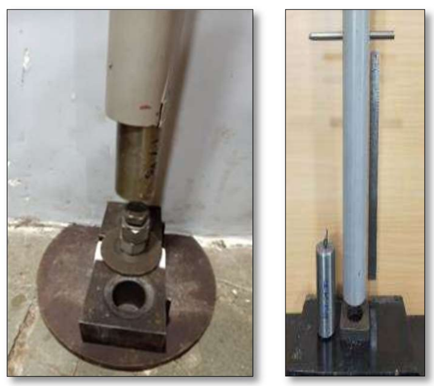

Figure 4. Drop Weight Impact Test Set Up

A drop weight impact test usually determines a material’s resistance to sudden external force. Table 2 shows the impact pararmeters.

Table 2. Impact parameters

Mass, m (Kg)	Impact Energy	Time, t (sec)	Velocity, v (m/s)	Speed, S (kmph)
1	10	0.92	3.30	11.87
2	20	0.92	4.66	16.79
3	30	0.92	5.71	20.56
4	40	0.92	6.59	23.74
5	50	0.91	7.41	26.68
6	60	0.91	8.12	29.23
7	70	0.89	8.87	31.93
8	80	0.89	9.48	34.13
9	90	0.89	10.06	36.20
10	100	0.87	10.72	38.60
11	110	0.86	11.31	40.71
12	120	0.83	12.02	43.29
13	130	0.82	12.59	45.33

14	140	0.79	13.31	47.92
15	150	0.76	14.05	50.58

Figure 5. Nature of Specimens after Impact

Figure 5 shows the nature of specimen after impact test. The deformation after each test is measured by means of dial indicator. The changes in the shape are denoted on the dial indicator scale. If one round of pointer moves, that means the changes in the surface of impact is obtained to be 1 mm. The smallest division of the dial indicator is 0.01 mm. Hence after each test, the deformation is measured.

4. Result and Discussion

4.1 Deformation Analysis

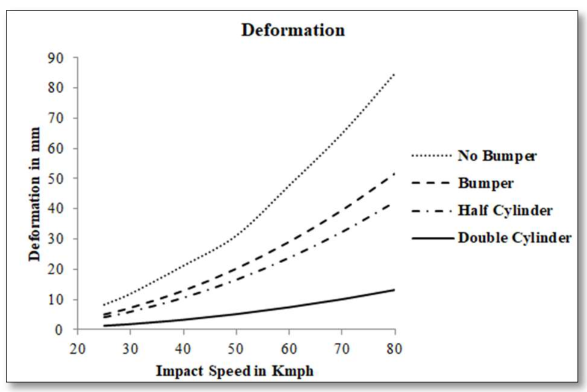

Figure 6. Response Analysis for Deformation in various sections

The response analysis of different impact speed for various sections as shown in Figure 6. The deformation produced in the body with bumper and no bumper system is more as that of half cylinder and double cylinder absorber. Hence, with respect to the simulation results, it can be state that, use of energy absorber can reduce the deformation which further affects the reduction in dislocation.

4.2 Experimental Investigation for Impact Strength

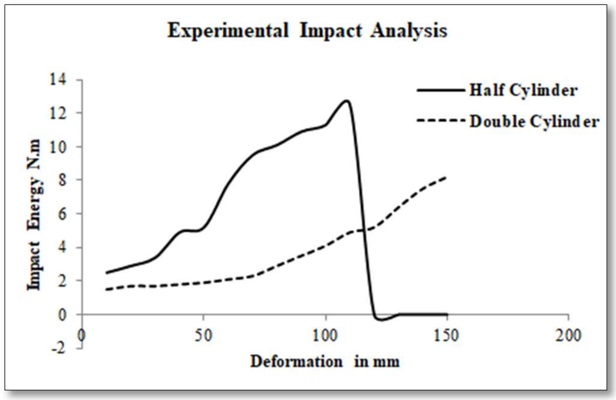

Figure 7. Experimental Analyses for Impact Strength

Figure 7 shows the experimental analyses for impact strength for half and double cylinder. Impact strength is capability of the material to withstand suddenly applied load on it and is expressed in terms of energy. The impact strength is expressed as the work required for the fracture of the specimen. As shown in the graph, the term of deformation produced in the half cylinder absorber increases from initial period of impact analysis less than 2 Kg. The material goes on deformation with promotion in increase in deformation. At the impact energy of 110 N.m, the material fails and crack is formed. The deformation in Double Cylinder is steady and absorbed. The material continues to sustain the impact and up to the extreme limit of machine set up the material undergoes deformation of 8mm. The deformation found in Double Cylinder absorber is found to be less as that of Half Cylinder component.

5. Conclusions

The double Cylinder model and Double Half Cylinder model is been selected as energy absorber component due its ease in manufacturing, its capacity and cost factor availably. In order to obtain the impact strength with low weight, polymers are the best material, hence the polymers of S-Glass is used. The Static analysis is performed for determination of impact strength for S-Glass Fibre Polymer materials. The sample specimen of absorbers is prepared in case of Half Cylinder and Double Cylinder arrangement. Double Cylinder arrangement is found to be better impact resistive material under different impact speeds. The Half cylinder failed under the speed of 40 Kmph whereas the double cylinder continues to resist with gradual increase in deformation for 50 Kmph.

The maximum energy is absorbed by the double cylinder which proves that the energy does not transmit to the vehicle front section, preventing the jerk or shock and also safeguarding the delicate components.

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