DESIGN ANALYSIS OF AUTOMATIC PNEUMATIC BUMPERS FOR 4-WHEELERS SUBJECTED TO DYNAMIC ANALYSIS

[#1]S REDDY AHMAD, M.Tech,Product design
[#2]DR. R.J.V.ANIL KUMAR, Assisant professor
DEPT OF MECHANICAL ENGINEERING
JNTUA CEA Anantapur.

ABSTRACT

The technology of pneumatics plays a major role in the field of automation and modern machine shops and space robots.. The aim is to design and develop a control system based intelligent electronically controlled automotive bumper activation and automatic braking system is called AUTOMATIC PNEUMATIC BUMPER AND BREAK ACTUATION BEFORE COLLISION. This project consists of IR transmitter and Receiver circuit, Control Unit, Pneumatic bumper system and pneumatic braking system. The IR sensor senses the obstacle. There is any obstacle closer to the vehicle (within 3-4 feet), the control signal is given to the bumper activation system and also pneumatic braking system simultaneously. The pneumatic bumper and braking system is used to product the man and vehicle. This bumper and braking activation system is only activated the vehicle speed above 30-40 km per hour. This vehicle speed is sensed by the proximity sensor and this signal is given to the control unit and pneumatic bumper and braking activation system.

INTRODUCTION

Increase in number of accidental deaths has made vehicle safety as one of the major areas of research in the automotive sector. New stringent legislations and growing concern of people support this research. Thin-walled metallic tubes used in the vehicles are of increasing interest with reference to safety and crashworthiness of vehicles. These thin walled structures are most conventional devices for absorbing impact energy effectively. The extensive research on the structural response of these tubes is going on continuously to improve the passenger safety.

1.1 Road Accidents in India

Highest number of accidents takes place in India. Having more than 1,30,000 deaths every year, the country has surpassed China and now has become the country having worst road traffic accident rate in the world. Road accidental deaths are increased by about 40 % between 2003 and 2008 (and by nearly 5.6% between 2010 and 2014) in India. The more progressive and developed states like Tamil Nadu, Maharashtra and Andhra Pradesh are the ones most affected. The highest rate of accidental deaths was reported from Puducherry 96.3 per one lakh of population. This was followed by Chhattisgarh (84.6), Gujarat (59.2), Haryana (58.5), Madhya Pradesh (57.6) and Maharashtra (57.0) against the national average rate of 36.3 per one lakh of population.

The aim of the research work was to increase the safety of the passengers, vehicles carrying passengers were considered here instead of goods carrier vehicles. The group of vehicles considered here for research work falls under a category of jeep as per National Crime Record Bureau (NCRB), to name a few 6 Tata-Sumo, Force-Trax**, Mahindra-Commander**, Jeep etc. The outcome of this research can be applied to all other vehicles in this group.

1.2 Introduction to Energy Absorbers

Many practical engineering systems have requirement for absorbing energy during impact events. An energy absorber (in the context of crashworthiness) is a device that converts impact kinetic energy into another form of energy, thus reducing the peak damaging forces transmitted to the structure being protected (Nagel 2005). The energy will be absorbed either totally or partially. Energy converted is either reversible, like pressure energy in compressible fluids and elastic strain energy in solids, or irreversible, like plastic deformation energy.Energy absorbing device may be classified in one of the three general categories; these are material deformation, extrusions and friction. This classification is made on the basis of the primary energy absorbing mechanism. In many devices there is more than one energy absorbing mechanism but, in general, one is dominant. The material deformation category includes a wide variety of energy absorbers which rely on the deformation of materials for the absorption of energy

1.2.1 Bumpers

Figure 1:Bumper

Bumper is divided in two types, they are front bumper and rear bumper. Main function both of them are for absorbing impact by reducing damage and to the potential for bodily injury during an accident. Car bumper system has three main components. They are the fascia, beam, attachment brackets and sometimes energy absorber. The fascia is the outer cover. It is attaches to the quarter panels and rear end panel. The energy absorber attaches to the beam. The beam is mounted directly to the vehicle body. These components were reviewed for differences in shape and construction prior to being assembled to the vehicles.

Bumper beams are usually made of aluminum, plastic, steel or composite material. Bumper design has a limitation in the proto-design stage: it should meet safety standards and of low weight contributing to overall weight reduction of vehicle to increase mileage of vehicle. Generally, most of the impact energy will be absorbed by two main longitudinal members with progressive folding deformation of the thin walled tubes. In this research work, energy absorbing tubes and beam are focused.

1.2.2 Function of a bumper system

The function of a bumper system is to minimize injury or damage by absorbing impact energy through elastic and plastic deformation during rear and frontal collisions with pedestrians, other vehicles and fixed obstacles at relatively lower velocities.

Legislative and insurance test procedures specify the conflicting requirements of a soft absorber for pedestrian safety with the following functionality:

- Prevent visible and structural damage due to low velocity impacts
- Minimize repair cost (insurance rating) due to medium velocity (15 km/hr) impacts.
- Manage load path and structural integrity for high velocity impacts to maximize occupant protection

1.3 Need of proposed research work

For improved frontal vehicle safety, it is essential to design a structure that will absorb sufficient energy in every realistic crash situation. For protection of the occupants, passenger compartment should not be deformed and also intrusion must be avoided. The available deformations distance in the front of the passenger compartment must be utilized completely for a predetermined impact velocity to prevent excessive deceleration levels. Thus in a given vehicle concept, the structure must have a specific stiffness. This is achieved with the introduction of the bumpers.

A bumper has a prime function of absorbing impact energy during a collision. There should be localized damage to the bumper in order to absorb impact energy of moving vehicle. The deformation in bumper will lower the deceleration pulse experienced by the passenger, thus the injury risk from impact. Vehicles have to pass the compulsory crash test as issued by the authorities. However, this test does not guarantee that vehicles are safe in crash situations that deviate from the prescribed one.

2.1 Solid Modeling

Solid modeling is the most advanced method of geometric modeling in three dimensions. Solid modeling is the representation of the solid parts of the object on your computer. The typical geometric model is made up of wire frames that show the object in the form of wires. This wire frame structure can be two dimensional, two and half dimensional or three dimensional. Providing surface representation to the wire three dimensional views of geometric models makes the object appear solid on the computer screen and this is what is called as solid modeling. Solid modeling (or modelling) is a consistent set of principles for mathematical and computer modeling of three-dimensional solids. Solid modeling is distinguished from related areas of geometric modeling and computer graphics by its emphasis on physical fidelity. Together, the principles of geometric and solid modeling form the foundation of computer-aided design and in general support the creation, exchange, visualization, animation, interrogation, and annotation of digital models of physical objects.

2.2 Problem statement

Bumper plays a big role to prevent more critical damage of the car. This problem based on the material has been used to make this bumper. The types of material play's a big role to influence the front car bumper condition after crashing.This study deals with material type that best suit to be a composite car bumper in order to absorption using supplementary attachment to optimize its performance in terms of energy and fulfill the aspect of strength, lightweight, and impact absorption along with the fatigue life of bumper.

2.3 3D CAD Models

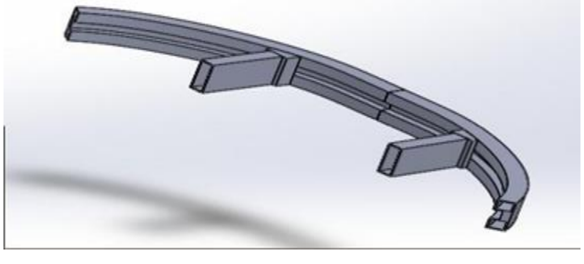


Figure 2:Metal Bumper beam **Figure 3: Fascia Model**

Imported geometry in ANSYS

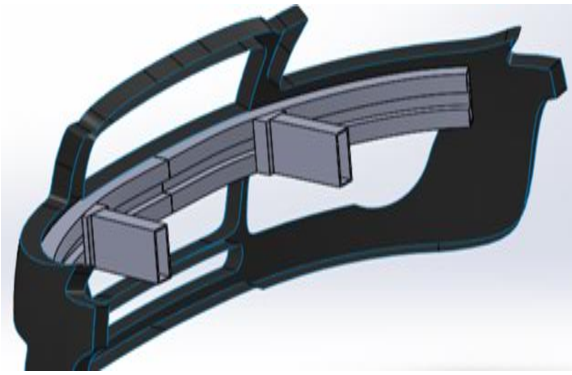


Figure 4:Complete Assembly of CAR Bumper

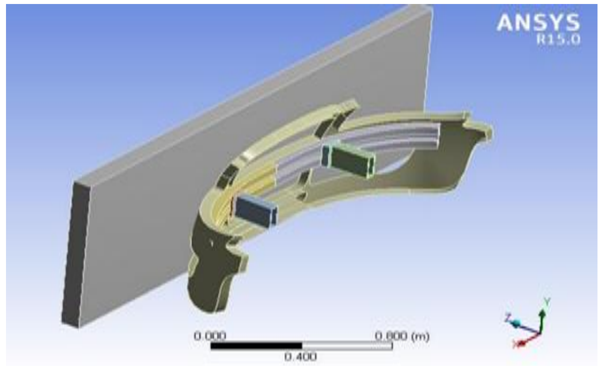


Figure 5:ANSYS Geometry window

2.4 Explicit Dynamics Analysis

An Explicit FEM analysis does the incremental procedure and at the end of each increment updates the stiffness matrix based on geometry changes (if applicable) and material changes (if applicable). Then a new stiffness matrix is constructed and the next increment of load (or displacement) is applied to the system. In this type of analysis the hope is that if the increments are small enough the results will be accurate. One problem with this method is that you do need many small increments for good accuracy and it is time consuming. If the numbers of increments are not sufficient the solution tends to drift from the correct solution. Furthermore this type of analysis cannot solve some problems. Unless it is quite sophisticated it will not successfully do cyclic loading and will not handle problems of snap through or snap back. Perhaps most importantly, this method does not enforce equilibrium of the internal structure forces with the externally applied loads.

Table 1: Velocity condition

Input type	Velocity
Coordinate system	**Global coordinate system**
X	0m/s
Y	0m/s
Z	16.67m/s(60kmph)

I.RESULTS AND DISCUSSION

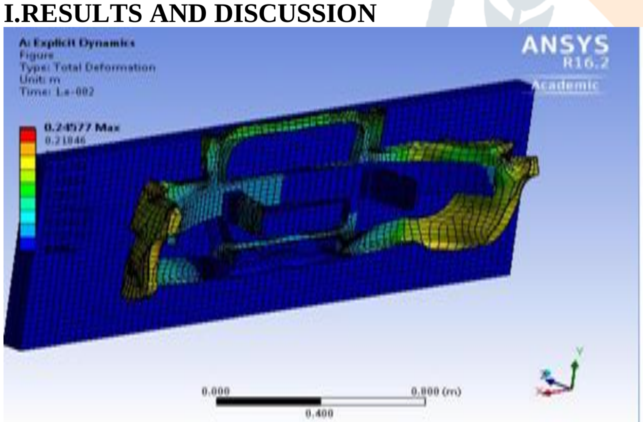


Figure 6:Deformation of bumper :

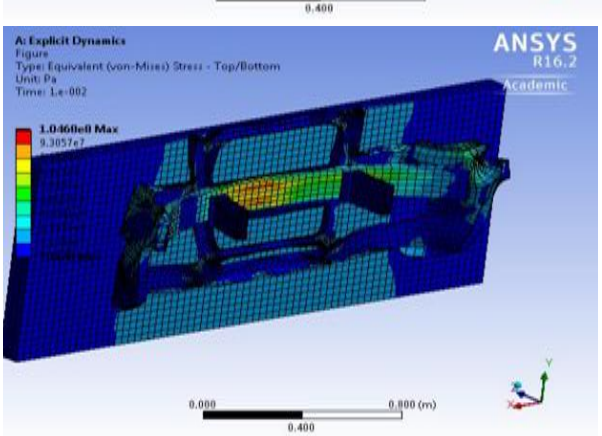


Figure 7:Von-Misses stress in bumper

3.1 Results of Mild steel

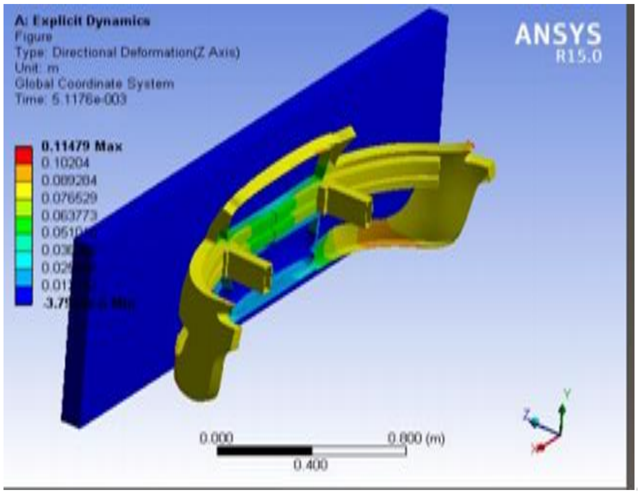


Figure 8:Directional deformation (Z axis)

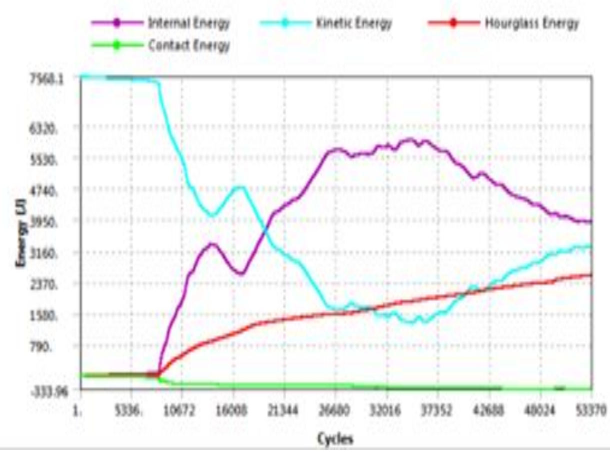


Figure 9:The Energy vs Cycle graph

3.2 Results of Aluminum Alloy

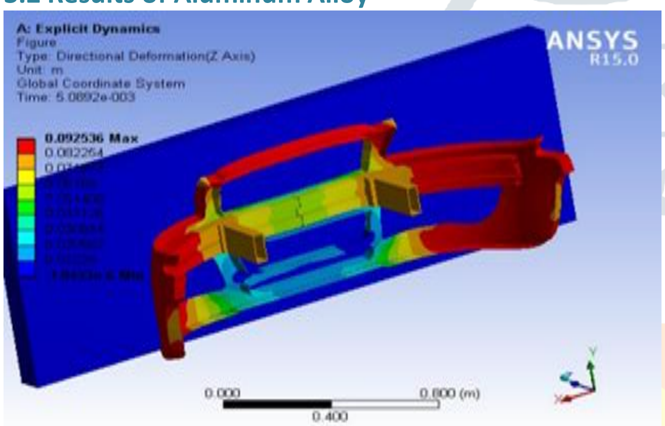


Figure 10:Directional deformation (Z axis)

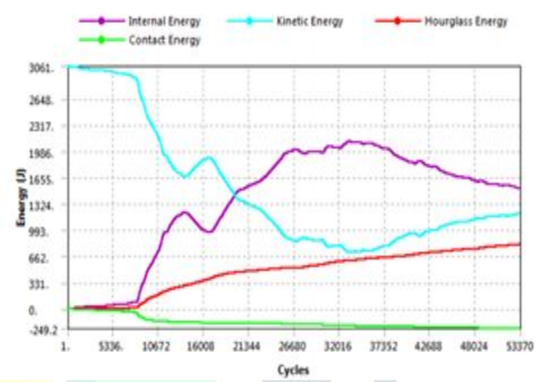


Figure 11:The Energy vs Cycle graph

3.3 Results of Magnesium Alloy

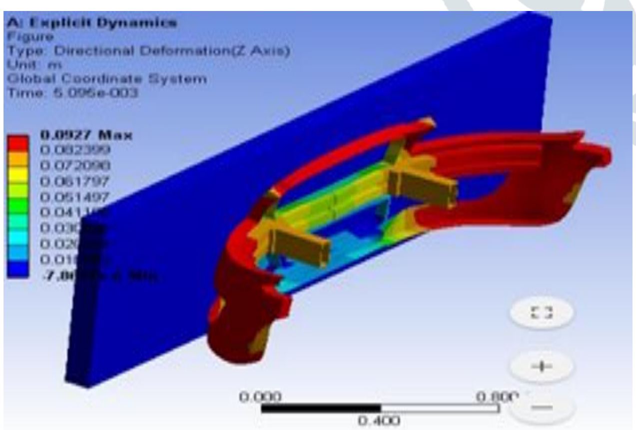


Figure 12:Directional deformation (Z axis)

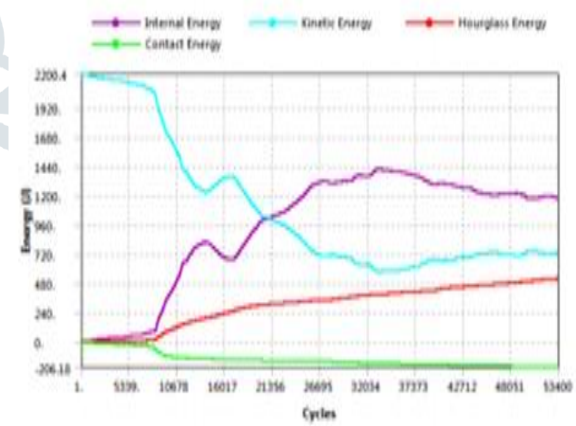


Figure 13:The Energy vs Cycle graph

3.4 Explicit Dynamic Results

Explicit Dynamic analysis result gives the information about total deformation, Equivalent stress and also energy absorption which is tabulated and shown in table

A) Total Deformation And Equivalent Stress

PARAMETERS	ALUMINIUM	MAGNESIUM	MILD STEEL
Total Deformation (m)	0.24577	0.24250	0.25392
Equivalent Stress (MPa)	104.68	105.84	364.39
Yield Stress (MPa)	280	193	250
Weight (Kg)	13.193	10.095	29.422

Table 1: Results of normal bumper

B) Energy Absorption

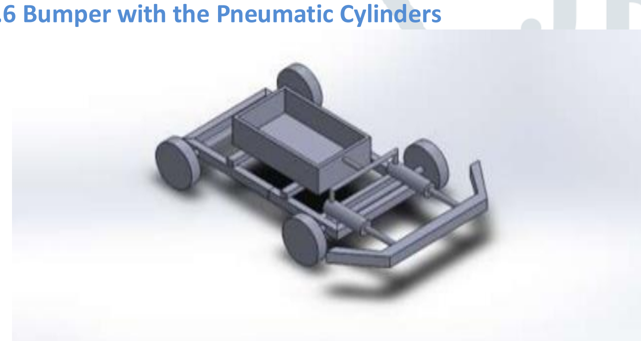
Parameter	ALUMINUM	MAGNESIUM	MILD STEEL
Cycles	19476.4	20822.1	1920
Kinetic Energy (KJ)	3061	2200.4	7568.1
Max Energy (KJ)	1423.23	1008	3792
Energy Absorbed (%)	46.69	45.80	50.01

Table 2: Energy absorption for normal bumper

3.5 Results of Bumper with Pneumatic Cylinder

This analysis carried out in ANSYS and the analysis done after the pneumatic cylinder actuator activated. When Pneumatic actuator activated bumper will maintain some distance with the car chassis body. Accordingly that phenomena we are carrying analysis and we are maintain some distance 25cm. The below cad model as per the specification we are designed

3.6 Bumper with the Pneumatic Cylinders



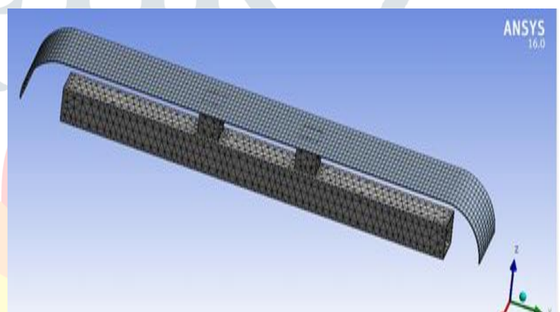


figure 14 : Meshed model

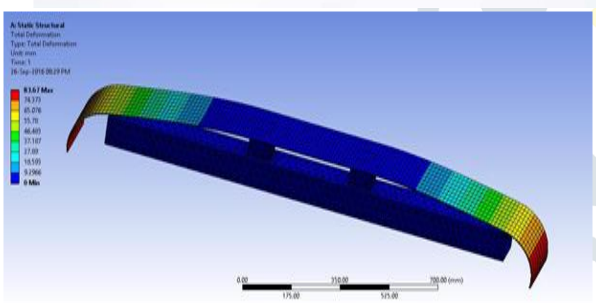


Figure 15:Total Deformation

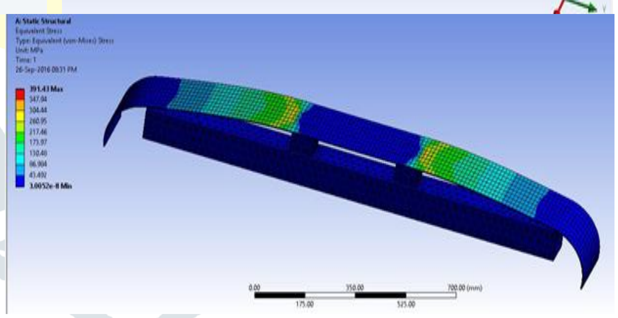


Figure 16:Von-misses stress

3.7 Explicit Dynamic Results

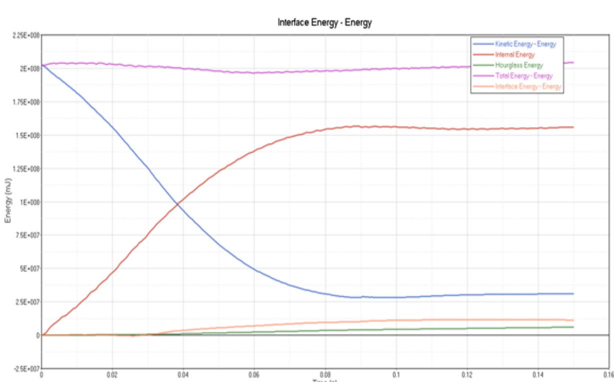


Figure 17:The Energy vs Cycle graph

3.8.Energy Absorption Table

Parameter	MILD STEEL	ALUMINUM
Kinetic Energy (KJ)	2258	2538.6
Max Energy (KJ)	1502	1459
Energy Absorbed (%)	66.52%	57.01%

3.9 COMPARISION RESULTS

	NORMAL BUMPER		PNEUMATIC BUMPER	
Parameter	**MILD STEEL**	**ALUMINUM**	**MILD STEEL**	**ALUMINUM**
Kinetic Energy (KJ)	7568.1	3061	2258	2538.6
Max Energy (KJ)	3792	1423.23	1502	1459
Energy Absorbed (%)	50.01	46.69	66.52	57.02

CONCLUSION:

In Explicit Dynamic Analysis energy absorption the maximum percentage of energy is absorbed by mild steel which is failed in equivalent stress and after mild steel it comes aluminum which absorbs about 46.69% energy that is higher than magnesium. So till now aluminum with appears to be best combination. In the Normal bumper Design.

In case of Pneumatic bumper Explicit dynamic analysis shows the maximum energy absorption observed in Mild steel but mild steel failed in equivalent stress so it comes aluminum which absorbs 57.02% energy.

When we compare both the analysis of normal bumper and pneumatic analysis in case of pneumatic bumper the energy absorption is increased almost 12% from the above result we conclude the pneumatic bumper is safe with aluminum bumper.

After considering all required criteria's and comparing all the results, we concluded that the best suitable material is aluminum. This is the final proposed solution of this project.

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