IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Comparative Analsis Of Impact Strength Of Polymer Based Composite Materials With Natural Fibres Material For Front Bumper Beam Of Automobile

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Abstract: Today, passenger safety is at the heart of every car manufacturer's concern. New standards are set for safety in a variety of collision conditions, such as frontal collisions, corner impacts, side effects, rear impacts and rollovers. In today's world, fuel consumption is also a serious issue to consider. Due to limitations, lighter and stronger composite materials are used in railways the front of the car compared to steel. Car carriers are usually made of heavy structural steel and have a relatively heavy weight. In this project, we can replace the front bumper of the car with good impact resistance or such material, but it can effectively reduce the weight of the car. Strength content can be configured best with polymer and metal matrix composites. From the polymer matrix, the material is used. From the metal matrix, a mixture of aluminum and magnesium is used. Hence in this study, a bumper has been designed and modelled in Creo software. The FEA is done for Impact strength using Polymer materials of Polyamide and Polyurethane. The alternative material of Bamboo Fibre and Deodar Fibre is proposed in Simulation.

***Index Terms* – Impact Strength, Polymer Composite Materials, Natural Fibre Materials.**

I. INTRODUCTION

A bumper is a shield made of a material such as steel, aluminum, rubber or plastic that is mounted on the front and rear of a passenger car. The function is that in the event of a collision at low speeds, the bumper system absorbs shock to prevent or reduce vehicle damage. Some fenders use energy absorbers or mounts and others are made of filler material

face. The car's bumper is designed to prevent or minimize further physical damage to the car. They are also designed to protect safety-related equipment such as hoods, trunks, grilles, fuel, exhaust and cooling systems, as well as parking lights, headlights and taillights in the event of a low-speed collision. It is not a safety device to prevent or reduce injuries to passengers in a passenger car. Crash car trips are designed so that the car can collide without causing significant risk to residents. Each car is surrounded by a wide rubber bumper that increases and spreads the collision force. [1]

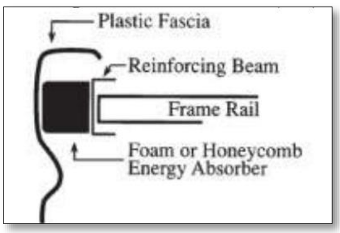


Figure1 Configuration of Common Bumper [1]

The main elements of this bumper are as follows:

- Front elastic band: Made of polypropylene (PEP) to reduce bad contact.
- Fascia: Refers to the aerodynamic shape of the bumper and acts as a bearing to retain the spring retaining system.
- Spring system: It has 26 vertical springs to convert kinetic energy into potential energy of spring, as well as 4 horizontal springs to connect the fascia to the base plate.
- Cone-shaped plates and bases: These are the main components of bumpers for energy absorption in high-speed communications (i.e. reinforcing beams).
- Attaching plastic parts: Two pieces of polypropylene (PEP) attaching to the car bumper base plate

II. Literature review

Dharmatija Kritiventi etc. Explains modeling and impact analysis of four-wheel drive bumpers: a pilot study. Most modern plastic bumper rims are made of thermoplastic olefin (TPO), polycarbonate, polyester, polypropylene, polyurethane, polyamide or a mixture thereof, for example, fiberglass, for structural strength and rigidity [1]. Yong Han et al. Explain the impact of vehicle collision speeds and the next size of vehicles on the risk of pedestrian injury. The purpose of this study was to examine the effect of vehicle collision speed, forward size of vehicles and pedestrian size on the risk of pedestrian injury in collisions [2]. A. Shiv Kumar etc. Demonstrates experimental inspection with milling box simulations of different segment cars using LS-DYNA. The main objective of this study is to design cracker boxes for different sections of the car and to verify its functionality by numerical simulation [3]. Gabriel Jiga etc. It states that in the event of a minor collision and obstruction between two vehicles or vehicles, the internal structure of the vehicle is irreparably damaged. To minimize the deterioration of the white chassis as much as possible, the new cars were equipped with so-called crash boxes on the front and rear of the car [4] Xie Xiao etc. Explains the crashworthiness design of bumper beams filled with functional foam. The automobile shock absorber beam is an important part of protecting residents and the vehicle from injuries and damage caused by a serious accident [5] Fuhao Mo et al. Explains the conceptual bumper energy absorbent design combined with pedestrian safety and low speed shock requirements. The aim of this study is to design a new type of self-adapted energy absorption unit for the front bumper system that can balance both performance. [6] Guibing Lee et al. Explains. The size of the front of the passenger car at risk of pedestrian injury was determined by detailed German accident statistics [7] Zhao Liu and others. Explains the lightweight design of an automotive composite bumper system using a modified particle swarm optimizer [8]. Muhammad Abdul-Beseth and others. Explains crash analysis of passenger car shock absorber assembly to improve crash test design [9]. SS Godara etc. Explains the analysis of the vehicle's next bumper beam using carbon fiber composite materials. In this current work, displacement and compression analysis and vehicle front bumper beam design are optimized by designing eight different cross-sections using software based on mechanical modeling [10].

\III. Problem Definition

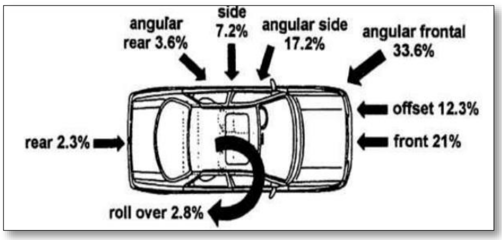


Figure 2 various types of Crash [3]

Many collision cases need to be investigated. For example, a front effect with different displacement values, a side effect of obstacles at different speeds, a low speed collision or a car flash. Nowadays, highly detailed models with a large number of components allow reliable predictions about occupancy performance.

Figure 3 Crash Boxes [3]

The collision component must convert the kinetic energy into tension energy in a controlled manner, provide adequate living space for the protected component, and maintain force and acceleration on the collision component. In cars, the incidence of frontal collisions is about 70%, including direct and overlapping frontal collisions. The bumper box is a component used in the frontal collision zone, usually inserted between the frame and the bumper. [3]

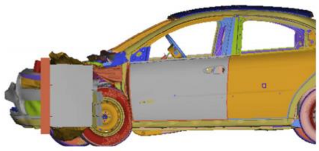


Figure 3 General Failure of Crush Boxes [5]

- Studies In several studies, the focus has been on finding the optimal cross-sectional shape of the collision box to ensure high energy absorption capacity without the collision edge. [4]
- Crush boxes use a variety of materials that can be recycled or joined together to form a component.
- It is a thin-walled construction and is therefore crushed by impact couplings that need to be replaced. It has been crushed so the absorption efficiency is low.

IV. Technical details

A. Bumper Beam Profile

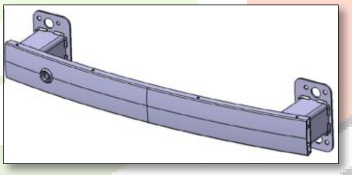


Figure 4 Computer Aided Model of Bumper Beam

Shock absorber is a structural component used in automobiles to absorb shock or sudden load, which is applied intentionally or unintentionally. The purpose of integrating the bumper is that when the vehicle is suspended from a sudden load or collision, it is used to absorb this shock energy and is beneficial to the occupants as well as the safety of the vehicle. In this study, bumper beam design for Tata Indica was considered to improve the design.

Table 1 Dimensional Parameter of the Bumper Beam

Parameter	Notification	Value
Length of bumper beam	L	1300 mm
Width of bumper beam	W	65 mm
Height of bumper beam	H	60 mm
Thickness of bumper beam	T	1.6 mm
Angle of bumper beam	ϴ	26^0

B. Specifications of Vehicle

Table 2 Specifications of Tata Indica

Parameter	Value
Max Power	60 PS @ 4500 rpm
Max Torque	105 Nm @ 2500 rpm
Overall Length (mm)	3685 mm
Overall Width (mm)	1625 mm
Overall Height (mm)	1485 mm
Kerb Weight (Kgs)	1400 Kg
Gross Vehicle Weight (GVW)	1800 Kg
Body Option	hatchback
Mileage (Diesel Fuel)	13.5 kmpl
Seating Capacity	4

C. Impact Forces :

Table 3 Impact Force Calculation for various Speeds

Speed (N) kmph	Kinetic Energy Joules	Deceleration (A) m/s^2	Impact Force (F) N
10	6944.44	27.78	50000
20	27777.78	55.56	100000
30	62500.00	83.33	150000
40	111111.11	111.11	200000
50	173611.11	138.89	250000
60	250000.00	166.67	300000
70	340277.78	194.44	350000
80	444444.44	222.22	400000
90	562500.00	250.00	450000
100	694444.44	277.78	500000

Using the results from the Table 3, the loading constraints for Static and Dynamics Analysis can be specified for Finite Element Analysis and simulation for explicit dynamics testing.

V. FINITE ELEMENT ANALYSIS

A. Purpose of Simulation :

- The main advantage of simulators is their ability to provide users with practical information when designing a real system.
- This allows the designer to determine the accuracy and effectiveness of the design before actually building the system.
- It gives an idea of the experimental environment using basic assumptions.
- This gives a clear idea of the effect of the component in specific test conditions.
- It gives results, without having to spend on expensive installers and qualified operators.

B. Ansys Loading :

Figure 6 Ansys Loading for Speed of 100 Kmph

The acceleration [a] is the part which consist of the force which is impacted to the component. The acceleration [a] is describes the velocity of the impactor. Force is actually the impact force [b] which is acting on the component by the impactor.

C. FEA of Bumper Beam for Polyamide:

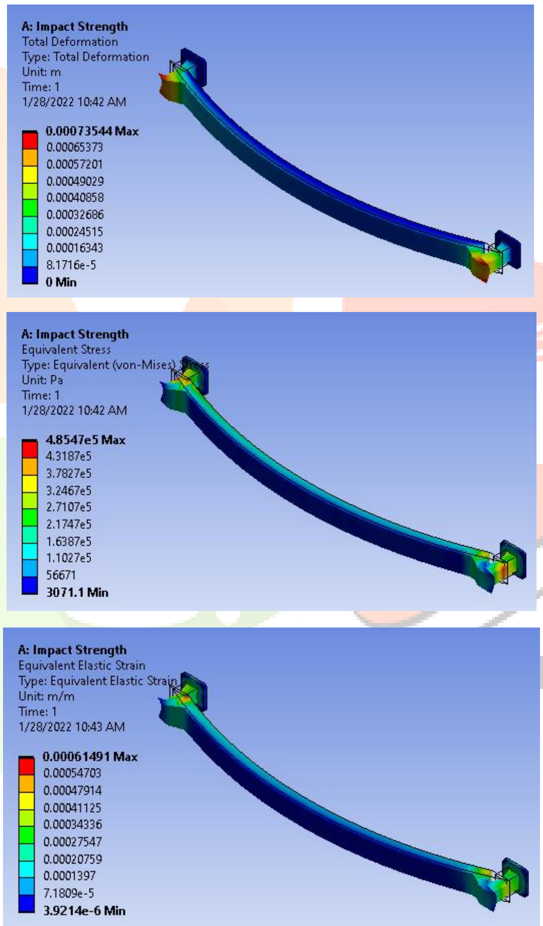


Figure 7 FEA of Bumper Beam for 100 kmph using Polyamide

The bumper beam is first considered using the material Polyamide hence the properties of the material is been upgraded as explained in the figure 7

- The Equivalent stress produced at 100 kmph is obtained as 0.48 MPa.
- The total Deformation is obtained as 0.73mm.
- The Equivalent strain generated for the deformation is produced as 0.0006149.

D. FEA of Bumper Beam for Polyurethane :

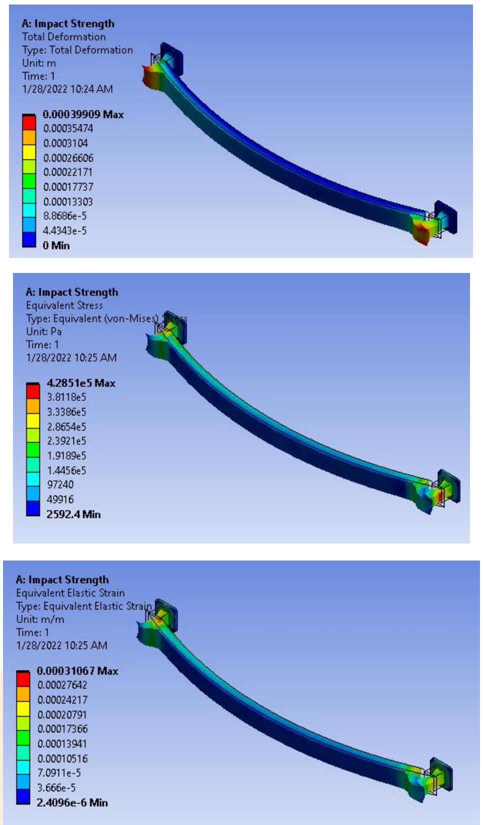
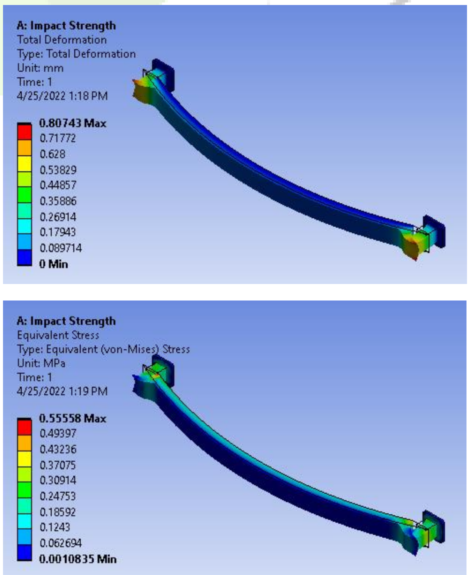


Figure 8 FEA of Bumper Beam for 100 kmph using Polyurethane

The bumper beam is secondly considered using the material Polyurethane hence the properties of the material is been upgraded as explained in the figure 8.

- The Equivalent stress produced at 100 kmph is obtained as 0.42 MPa.
- The total Deformation is obtained as 0.39 mm.
- The Equivalent strain generated for the deformation is produced as 0.000310

E. FEA of Bumper Beam for Bamboo Fibre:



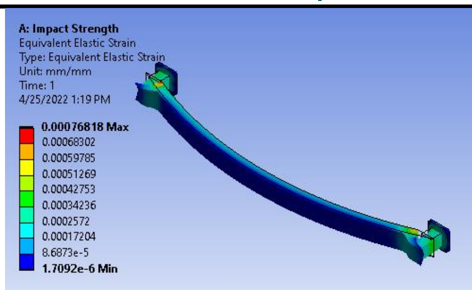


Figure 9 FEA of Bumper Beam for 100 kmph using Bamboo Fibre

The bumper beam is first considered using the material Polyamide hence the properties of the material is been upgraded as explained in the figure 5.10.

- The Equivalent stress produced at 100 kmph is obtained as 0.55 MPa.
- The total Deformation is obtained as 0.81mm.
- The Equivalent strain generated for the deformation is produced as 0.0007

F. FEA of Bumper Beam for Deodar Fibre:

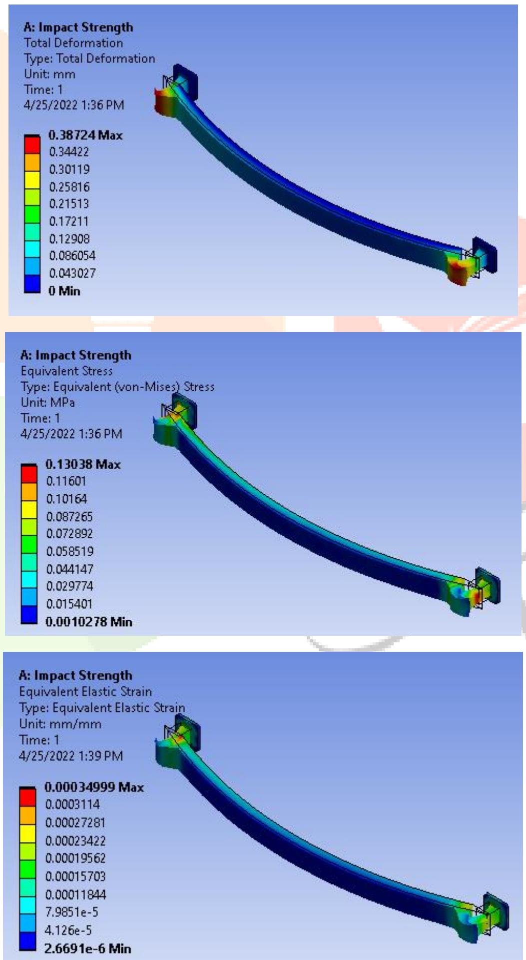


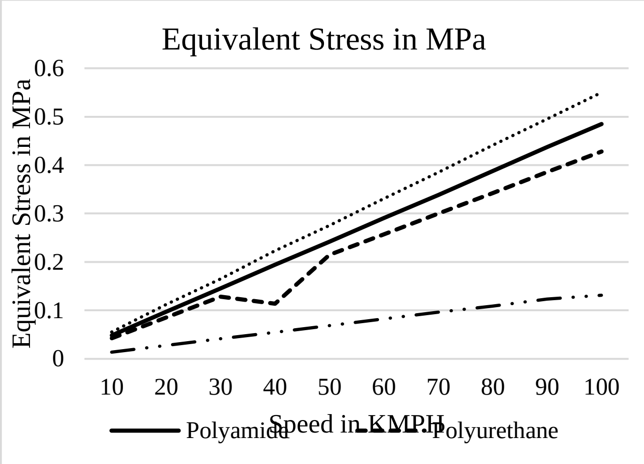
Figure 10. FEA of Bumper Beam for 100 kmph using Deodar Fibre

The bumper beam is first considered using the material Polyamide hence the properties of the material is been upgraded as explained in the figure 5.11.

- The Equivalent stress produced at 100 kmph is obtained as 0.130 MPa.
- The total Deformation is obtained as 0.38mm.
- The Equivalent strain generated for the deformation is produced as 0.0003

VI. Result and Discussion

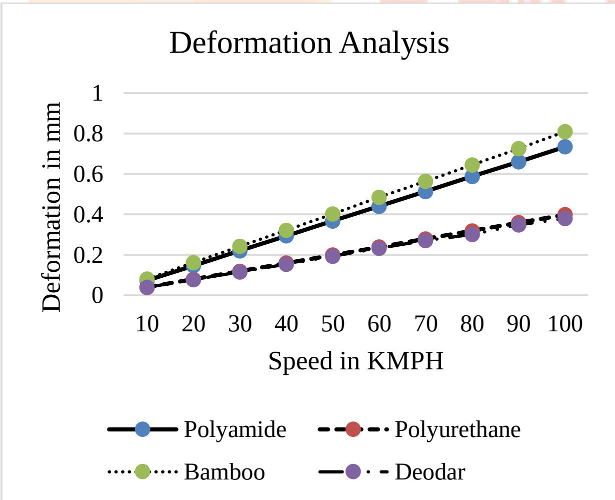
A. Response Analysis of Equivalent Stress :



Graph 1 Response analysis for Equivalent Stress Produced in Simulation

The above figure shows the nature and intensity of stress distribution in all the material. The amount of stress distribution is more in Bamboo fibre as that of other three materials. The graph shows the nature of stress generation which is maximum at the point of the deflection. As the bumper acts as beam which is supported by either two sides hence the stress concentration takes place at the fixing points. The difference in both the materials is slightly similar but bamboo fibre shows more stress concentration. Comparatively, no much difference is observed in the results, hence it also be said as bamboo and deodar fibre satisfies the criteria of strength so far as simulation is considered.

B. Response Analysis of Deformation:

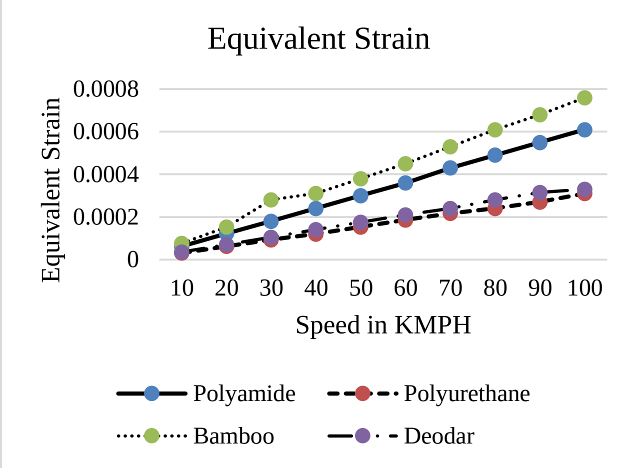


Graph 2. Response analysis for Deformation Produced in Simulation

Directional deformation can be put as the displacement of the system in a particular axis or user defined direction. Total deformation is the vector sums all directional displacements of the systems. From the above graph, it is seen that the deformation produced under different loading conditions for all the materials is similar. The design constraints for deformation of optimized material slightly varies to larger range, but as the numbers are below the decimals of zero, hence can be neglected and we can say that the Composites Satisfies the criteria for deformation. Whereas considering nature of deformation in terms of concentration, the intensity and core of all the material also looks similar.

C. Response Analysis of Deformation:

A scalar quantity called the equivalent strain, or the von Misses equivalent strain, is often used to describe the state of strain in solids. Strain defines, the change in shape and size at any location of the component. Strain is generally relation between deformation in magnitude and stress produced.



Graph 3. Response analysis for Strain Produced in Simulation

The strain generation is more for Bamboo and Polyamide as in case of Polyurethane deodar and Polyurethane material. The graph shows the difference in the readings which clearly explains the changes in the materials. As the impact speed goes on increasing the strain generation started increasing for all the materials but increases finely with Bamboo and Polyamide. The nature of strain shows similar up till the impact speed of 40 Kmph but as the speed goes on increasing the strain for polyamide increases rapidly.

VI. CONCLUSIONS

- Impact power and energy were calculated for different vehicle speeds for FEA performance.
- The main stresses caused by different loading conditions of polyamide and polyurethane are the same as other materials.
- The stress The Impact forces and energy for different vehicle speeds has been calculated for performance of FEA.
- The Principal Stresses produced under different loading conditions for Polyamide, Polueurathene, Bamboo and Deodar. The stress for Polyamide composites is finding out to be slightly more than other materials but as the values are very less in numbers and in decimals, hence the difference can be neglected.
- The deformation is similar for all the materials are comparatively similar. As the speed increase, the deformation in bamboo fibre starts increasing rapidly as that of Deodar fibre.
- The car bumpers are generally made of Polypropylene and carbon fibre composites. The cost of carbon fibre is generally more than the polypropylene but possess more strength. Hence in this study an attempt is made to study the impact strength of Polyamide, Polyurethane, and Bamboo and Deodar material considering the bumper strength.
- The approach is made to find the alternate material for polymer matrix component, so that the uneven manufacturing and material cost of the material can be decreased without affecting the strength of the material. Hence the Bamboo and Deodar fibre can be successfully used in bumper.
- There is still scope in the research work of preparing the bumper specimen in form of beam and validating the beam with bending impact test which can give more clarity in idea under practical situation.

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