International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 10 Oct. 2022, pp: 1131-1136 www.ijaem.net ISSN: 2395-5252

A Review on Virtual Crash Analysis of Front Bumper used for Hatchback Car

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Date of Submission: 15-10-2022 Date of Acceptance: 31-10-2022

ABSTRACT: Front can bumper not only provide aesthetic look to the car, but also it provides safety to the car passenger. It is generally made up by plastic, rubber, fiber material to withstand up to certain amount of impact. On higher impact it should collapse and should not create any damage on other car parts, body as well as passenger. Maximum impact force must be absorbed by the bumper. There are other several reasons why we use the plastic material for manufacturing car bumper.

The cost of the bumper is also an important factor which should be considered while the manufacturing. But the ultimate aim of the car bumper is to provide the maximum safety to the car passenger and other parts by absorbing maximum impact shock. While development of the bumper several tests are to be taken with different materials. Like vibration test, Crash test, Load test, Buckling Test etc. Results of these tests decide the usability of the bumper.

In this paper various literatures available on the virtual crash analysis of front, rear, side car bumper is reviewed and studied well. The further conclusion is drawn on the basis of results generated in the study.

KEYWORDS: Car Bumper, Vibration test, Crash test, Load test, Buckling Test

I. INTRODUCTION

In this paper i.ecamless engine, the valve motion is controlled directly by a electromagnetic actuator there's no camshaft or connecting mechanisms .Precise electromagnetic actuator or solenoid controls the valve operations, opening, closing etc. The project looks at the working of the electromagnetic actuator camless engine, its general features and benefits over conventional engines Since the invention of engine and till now four stroke IC engines are working on camshaft Mechanism. Although the conventional system has proven to be convenient and safe. Its fixed valve timing is necessarily a compromise of combustion stability, fuel economy and maximum torque objectives. Cam is an integral part of an engine as it controls valve actuation which in turn is responsible for supply of air-fuel mixture into the combustion chamber and for the removal of exhaust gases from the combustion chambers.

While no current-era automobile front suspension incorporates a physical kingpin, the axis defined by the steering knuckle pivot points acts a "virtual kingpin" about which the wheel turns. This virtual kingpin is inclined toward the centreline of the vehicle at an angle called the kingpin angle. Virtual or physical, the kingpin angle may also be referred to by its acronym KPA, kingpin inclination (KPI), or steering axis inclination (SAI), and remains a fundamental vehicle design parameter. On most modern designs, the kingpin angle is set relative to the vertical, as viewed from the front or back of the vehicle, and it is not adjustable, changing only if the wheel spindle or steering knuckles are bent. [1]

1.1. Types of Car Bumpers

Plastic Bumper: Most modern cars use a reinforced thermoplastic bumper, as they are cheap to manufacture, easy to fit and absorb more energy during a crash.

Boby Kit Bumper: Modified cars often now have a full body kit rather than just a front and rear bumper. These kits act as a skirt around the entire body of the car and improve performance by reducing the amount of air flowing underneath the car and so reducing drag.

Carbon Fiber Bumper: Carbon fiber body work is normally the thing of super-cars, but many car companies, and specialist modifiers, are starting to use it for replacement body part on everyday cars. This is because it is very light and is safe during a

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crash. It is, however, a lot more expensive than normal thermoplastic.

Steel Bumper: Originally plated steel was used for the entire body of a car, including the bumper. This material worked well, as it was very strong in a crash, but it was very heavy and dented performance. As car engine design has improved, steel bumpers have pretty much disappeared for anything except classic cars. [1]

GMT has rate dependant properties, which is due to the viscoelastic properties of Polypropylene which is used as matrix in the material. As a result of this viscoelastic behavior, the strength (and energy absorption) at practically encountered deformation rates in crash loaded automotive parts is significantly higher than the "quasi¬-static" strength measured at an elongation rate of 0.001 (1/s).

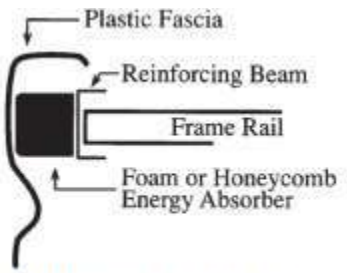

Fig. 1: Configuration of Common Bumper Type [1]

The main elements of this bumper are as follows:

- Front rubber tape: that is composed of polypropylene (PEP) for damping of poor contacts.
- Fascia: it indicates the aerodynamic form of the bumper and is used as a bearing for spring system retainer.
- Spring system: it contains 26 vertical springs for converting the kinetic energy to the spring potential energy, In addition to 4 horizontal springs for connecting the fascia to base plate.
- Conics and base plate: they are main elements of the bumper for energy absorbing in high speed contacts (i.e. reinforcing beam).
- Connecting plastic parts: two propylene (PEP) parts that connect the bumper base plate to the car. [1]

II. LITERATURE SURVEY

DharmatejaKruthiventi, 2 M. Venkaiah, "Modeling and Impact Analysis of Four Wheeler Car Bumper: An Empirical Study". The majority of modern plastic car bumper system fascias are made of thermoplastic olefins (TPOs), polycarbonates, polyesters, polypropylene, polyurethanes, polyamides, or blends of these with, for instance, glass fibers, for strength and structural rigidity. Bumper is an important part which is used as protection for passengers from front and rear collision. Bumpers play an important role in preventing the impact energy from being transferred to the automobile and passengers. Saving the impact energy in the bumper to be released in the environment reduces the damages of the automobile and passengers. The use of plastic in auto bumpers and fascias gives designers a tremendous amount of freedom when it comes to styling a prototype vehicle, or improving an existing model. Plastic bumpers contain reinforcements that allow them to be as impact-resistant as metals while being less expensive to replace than their metal equivalents. His paper describes the structure and material employed for car bumper in one of the car manufacturer. In his study, the most important variables like material, structures, shapes and impact conditions are studied for analysis of the four wheeler car bumper beam. [1]

T.Krishnamoorthi, R.Girimurugan, M.Vairavel, S.Elango, D.Karthick, V. Muthurathnagiri, 7S.Velusamy, "Design and Impact Analysis of Automobile Front Bumper Beam by Varying Materials". Front and rear collision is consistently taken over by a main part of an automobile vehicle which is called bumper beam. In thEIR study, impact analysis on a typical automobile front bumper beam was carried out successfully by varying the materials. The ultimate objective of their analysis is to design an automobile front bumper beam and establish the different impact behavior of the bumper beam by varying the material. In their analysis, bumper material was varied and the corresponding impact behaviors were studied on bumper beam with the aim of material optimization. The imitation and impact analysis of an automobile front bumper beam is distinguished by impact modeling using CREO modeling software and ANSYS 18.1 software to establish the results. Different impact analysis outputs were established and compared with each other for three bumper beam materials through ANSYS 18.1 software. Impact analysis results revealed that the superior impact behaviour was found in Carbon fiber F300 material which is higher than other two materials. [2]

Nitesh joshi*1 Rupesh tiwari 2 G.V.R.Seshagiri Rao3, "Design and analysis of Front Bumper for Light Passenger Vehicles". Bumper is one of the main parts which are used as protection for passengers from front and rear collision. The aim of their study is to analyze and study the structure and material employed for car

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bumper in one of the car manufacturer. In this, the most important variables like material, structures, shapes and impact conditions are studied for analysis of the bumper beam in order to improve the crashworthiness during collision. The model of the bumper is drawn in Ansys 14.0 considered thickness as 10 mm. Structural analyses has been performed for all the two cases and the results obtained are compared with the standard previous results. [3]

Lu Weia, Yao Jiab,* Liu Xiangdongc, Xing Leid, LvXingwange, Yao Jingf, "Optimization Design of Inner Structure and Material of Cars Front Bumper Based on Finite Element Method". The ideal design of the bumper should take full advantage of the bumper plastic deformation to absorb most crash energy in automobile collisions. In their paper, the bumpers with different inner structure (circular cross section form and honeycomb cross section), different materials (Al alloy, structural steel and polyethylene) have been researched by finite element method. The simulation of the bumper deformation in the collision process through simulation calculation has been obtained. The collision resistance of the bumper has been evaluated, and the cross section shape and material parameters have been optimized. When the simulation method used for the enterprise design bumper, the design cycle, test times and costs saving can be reduced effectively. [4]

R. Sampathkumar, "Design and Analysis of Automobile Bumper". A good design of car bumper must have optimized weight and must provide safety to passengers. Different countries have different performance standards for bumpers. Under the International safety regulations originally developed as European standards and now adopted by most countries outside North America, a car's safety systems must still function normally after a straight-on pendulum or moving-barrier impact of 4 km/h (2.5 mph) to the front and the rear, and to the front and rear corners of 2.5 km/h (1.6 mph) at 45.5 cm (18 in) above the ground with the vehicle loaded or unloaded. Due to increasing competency now a day's tests are carried out at some higher velocities such as 10 m/s to increase the safety level of vehicle. Increased safety of vehicle helps to claim for larger insurance amount. Automotive development cycles are getting shorter by the day. With increasing competition in the marketplace, the OEM's and suppliers main challenge is to come up with time-efficient design solutions. Researchers are trying to improve many of existing designs using novel approaches. Many times, there is conflicting performance and cost requirements, this puts additional challenge with R&D units to come up with a number of alternative design solutions in less time and cost compared to existing designs. These best solutions are best achieved in a CAE environment using some of the modern CAD and FEM tools. Such tools are capable of effecting quick changes in the design within virtual environment. [5]

Laxmikant G Keni, Vaibhav Singh, Navjoth Singh, Akash Thyagi, Sagar Kalburgi &Chethan K N, "Conceptual design and analysis of a car bumper using finite element method". The automotive bumper beam is one of the essential components in passenger cars. Bumper beams reduce or minimize the extent of impact caused at the front and rear ends during a collision in passenger vehicles. It absorbs the impact energy. The important physical parameters in the bumper beams such as material, size, and design to improve the extent of crashworthiness are studied and discussed in their work. Comparative analysis between 2 mm thickness and 4 mm thickness bumper with honeycomb structure is studied. An ideal design composition is considered. This helps in advanced safety precautions. [6]

K. Kiranmai 1, B. Anjaneyulu2, K. Kiran Kumar Rao3, G.Nagamalleswara Rao4, "Design and Analysis of Four Wheeler Car Bumper". The goal of their paper is to design a bumper with minimum weight by employing the Glass Material Thermoplastic (GMT) materials. That bumper either absorbs the impact energy with its deformation or transfers it perpend icular to the impact direction. To reach this aim, a mechanism is designed to convert about 80% of the kinetic impact energy to the spring potential energy and releas e it to the environment in the low impact velocity according to American standard. In addition, since the residual kinetic energy will be damped with the infinitesimal elastic deformation of the bumper elements, the passengers will not sense any impact. It should be noted that in their paper, modeling, and result's analysis are done in Pro -E and ANSYS software respectively. [7]

Maheshkumar V. Dange1, Dr. Rajesh. B. Buktar2, Dr. Nilesh. R. Raykar3, "Design and Analysis of an Automotive Front Bumper Beam for Low-Speed Impact". Automotive bumper beam assembly plays very important role in absorbing impact. In their paper, the most important parameters of an automotive front bumper beam such as material, shape and impact condition are to be studied to improve the crashworthiness. The simulation of bumper beam is done under low-velocity impact as per the standards of automotive

stated in E.C.E. United Nations Agreement, Regulation no. 42, 1994. The strength of the bumper beam in elastic mode is investigated with energy absorption and impact force in maximum deflection situation. Similar bumper beams made of different materials are simulated to determine the deflection, impact force, stress distribution and energy-absorption behavior, these characteristics are compared with each other to find best choice of material. The results show that a M220 material can minimize the bumper beam deflection, impact force and stress distribution and also maximize the elastic strain energy. In addition, the effect of passengers in the impact behavior is examined. The time history of the calculated parameters is showed in graphs for comparison. [8]

Nitin S. Motgi, P.R. Kulkarni, Sheelratan S. Bansode, "Design Improvement in Front Bumper of a Passenger Car Using Impact Analysis"-A Review. Car accidents are happening every day. We must take into account the statistics – ten thousand dead and hundreds of thousands to million wounded each year. These numbers call for the necessity to improve the safety of automobiles during accidents. Automotive bumper system is one of the key systems in passenger cars which helps to protect the vehicle during impacts. Their paper deals with the design improvements in the front bumper of passenger cars in India, using impact analysis. The modification will be made considering size, shape and material. [9]

Manjeet Singh Pathania, Akash Chaturvedi, Archittomar, "Design and Analysis of Automotive Bumper Using Polymer Composites". Automobile bumper subsystem is a frontal and rear structures of the vehicle that has the purpose of energy absorption during low velocity impact. The bumper beam is the main structure for absorbing the energy of collisions. Automotive bumper beam is one of the key system in car. Bumper beam design to prevent or reduce physical damage to front or rear end of the Motor vehicle in collision conditions they protect the hood, trunk, grill, fuel, exhaust and cooling system as well as safety related equipment such as the parking light, head lamp and tail light etc. A good design of the car bumper must provide safety for passengers and should have low weight. [10]

Gandla Pradeep, P. Chandra kumar, "Design And Experimental Analysis On Car Bumper With Composite Materials". The main criteria of the project is to minimize the cost & increase the strength of the bumper by using composite materials. Design should be under attention of safety of the passenger meanwhile with low weight. In point of safety, efficiency & emission gas regulation are very important in recent years that enforce the manufacturer to reduce the weight of passenger cars. For the design & analysis of a bumper chosen with composite material of Carbon fibre& Jute fibre with low cost and good strength. Study done by using software solid works & Ansys. Tests done on bumper is Tensile strength and Impact analysis. [11]

Tushar Kale1, Gaurang Gulwade2, "Study and Design of Front Bumper for Light Motor and Heavy Motor Vehicles". In their research paper they have discussed about structural changes and component by putting which we can make bumpers stronger and more effective, design analysis of that component. [12]

T.ganapathi rao1, P.J.kiran, "Design and Impact Analysis of Car Front Bumper". Bumpers play an important role in preventing the impact energy from being transferred to the automobile and passengers. In their work, a bumper used for light motor vehicle is used for our analysis purpose. This bumper either absorbs the impact energy with its deformation or transfers it perpendicular to the impact direction at different speeds (40, 60, 90 and 100 km/hr). The materials used for these analyses are Aluminum B390 alloy, Mild Steel and Glass Mat Thermoplastic (GMT) materials. Static & impact analysis is to determine the deformation and stress of the car bumper. Modal analysis is to determine the natural frequency and deformation for mode shapes. [13]

E. S. Roopesh, L. Bhaskara Rao, "Design and Analysis of an Automotive Frontal Bumper Beam for Low-Speed Crashes". The crash analysis is performed on bumper by considering aluminum and composite materials in order to compare the deflection and Von-mises stresses in order to know the behavior of impact. In maximum deflection situation, under the elastic mode the strength is investigated with impact force and energy absorption. Designing a bumper beam of automotive should be good enough in order to provide the safety of passengers, which should also be of low weight to improve the efficiency of the passenger car. Apart from the safety factor, gas emission and fuel efficiency regulations are also considered importantly which gives the advantage to the manufacturer in weight reduction of automotive. [14]

Yeswanth S, Dr. G. Swaminathan, Mr.S.D.Kumar, "Design and Dynamic Impact Analysis of Front Frame Bumper". In their paper, the modification of an existing front inner bumper of a passenger automobile is described in their study. Scanning the generated bumper with the ATOS-GOM three-dimensional scanner yielded the

CAD cloud geometrical data. IMPACT, a dynamic explicit time stepping algorithm program, was used to conduct the impact study. The program was initially tested against known experimental findings of a beam impacting at a low velocity. With a fluctuation of 1.6 to 9.5 percent, the simulated and experimental findings of the deflected beam were substantially close. The genuine bumper was then subjected to two impact simulations: a 40 percent offset collision and a complete frontal collision. Collisions were attempted at speeds of 48 km/h, 64 km/h, and 110 km/h. The data was used as a benchmarking tool to improve the bumper's performance. Two different design modifications were attempted. Internal energy adsorbed increases significantly in both design A and B. Despite the fact that both designs absorb more energy, design B is superior in every manner. [15]

Akash Kulkarni, Rushabh Vora and K Ravi, "Study design and analysis of automobile bumper for pedestrian safety". Their paper aims to design and analyse the bumper beam structure, in order to ensure the protection of the pedestrians along with the occupants inside the vehicle. The concern shown towards the pedestrian safety is because, each year about 2,70,000 pedestrians are killed in road accidents that accounts to 22 % of the total deaths. From the literature review, it was inferred that the mounting position of bumper and material selection play a crucial role in maximising the pedestrian safety. Hence in this paper, the effects of bumper mounting position and the bumper beam material have been studied, with reference to an explicit dynamic collision involving with a dummy human lower leg set-up. The acceptance of a particular mounting position/material was based on the fact that the maximum stress and deformation induced were less than the yield limits of the human leg form structure (representing the skin, femur and tibia). [16]

III. CONCLUSION

By studying all above research and papers following conclusions are drawn.

1) Several study literatures are available on the crash test of car bumper.
2) Comparision of different bumper material is to be focused for obtaining best suitable material.
3) Buckling and vibration effects are also to be considered while analyzing bumper.
4) It is observed that the vibrations are also responsible for failure, Hence large scope is available to study vibrations on Bumper.

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