MODELING AND SIMULATION OF FASCIA CRASH ANALYSISANGLES USING LS-DYNA

Dr. B. Ravi Associate Professor, Department of Mechanical Engineering, Swarna Bharathi Institute of science & Technology, Khammam, TS- 507002, India.
Dr. G. Raja Kumar Professor, Department of Mechanical Engineering, Swarna Bharathi Institute of science & Technology, Khammam, TS- 507002, India.
Email id's: bravi1234@gmail.com, rajkumardotcom@yahoo.com

Abstract

Automotive bumper beam assembly plays very important role in absorbing impact energy and protects passengers from front and rear collisions. A crash-test is a form of destructive testing usually performed in order to ensure safe design standards in crashworthiness and crash compatibility for automobiles or related components. The simulation of vehicle crashes by using computer software's has become an indispensable tool for shortening automobile development time and lowering costs. This project reports on the simulated crash test of car frontal fascia. The model used here was that of a Toyota Camry 2012 passenger car. The car fascia is designed in AUTOCAD version 14.0 with thickness of 2.15 mm. The designed car fascia was meshed in HYPERMESH-12 with mixed elements of size 4 mm for getting better accuracy and simulated in LS-DYNA. The results are interpreted by using LS-PREPOST to analyze the energy absorption characteristics during crash for different materials at a velocity of 30mm/ms which is approximately 108 km/hr for the duration of 15ms. The project is carried out for three cases and they are different material models, constant velocity for particular selected material model and using same thickness for particular material model. With the help of LS-DYNA codes nonlinear dynamic contact analysis by using different materials can be done effectively and accurately. The results found that steel material absorbs maximum internal energy of 88.25% followed by aluminium and plastic materials with 82.28 and 72.23% respectively. This is because steel has high Young's Modulus when compared to aluminum and plastic material and impact force distribution is uniform in steel material.

Keywords: Car Frontal Fascia, Hypermesh, LS-DYNA, Energy Absorption Characteristics, Crash Test.

Introduction

A metal Facebar system consists of a single metallic bumper that decorates the front or rear end of a vehicle and acts as the primary energy absorber in a collision. The bumper regulations in the United States require passenger cars to withstand a 2.5 mph (4 km/hr) impact at the curb position plus or minus two inches (50 mm) with no visual damage and no damage to safety related items. The North American OEMs voluntarily design their passenger car bumpers to withstand a 5 mph (8 km/hr) impact with no visual damage and no damage to safety items. Current facebar systems can only withstand a 2.5 mph (4 km/hr) impact at the curb position plus or minus 2 inches (50 mm) with no visual damage and no damage to safety items. For this reason, the use of current facebar systems is restricted to light trucks, often to meet voluntary internal OEM design standards. The aesthetics of facebars match the styling trend for full size vans, pickups and sport utilities. Thus, most facebars are presently being applied to these vehicles. If the voluntary internal OEM design standard for light truck bumpers were to rise to the 5 mph (8 km/hr) voluntary passenger car standard, then the facebar systems used on full size vans, pickups and sport utilities would have to be redesigned. For the reason of weight, such redesigns would likely revert to systems that employ a reinforcing beam. This consists of a plastic fascia and a reinforcing beam that is fastened directly to the vehicle frame or motor compartment rails. It is primarily used for rear bumper systems in passenger cars since the crash requirements are less severe and there is less need for mechanical energy absorbers and foam. Bumper systems with a plastic fascia, reinforcing beam and energy absorption systems are the most common type of bumper system in North America. They are used on both front and rear bumper systems and readily meet the 5 mph (8 km/h) voluntary bumper standard set by North American

OEMs. While most passenger cars, SUVs, crossovers, and minivans, have this type of bumper system, the energy absorption method varies.

Statement of the Problem

The term Car crash also known as a traffic accident (motor vehicle collision, motor vehicle accident, car accident, automobile accident, road traffic collision, or car smash) refers to the general term used for a traffic accident involving collisions or impact between an automobile and another automobile, collision between vehicle and roadside hazards, pedestrians, or animals Roadside hazard is a stationary obstruction by the side of a road that could increase the probability of vehicle crash or occupant injury or fatality if a motor vehicle leaves the roadway. The fixed obstructions may include trees, utility poles, luminaries supports, sign posts, bridge rails and end treatments, fences, embankments and cuttings, ditches, guard rails (and guard rail end treatments), mail boxes and drainage structures. A crash-test is a form of destructive testing usually performed in order to ensure safe design standards in crashworthiness and crash compatibility for automobiles or related components. To test the cars safety performance under various conditions and during varied types of crashes, vehicle manufacturers crash test their cars from different angles, different sides and with different objects, including other vehicles.

Objectives of the study

- Automotive homologation is the process of certifying vehicles or a particular component in a vehicle that it has satisfied the requirements set by various statutory regulatory bodies. It is mandatory to get this approval to export automobile products or components. Homologation standards are applicable to all kinds of automobiles especially in the areas of environment and safety.
- Prior to sales of motor vehicles, automotive systems and their components should necessarily have approvals according to the official standards of their destination countries to access the permission for driving the vehicle on the streets it needs to obtain homologation. Standard homologation procedures require demonstration of vehicle safety test known as "crash test analysis".
- To achieve maximum safety for occupant, also for the pedestrians we need to do crashworthiness of a vehicle, so Euro NCAP has prescribed various standards according to which crash test of vehicle have to perform. Here without considering the whole vehicle for analysis, only a bumper beam system is taken, to minimize the computational work and errors.

Review of Literature

Dynamic characteristics and leakage performance of liquid annular seals in centrifugal pumps EskildStorteig[1] Department of Marine Engineering Norwegian University of Science and Technology NTNU Submitted 99 defined we create the blade in the blade gen technology where we assign the values of the blade to be generated. Multiphase Pumping: Achievements and Perspectives J. Falcimaigne et al.[2] observed turbo mesh should be created as the turbo mesh is generated only with the optimization of the blade without any error in the blade or the created impeller body. Optimum values of design variables versus specific speed for centrifugal pumps, H.W Oh et al. [3], "Centrifugal pumps and blowers" Metropolitan book Co. Pvt. Limited analyzed these numerical experiments on the centrifugal pump gives the reference for the numerical experiments that we are doing in the number of blades that we are keeping in the impeller. Lazarkiewiz **[4] i**n this paper they discussed about the impellers and the pumps design when compared to the centrifugal and other Rota dynamic pumps. This paper shows how the impeller design should be kept in the centrifugal pumps with the minimum number of blades. Effect of Reynolds-number and surface roughness on the efficiency of centrifugal pumps J.F. Gülich and Sulzer[5] defined a turbulent steady flow through a volute casing of a centrifugal pump for static pressure distribution"In this paper the static pressure distribution of a centrifugal pump is analysed by CFD. Yagnesh Sharma.N, and KaranthK.V. 2003[6] As from this reference we have done investigation on the velocity parameters of an impeller blade using (Computational fluid machinery) CFX by varying the number of blades in the impeller and the blade angles to increase the velocity parameter and efficiency of the fluid flow.

Research Methodology

For simple geometries such as simply supported beams or cantilever beams it is easy to visualize point of maximum stress and displacement. But in real life for parts or assemblies with complex geometrical shapes, made of different materials with many discontinuities subjected to flexible constraint, complex loading varying with respect time and point of application, further complicated by residual stresses and joints like spot and arc welds etc., it is not easy to predict failure location. Imagine someone shoes you a complicated engine block unless and until you have years of experience in the similar field. But with tools like CAD & CAE, if modeled in appropriate fashion, one can easily get stress contour plots clearly indicating locations of high stress or displacement.

CAE plays an important role in reducing no. of prototypes. Test results of the first prototype are compared with finite element model. 10 to15% difference in FEA & experimental result is considered as good correlation. FE model behaving in the same way as predicted by test is key to success. Now further permutations and combinations (like changing thickness, material, fillet, addition of ribs etc.) could be performed by very fast and in optimum way with the help of CAE as shown in Figure 1.

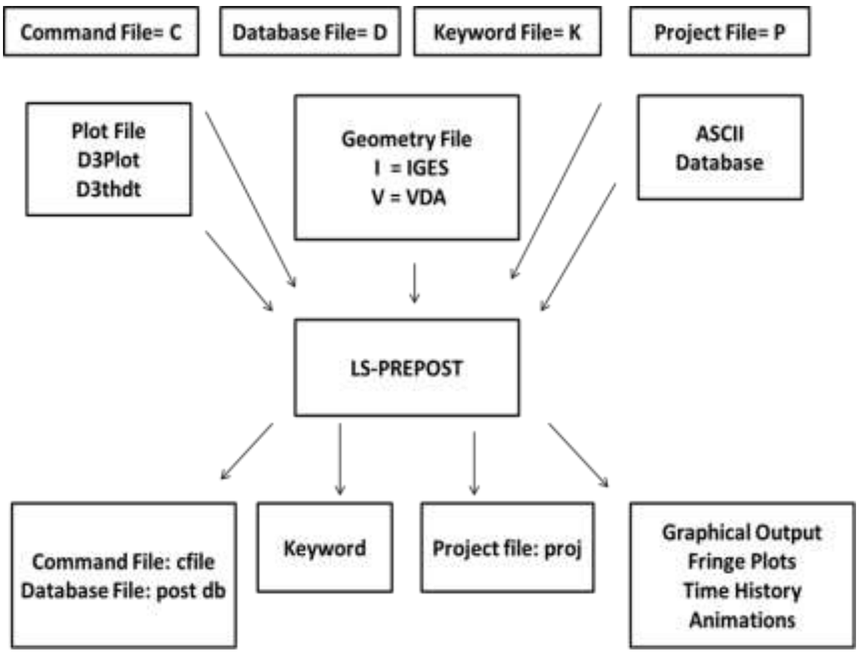

Figure 1: File Organization in Ls- PrePost

Results:

Toyota Camry 2012 model car fascia is taken which is designed in Auto CAD. The file then exported to Hypermesh software for meshing purpose. To import the file in hypermesh the file should be in .hm format. The imported file in hypermesh window in shown the Figures 2- 4.

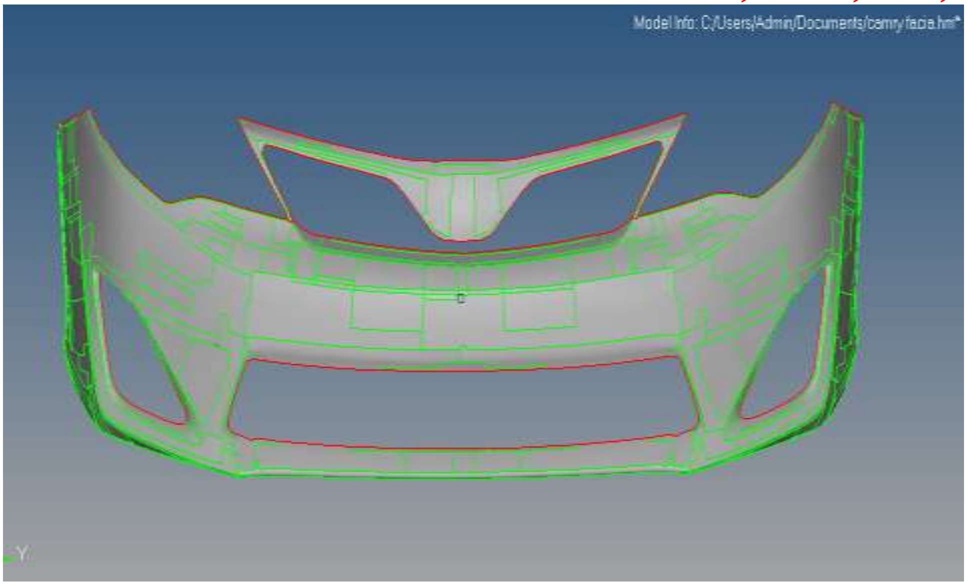

Figure 2: Designed Model of Toyota Camry Fascia

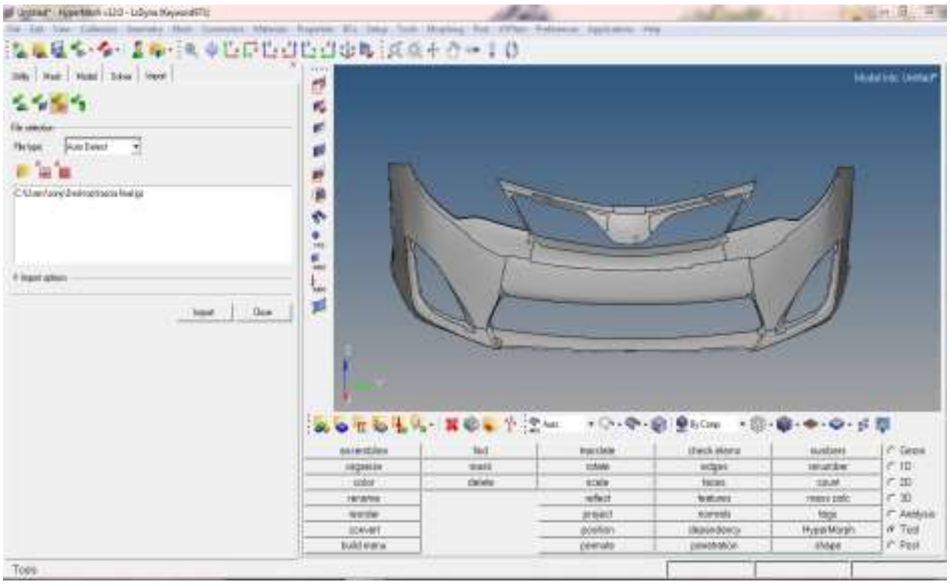

Figure 3: Toyota Camry Fascia Imported in Hypermesh

The imported fascia is not meshed directly. First, a mid surface is extracted because mathematically element thickness (specified by user) is assigned half in +Z axis (element top) and half in -Z axis (element bottom). Hence, for appropriate representation of geometry via 2-d mesh it is necessary to extract mid surface and generate nodes and elements on the mid surface. The thickness of fascia is 2.15 mm. The meshed fascia consists of 18182 nodes and 17675 elements throughout its surface. The size of element maintained throughout meshing is 4 mm.

Different quality parameters like skew, aspect ratio, included angles, Jacobian, stretch etc are the measures of how far a given element deviates from ideal shape. Square means all angles 900 and equal sides, while equilateral triangle is all angles 600 and equal sides. Some of the quality checks are based on angles (like skew, included angles) while others on side ratios and area (like aspect, stretch)

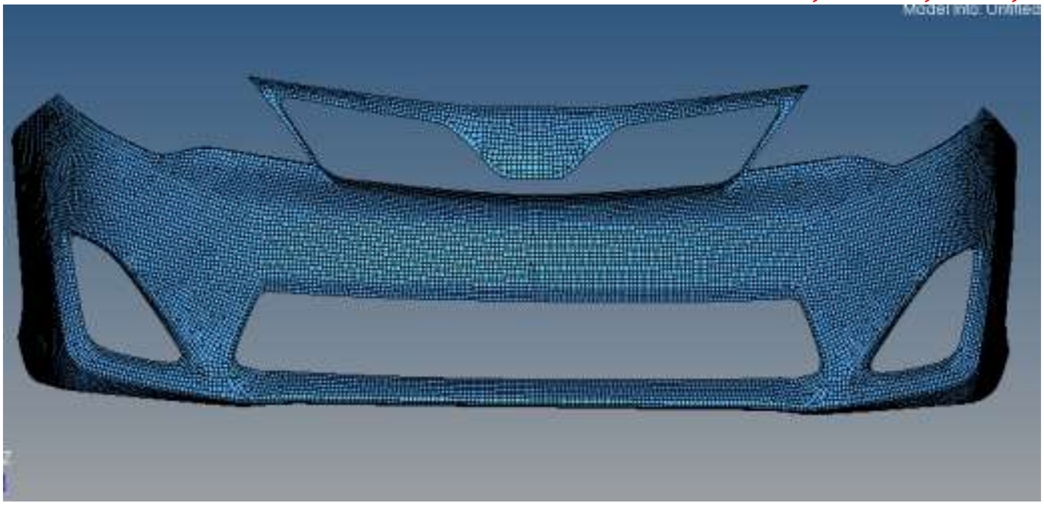

Figure 4 Toyota Camry Fascia Meshed in Hypermesh

Table 1 Mesh Quality Parameters

						trias:		
warpage	>	5.000	length	<	7.500	min angle	<	20.000
aspect	>	5.000	length	>	20.000	max angle	>	120.000
skew	>	60.000	jacobian	<	0.700	quads:		
chord dev	>	0.100	equia skew	>	0.600	min angle	<	45.000
cell squish	>	0.500	area skew	>	0.600	max angle	>	135.000
			taper	>	0.500			

To assign the velocity for fascia, the velocity should be given to all the nodes on fascia. It is difficult to assign velocity to each and every node. So it is better to create a set for all the nodes so that the velocity for all the nodes on the fascia can be assigned at a time. The selected nodes on the fascia are shown in Fig. 5.

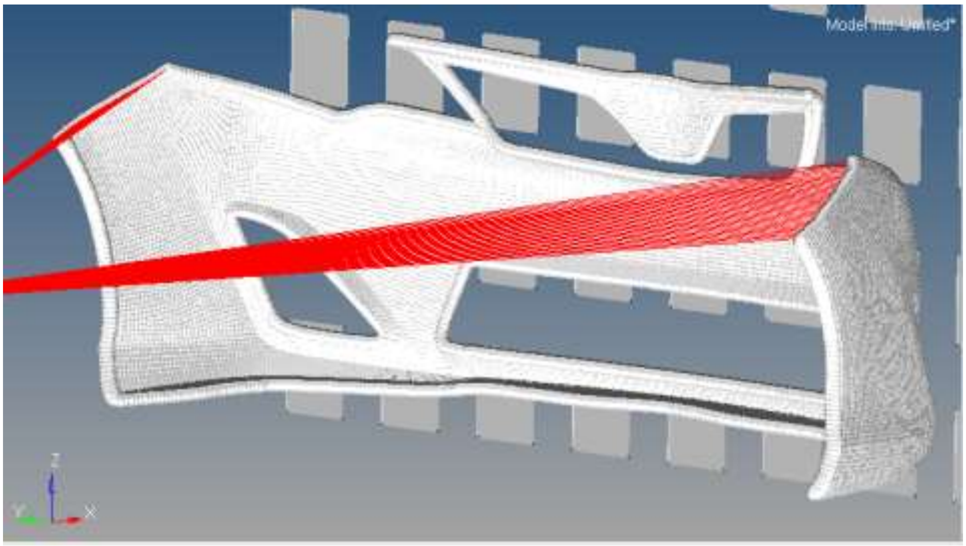

Figure 5 Node Set for Assigning Velocity

From Figure 6 &7, Sliding Energy with respect to Time, it is clear that sliding energy values for steel, aluminium and plastic are 4.55, 7.63 and 12.35% respectively. The higher sliding energy value indicates the instability of material. Higher the sliding energy value, higher the deformation of material and instability [Hallowell (1996)]. So, a material with good absorption capacity posses less sliding energy value. As steel posses less value, one can say it has the capacity to absorb more energy with sustainable deformation.

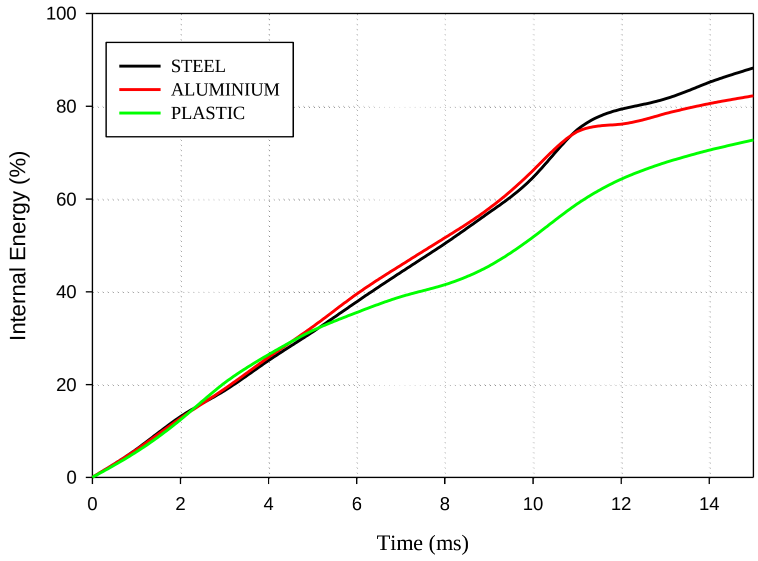

Figure 6 Internal Energy with respect to Time

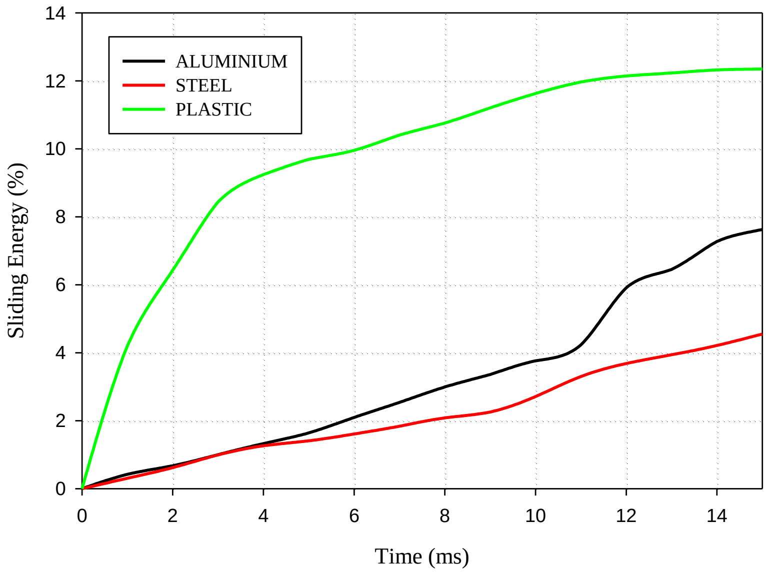

Figure 7 Sliding Energy with respect to Time

Conclusion

Car fascia is the first and foremost part that gets damaged and absorbs energy during a crash. If fascia is made of suitable materials, then it absorbs substantial part of energy during crash and protects the occupants. In our work, Steel, Aluminium and Plastic used as materials for fascia and crash simulation is carried out at 30 mm/ms i.e. 108 km/hr for 15 ms. From the results, the following conclusions can be drawn.

1. Among the three materials, steel material absorbs maximum internal energy of 88.25% followed by aluminium and plastic materials with 82.28 and 72.73% respectively. This is because, steel material has high Young's Modulus when compared to aluminum and plastic material and also impact force distribution is uniform in steel material.

2. The conversion of sliding energy from the available kinetic energy is more in plastic material followed by aluminium and steel materials. It shows the instability of plastic because of lowest young's modulus.

3. . The conversion of hourglass energy from the available kinetic energy is more in plastic material followed by aluminium and steel materials. This is because elements in plastic material deforms more without absorbing energy due to less element stiffness when compared to aluminium and steel materials.

4. The decrease in kinetic energy during impact is more in steel material with 3% followed by aluminium and plastic materials with 1 and 0.3% respectively.

References

1. EskildStorteig, Dynamic characteristics and leakage performance of liquid annular seals in centrifugal pumps Department of Marine Engineering Norwegian University of Science and Technology NTNU Submitted 99
2. J. Falcimaigne1, J. Brac1, Y. Charron1, P. Pagnier1 and R. Vilagines1, Multiphase Pumping: Achievements and Perspectives Oil & Gas Science and Technology – Rev. IFP, Vol. 57 (2002), No. 1, pp. 99-107Copyright © 2002, Editions Technip
3. H.W Oh and M. K Chung,Taejon, Optimum values of design variables versus specific speed for centrifugal pumps, , Korea A05098 IMechE 1999
4. Lazarkiewiz, "Design of Pumps and impellers" Herbertaddision, "Centrifugal and other rotadynamic pumps".3D flow simulation in an axial flow pump using computational fluid dynamic method, B.C Bhayal , R & D division , INDIAN pumps 2002.
5. J.F. Gülich, Effect of Reynolds-number and surface roughness on the efficiency of centrifugal pumps, Sulzer Pumps, Winterthur and Ecole Polytechnique, Lausanne, Switzerland ASME Journal of Fluids Engineering 125 (2003) 4, 670-679
6. Yagnesh Sharma.N, and KaranthK.V., 2003, "CFD analysis of a turbulent steady flow through a volute casing of a centrifugal pump for static pressure distribution", ISME, Pp MD-036.