Crash Analysis of Bumper with Various Impact Conditions Using LS DYNA

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Abstract— **The bumper is one of the key components used to protect passengers from front and rear collisions. The aim of this study was to investigate and study the structure and material used for automobile bumper in one amongst the manufacturer. In this study, the foremost necessary variables like completely different materials, structure, shapes and completely different impact conditions square measure learning for analysis of the bumper so as to enhance the crashworthiness throughout collision. The simulation of a bumper is characterized by impact modelling victimization Pro/Engineer, linear and non-linear analysis done by ANSYS, LS DYNA. Linear and non-linear analysis will assist you avoid overdesign and create better products.**

Keywords— **Bumper, material properties, impact loads.**

I. INTRODUCTION

An automobile's bumper is that the front-most or rear most half, apparently designed to permit the automobile to sustain an effect while not injury to the vehicle's safety systems. They're powerless of reducing injury to vehicle occupants in high-speed impacts, however square measure more and more being designed to mitigate injury to pedestrians smitten by cars. What were then easy metal beams connected to the front and rear of an automobile have evolved into complicated, built parts that square measure integral to the protection of the vehicle in low-speed collisions. The use of plastic in motorcar bumpers and fascia's provides designers an amazing quantity of freedom once it involves styling a paradigm vehicle, or rising AN existing model. Plastic may be titled for each aesthetic and useful reason in many ways while not greatly moving the value of production. Plastic bumpers contain reinforcements that permit them to be as impact-resistant as metals whereas being less costly to exchange than their metal equivalents. Plastic automobile bumpers usually expand at constant rate as metal bumpers below traditional driving temperatures and don't sometimes need special fixtures to stay them in situ. a number of the plastic merchandise employed in creating motorcar bumpers and fascia's may be recycled.

BUMPER

The bumper may be a safety system is employed to watch the low speed collision. It's placed in automobile body. The automobile bumper is meant to stop or scale back physical injury to the front and rear ends of rider automobiles in low-speed collisions. Automobile bumpers don't seem to be generally designed to be structural parts that might considerably contribute to vehicle crash worthiness or inhabitant protection throughout front or rear collisions. It's not a security feature meant to stop or mitigate injury severity to occupants within the rider cars. Bumpers square measure designed to shield the hood, trunk, grille, fuel, exhaust and cooling system also as safety connected instrumentality like parking lights, headlamps and taillights in low speed collisions. The bumper customary prescribes performance necessities for rider cars in low-speed front and rear collisions. It applies to front and rear bumpers on rider automobiles to stop the injury to the car body and safety connected instrumentality.

A. Necessities of Bumper Material

1. It ought to absorb a lot of energy whereas collision.
2. It ought to have sensible rust resistance.
3. It ought to have high strength.
4. Light-weight in weight.
5. Simple to manufacture in great quantity.
6. Low cost.

Organization of this paper.

Organization of the Paper arranged as follows. Section I gives the Introduction on bumper, Section II describes the literature of review, Section III provides Design of Car Bumper by Pro-E Software, Section IV gives the Material for Bumper, Section V shows the Analysis of Automotive Bumper with FEA Software System VI gives the conclusion.

II REVIEW OF LITERATURE

K. Kiranmai et., al.,[8]In this paper to design a bumper with minimum weight by employing the Glass Material Thermoplastic (GMT) materials. This bumper either absorbs the impact energy with its deformation or transfers it perpendicular 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 release it to the environment in the low impact velocity according to American standard. It should be noted that in this paper, modeling, and result's analysis are done in Pro -E and ANSYS software respectively.

Bhavesh A. et.,al.,[9]. In this paper, review of 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. More emphasis is given on selection of bumper material.

P.Sudha sagar et., al., [10] In this paper discussed to design a bumper system which can improvise on the existing systems and elevate the crash-worthiness of the bumper beam. This paper discusses about the Material, Structure, Shape and loading conditions over a bumper in case of a head-on crash and studies the Analysis results to corroborate with the existing ones and propose modifications for design improvement or change.

Raj Kumar G.,et.al.,[11] In this paper dealt with the crash investigation of Bumper for different materials using ANSYS Workbench. Bumper is a vital parameter which is used as safety protection for passengers from accidents by means of impact energy absorption from collision environment. The ultimate focus of this work is material optimization for

Bumper by performing impact analysis with the help of ANSYS.

V.Mohan Srikanth et., al.,[12] In this paper study was to analyze and study the structure and material employed for car bumper in one of the car manufacturer. In this study, the most important variables like material, structures, shapes and impact conditions are studied for analysis of the bumper beam in order to improve the crash worthiness during collision.

Sumeet Kumar Shukla et., al.,[13] In this research paper, try to improve the impact strength of an existing car bumper by material optimization in economic way. We also emphasis on the light in weight of bumper to reduce the gross weight of vehicle which is very essential to increase fuel efficiency of vehicle.

Ranjithkumar et.,al.,[14] In this research paper, analysis is done for speed according to regulations and also by changing the speeds. Simulation using Finite Element Analysis software, which is SOILD WORKS, was conducted. The material used for bumper is ABS Plastic ands2 Glass Epoxy.

III DESIGN OF CAR BUMPER BY PRO-E SOFTWARE

Pro/Engineer may be a software package application inside the CAID/CAD/CAM/CAE class, alongside alternative similar merchandise presently on the market. Pro/Engineer may be a constant quantity, feature - based modelling design incorporated into one information philosophy with advanced rule-based style capabilities. Modelling of automobile bumper is completed with facilitate of Pro-e software package and dimensions square measure elite from one amongst automobile bumper. Because the impact is a lot of for the front portion of bumper solely outer dimensions of automobile bumper has been thought-about for modelling, Slots provided in middle of automobile bumper is employed for reducing drag result in automobile bumper.

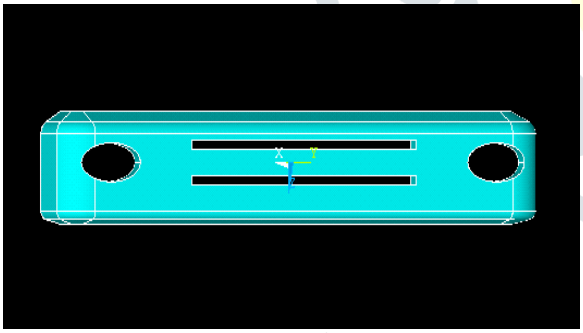

Fig.3.1. Design of Car Bumper

III. MATERIAL FOR BUMPER

In the field of thermoplastics style, there's a growing awareness of the importance of stress analysis. In a few years, plastics are used for supporting structural elements within the automotive, aerospace, sporting, and construction industries. Hence, style engineers are progressively involved concerning stress-related issues, usually with the strength, stiffness and anticipation of their merchandise. About a few years ago, these issues were primarily related to the gilded elements. Stress analysis has perpetually been knowledge domain, as a result of an efficient analysis has to collect an intensive information of the in operation characteristic of the merchandise, material behaviour, structural behaviour and solid mechanics. Structural plastics style may be a field that's evolving within the same manner as did the aero-space and nuclear energy industries. That is, a sequence of merchandise innovations, and higher ways of style and analysis incessantly reinforce one another and cause the optimum style of the merchandise.

The following materials are hand-picked for automotive bumper:

A. Steel
B. ABS Plastic
C. Poly-Ether-Imide (PEI)

A. Steel

Steel is associate alloy of iron and a little quantity of carbon. Carbon is that the primary alloying component and its content within the steel is between 0.002% and 2.1% by weight. Further components may additionally gift in steel: metal, phosphorus, sulphur, silicon, and traces of O_2, N_2 and Al.

Properties

- Density ranges between 7,750 and 8,050 kg/m^3
- Young's Modulus-2*10^5 N/mm²
- Poisson's Ratio -0.333
- Tensile Strenth-460 N/mm²

B. *ABSPlastic*

Acrylonitrile butadiene styrene (ABS) (chemical formula (C8H8)x• (C4H6)y•(C3H3N)z) may be a common thermoplastic. Its glass transition temperature is just about 105°C (221 °F). ABS is amorphous and thus has no true freezing point.

Properties

- Tensile strenth-3*10^7 N/mm²
- Elastic Modulus-2*10^9 N/mm²
- Poisson's Ratio -0.394
- Mass Density-1020 Kg/m³

C. Polyetherimide(PEI)

Polyetherimide (PEI) is associate amorphous, amber-to-transparent thermoplastic with characteristics like the connected plastic PEEK. Relative to PEEK, Pei is cheaper and lower in impact strength, however includes a lower use temperature.

Properties

- Tensile strenth-2.41*10^8 N/mm²
- Elastic Modulus-3.38*10^10 N/mm²
- Poisson's Ratio -0.4
- Mass Density-1480 Kg/m³

V.ANALYSIS OF AUTOMOTIVE BUMPER WITH FEA SOFTWARE SYSTEM

The ANSYS software may be a massive scale utile finite component program, which can be used for determination many categories of engineering analyses. The analysis capabilities of ANSYS embrace the flexibility to unravel static and dynamic structural analyses, steady state and transient heat transfer issues, mode frequency and buckling Eigen worth issues, static or time varied magnetic analyses and numerous steps of field and coupled-field applications. During this project ANSYS 14.0 has been used as a tool to attain the project target. The static-nonlinear analysis is disbursed to search out the deformation, stress distribution over the structure.

A. Boundary Condition

The velocities 40, 60 and 90kmph are applied at the centre (547.88mm from both the ends). It is common for both steel and composite bumper.

B. Meshing

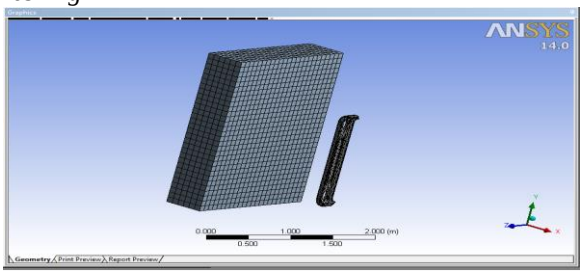

Fig.5.1 Meshing of Car Bumper with vertical wall

C. Deformation of Steel Bumper

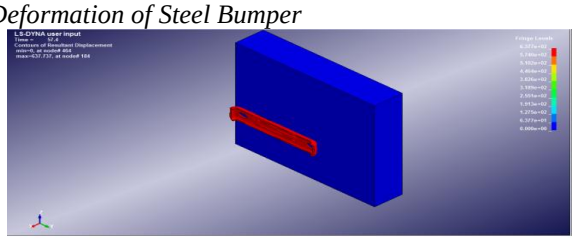

Fig.5.2.Deformation of Steel Bumper at 40kmph

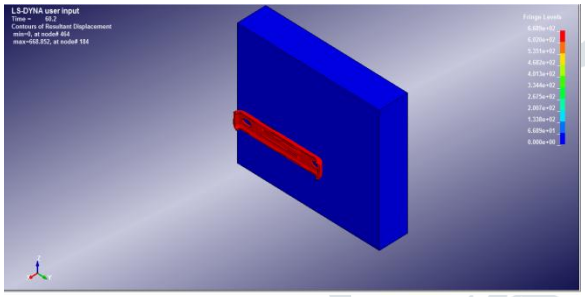

Fig.5.3.Deformation of Steel Bumper at 60kmph

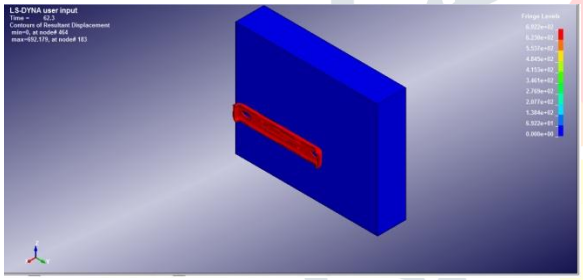

Fig.5.4.Deformation of Steel Bumper at 90kmph

D. Stress Distribution of Steel Bumper

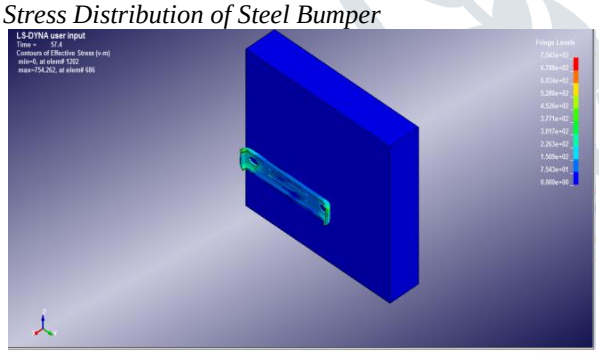

Fig.5.5.Maximum von misses stress at 40kmph

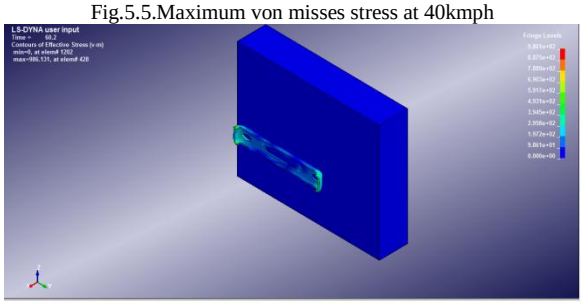

Fig.5.6.Maximum von misses stress at 60kmph

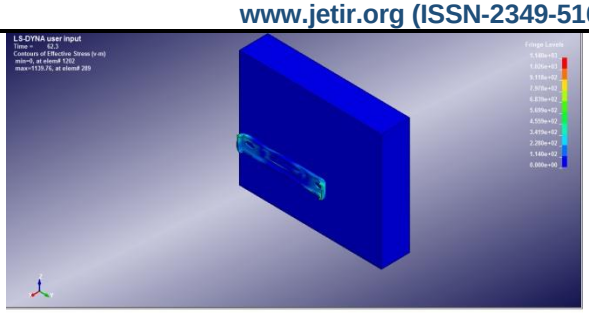

Fig.5.7.Maximum von misses stress at 90kmph

CASE-1 Crash Analysis of Steel bumper

The Crash analysis is performed for the three different speeds 40, 60 and 90kmph, and the results are shown in the table 1 and 2. The figures 5.2, 5.3 and 5.4 shows deformation and figures 5.5, 5.6 and 5.7 shows von misses stress of steel bumper for the speeds 40, 60 and 90kmph respectively.

E. Deformation Acrylonitrile Butadiene Styrene (ABS) Plastic

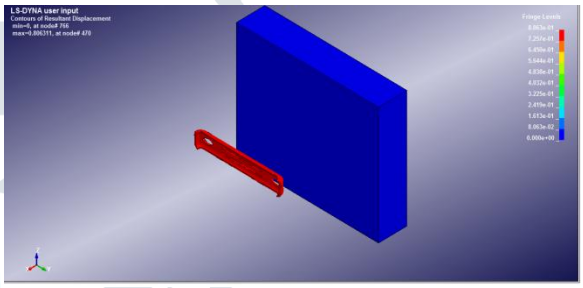

Fig.5.8.Deformation of ABS Plastic Bumper at 40kmph

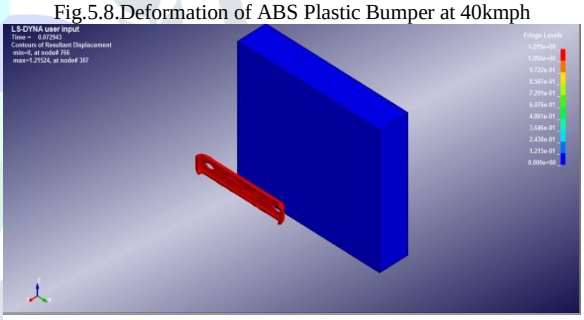

Fig.5.9.Deformation of ABS Plastic Bumper at 60kmph

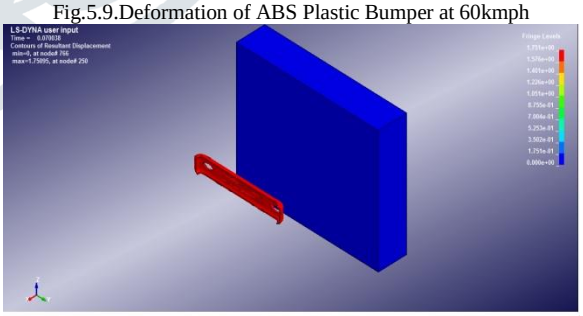

Fig.5.10.Deformation of ABS Plastic Bumper at 90kmph

F. Stress Distribution for ABS Plastic

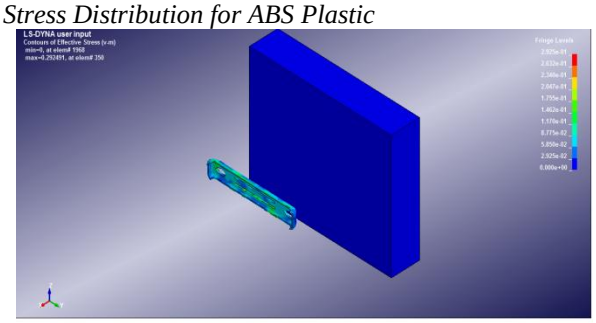

Fig.5.11.Maximum von misses stress at 40kmph

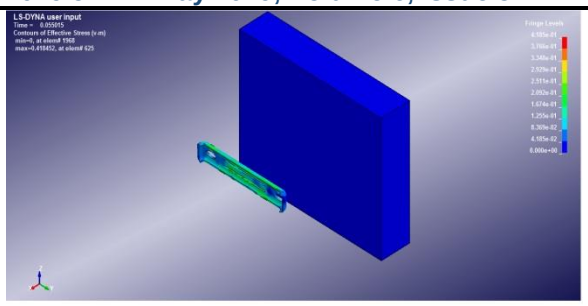

Fig.5.12.Maximum von misses stress at 60kmph

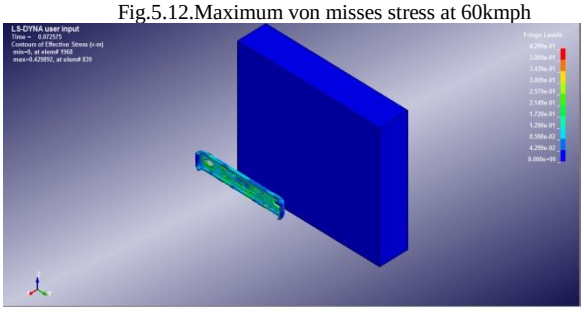

Fig.5.13.Maximum von misses stress at 90kmph

CASE-2 Crash Analysis of ABS Plastic Bumper

The Crash analysis is performed for the three different speeds 40, 60 and 90kmph, and the results are shown in the table 1and 2. The figures 5.8, 5.9 and 5.10 shows deformation and figures 5.11, 5.12 and 5.13 shows von misses stress of ABS Plastic bumper for the speeds 40, 60 and 90kmph respectively.

G. Deformation Poly Ether Imide (PEI)

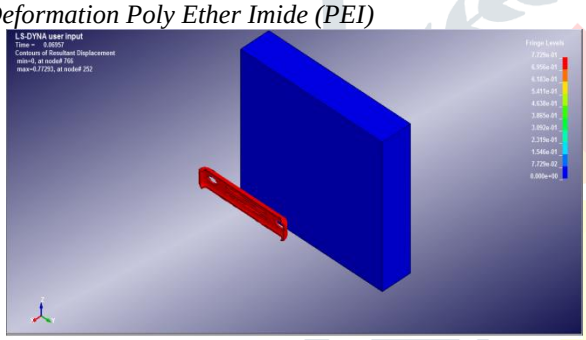

Fig.5.14.Deformation of PEI Bumper at 40kmph

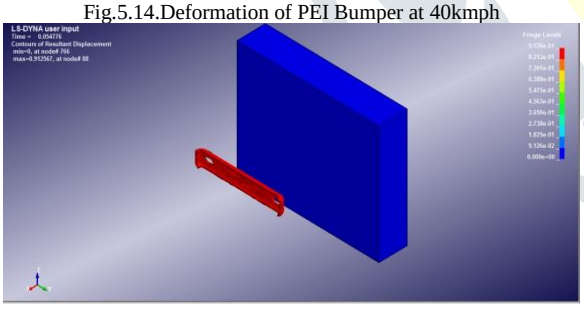

Fig.5.15.Deformation of PEI Bumper at 60kmph

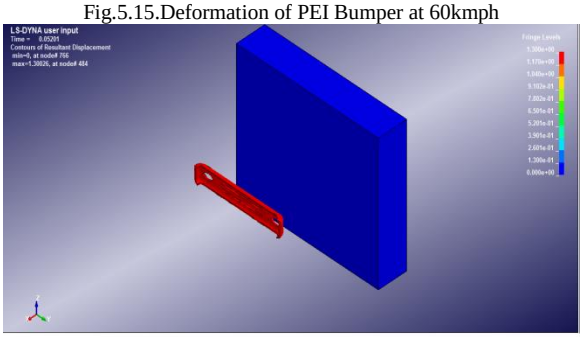

Fig.5.16.Deformation of PEI Bumper at 90kmph

H. Stress Distribution For Polyetherimide(PEI)

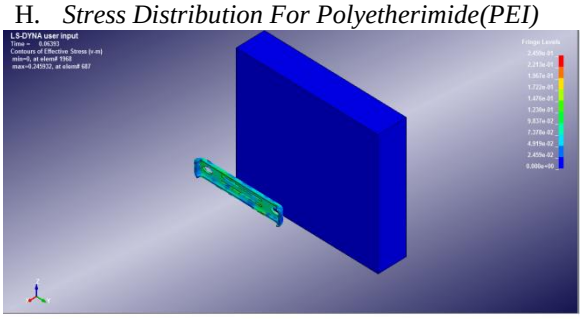

Fig.5.17.Maximum von misses stress at 40kmph

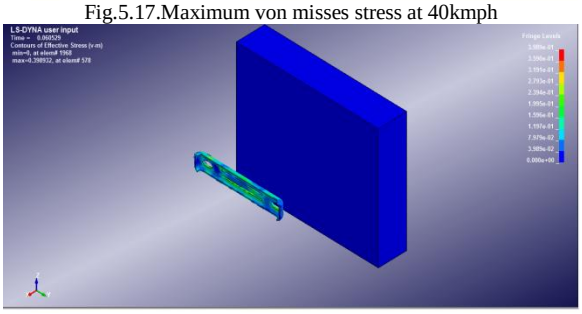

Fig.5.18.Maximum von misses stress at 60kmph

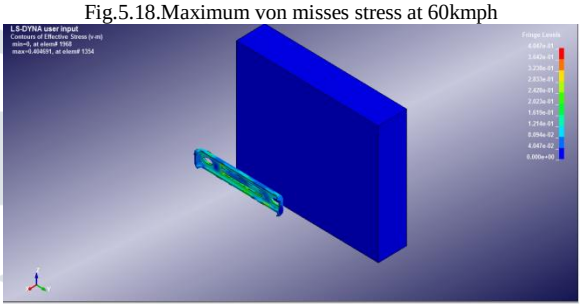

Fig.5.19.Maximum von misses stress at 90kmph

CASE-3 Crash Analysis of Polyetherimide Bumper

The Crash analysis is performed for the three different speeds 40, 60 and 90kmph, and the results are shown in the table 1and 2. The figures 5.14, 5.15 and 5.16 shows deformation and figures 5.17, 5.18 and 5.19 shows von misses stress of PEI bumper for the speeds 40, 60 and 90kmph respectively.

TABLE 1
DISPLACEMENT COMPARISON

SPEED	STEEL	ABS PLASTIC	PEI
40Km/hr	6.37737	0.806311	0.77293
60Km/hr	6.68852	1.21524	0.91256
90Km/hr	6.92179	1.75095	1.30026

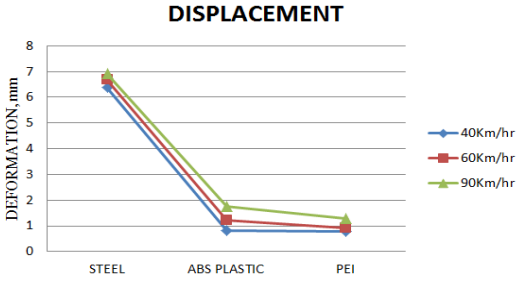

Fig.5.20.Displacement comparison between three materials

TABLE 2
STRESS COMPARISON

SPEED	STEEL	ABS PLASTIC	PEI
40Km/hr	754.262	0.292491	0.245932
60Km/hr	986.131	0.418452	0.398932
90Km/hr	1139.76	0.429892	0.404691

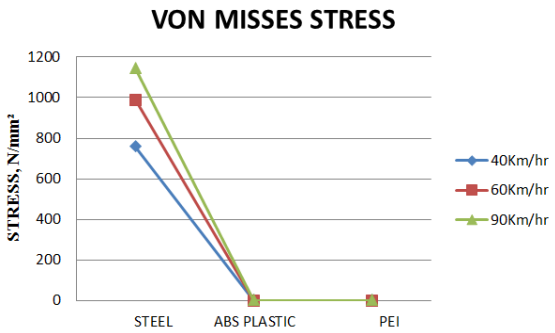

Fig.5.21.Stress comparison between three materials

VI. CONCLUSION

Modelling of an automotive bumper is completed by 3D modelling software system Pro/Engineer. The finite component analysis is performed on the car bumper for various materials steel, plastic and Carbon Fibre-Reinforced Poly-Ether-Imide in ANSYS 14.0 (LSDYNA). General, Steel is used for automotive bumper. Steel is replaced by ABS Plastic and Carbon fibre -Reinforced Poly-Ether-Imide. The density of plastic and PEI is a less than that of steel. There by the general weight of automotive bumper is reduced. From the results, the Carbon fibre -Reinforced Poly-Ether-Imide bumper is better than the steel an ABS Plastic bumper in the event of collision. It is found that the results in terms of displacement and stress of PEI bumper are much better than the other two bumpers. Therefore, it can be concluded that the PEI bumper is an effective replacement for steel and ABS Plastic.

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