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Design and Analysis of Automotive Bumper by using Aluminium Al 6061 Material

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A B S T R A C T

The work is limited to the standardized crash tests in which the force acts longitudinally along the vehicle. Two different types of modelling perspectives are investigated. With the traditional approach, the aim is to obtain agreement of the results from the Ansys simulation. It is shown that the required mass reduction is dependent on vehicle and bumper characteristics as well as on the loading conditions. Also, the simple method of mass reduction leads to difficulties in attaining high agreement for time history of force and compression. In contrast to this, the idea with the second modelling technique is to reach a high agreement of the time history of force and compression of the bumper system. In this study aluminum Al 6061 has been used to develop the bumper.

Keywords: Bumper, Simulation, Aluminium alloy, Deformation, Stress

1. INTRODUCTION

Bumpers were at first just rigid metal bar. George Albert Lyon invented the first car bumper. The first bumper seen on a vehicle in 1897, and it was installed by Nesselsdorfer Wagenbau-Fabriksgesellschaft, a Czech manufacturer. The constructions of these bumper were not reliable as they featured only an aesthetic function. Early cars had the front spring hanger bolt replaced with ones long enough to be able to attach a metal bar.G.D. Fisher patented a bumper bracket to simplify the attachment of the accessory. The first bumper designed to absorb impact appeared in year 1901.

Bumpers were added by manufacturer in the mid-1910s but consisted a bar of steel across the front and backside of the vehicle. Often treated as an optional accessory, bumpers use increased more and more in the 1920s as automobile designers made them more complex and substantial. Over the next decade, chrome plated bumpers became heavy, elaborative, and increasingly decorative until the late 1950s when US manufacturer began establishing new bumpers trend and brand specific designs. The 1960s saw the use of lighter weight chrome plated blade like bumpers with a painted metal valance filling the space below it. Multi piece construction became the norm as manufacturer incorporated grilles, lighting, and even rear exhaust come into the bumpers. Figure 1 Shown the 3D design of the bumper.

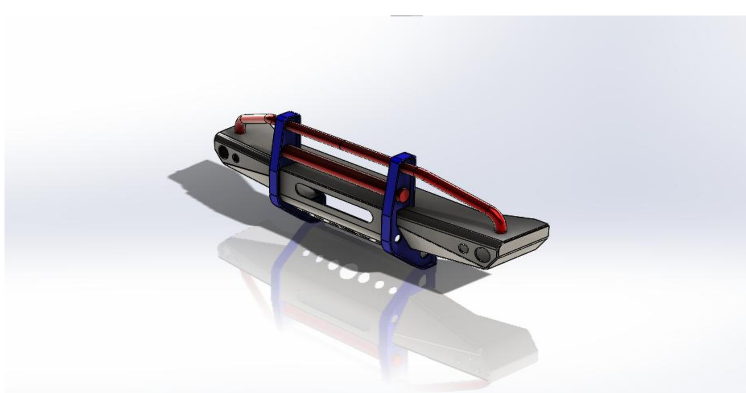

Fig 1 3D design of Bumper

The automotive body is one of the critical subsystems of an automobile, and it carries out multiple functions. It should hold the parts of the vehicle together and serve to filter noise and vibration. Additionally, it should be able to protect its occupants when accidents happen. To do this, the automotive body designer should create a structure with significant levels of strength, stiffness, and energy absorption Because of these limitations, the fatality rate increases dramatically in high speed impacts. In order to design a successful lightweight vehicle and significantly improve the crash performance of current cars, technological development is still needed. If the automotive body could extend its front end during or right before a crash, the mechanism of absorbing the crash energy would be totally different from that of the passive structure. During a frontal crash, the front side member is expected to fold progressively, to absorb more energy and to ensure enough passenger space. To do so, various cross sections and shapes have been investigated for the front rail of the automotive body to maximize crashworthiness and weight efficiency; their design included reinforcing the cross-section. Mohapatra S discusses that 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. Hosseinzadeh et al. studied the structure, shape, and impact condition of glass mat thermoplastic (GMT) bumper by using LS-DYNA pre-solver and the results are compared with conventional metals like steel and aluminium. GMT showed very good impact behaviour compared with steel and aluminium, which all failed and showed manufacturing difficulties due to strengthening ribs or weight increase due to use more dense materials.

Andersonet al. has discussed that to increase crash performance in automotive vehicles it is necessary to use new techniques such as use of energy absorber and materials. Components linked to crash safety should transmit or absorb energy. The energy absorbing capability of a specific component is a combination of geometry and material properties.

Evans D and Morgan T have studied that as vehicle manufacturers continue to become more aggressive with the styling of new vehicles, bumper system technologies will be required to find new solutions that fit into the reduced package spaces while continuing to meet the vehicle performance and cost requirements. It was suggested to introduce new and innovative Expanded Polypropylene (EPP) foam technologies and techniques.

Bautista et al. studied the different impact standards and for the specific material they optimized the shape of bumper beam by performing the software simulation. They also studied the effect of metallic energy absorber in bumper system. Maximum stress and deformation were used as design criteria. They have complied many international standards for bumper beam design.

Hosseinzadeh RM and et.al in their paper says that bumper beams are one of the main structures of passenger cars that protect them from front and rear collisions. In this paper, a commercial front bumper beam made of glass mat thermoplastic (GMT) is studied and characterized by impact modelling using LS-DYNA ANSYS 5.7 according to the E.C.E. UNITED NATIONS AGREEMENT [UNITED NATIONS AGREEMENT, Uniform Provisions concerning the Approval of Vehicles with regards to their Front and Rear Protective Devices (Bumpers, etc.), E.C.E., 1994]. Three main design factors for this structure: shape, material and impact conditions are studied, and the results are compared with conventional metals like steel and aluminium. Finally, the aforementioned factors are characterized by proposing a high strength SMC bumper instead of the current GMT.

From above published work it is clear that different countries have different standards, but few are accepted globally. For this study E.C.E. United Nations Agreement, Regulation No. 42, 1994[4] selected. Design criteria selected as follows. Maximum Von-Mises stress should be less than the yield strength and deformation should be less than the specified limit which depends on gap space available in the design. For this paper deformation limit is 40mm.

Niranjan K.N et al :(2017): their work was on the investigation of hybrid composites i.e., aluminium alloy 6061 as a base material and reinforced material as sic (6%) and graphite (3%,6%&9%). They calculated mechanical properties of tensile, compressive and hardness tests. They have increased the percentage of reinforcement (graphite), then the hardness will be decreased, and tensile, compressive strength will be increases with the influence of sic particles. From the above research paper, I concluded that the mechanical properties of MMCs having aluminum as lattice profoundly depends on the particles utilized for fortifications, increased the percentage of reinforcement (graphite), then the hardness will be decreased, and tensile, compressive strength will be increases with the influence of sic particles. Current analysis is performed in CAD model using two materials namely aluminum & Al 6061 using two approaches quasistatic method and dynamic analysis. Equivalent stress generated from collision of bumper of vehicle using normal structure by changing materials from carbon steel, aluminum ceramic composite ,and cast iron are compared.

2. PROCEDURE OF SIMULATION

2.1 Aluminium 6061

Aluminium metal and its alloys are implemented in most, if not all modern industrial processes due to its wide availability and the vast number of uses. An alloy is a metal made by combining two or more metallic elements to achieve improved material properties. The process of alloying involves adding specific metallic "alloying" elements into a base metal to give it distinct properties such as increased strength, corrosion resistance, conductivity, toughness, etc., or a desired combination of these traits. Alloys with low percentages of alloying elements (around <4%) are classified into wrought alloys and are workable, whereas those with higher percentages (up to 22%) are classified into cast alloys and are usually brittle. The Aluminium Association (AA Inc.) is the foremost authority on aluminium alloys and has developed a four-digit naming system used to characterize distinct wrought alloys from one another based on their main alloying elements. In this article, 6061 aluminium alloy will be discussed in detail, highlighting its physical properties as well as the common applications for this highly useful material. Table 1 shown the material properties of Al 6061. Table 2 Shown summary of mechanical properties for 6061 aluminium alloy.

Table 1, Composition of Al 6061

Al	Mg	Si	Fe	Cu	Cr	Zn	Ti	Mn	Remainder
95.85 - 98.56	0.8 - 1.2	0.40 - 0.8	0.0 - 0.7	0.15 - 0.40	0.04 - 0.35	0.0 - 0.25	0.0 - 0.25	0.0 - 0.15	0.05 each, 0.15 total

Table 2: Summary of mechanical properties for 6061 aluminium alloy.

Mechanical Properties	Metric	English
Ultimate Tensile Strength	310 MPa	45000 psi
Tensile Yield Strength	276 MPa	40000 psi
Shear Strength	207 MPa	30000 psi
Fatigue Strength	96.5 MPa	14000 psi
Modulus of Elasticity	68.9 GPa	10000 ksi
Shear Modulus	26 GPa	3770 ksi

2.2 Mesh Size and Distribution

An important aspect of meshing in ANSYS AIM is the size function, which controls how the mesh size is distributed on a face or within a body.

The researcher can enable the Settings > Use predefined settings control to automatically set the fineness of the mesh or disable it to set individual Global Sizing properties manually. In either case, you can set the Global Sizing > Size function method control according to your preference for mesh size distribution calculations. You determine which refinement mechanisms are activated by selecting Curvature and proximity, Proximity, Curvature, Fixed, or Adaptive. Depending on the selected Size function method.

2.3 Meshing

Meshing is an integral part of the engineering simulation process where complex geometries are divided into simple elements that can be used as discrete local approximations of the larger domain. The mesh influences the accuracy, convergence and speed of the simulation.

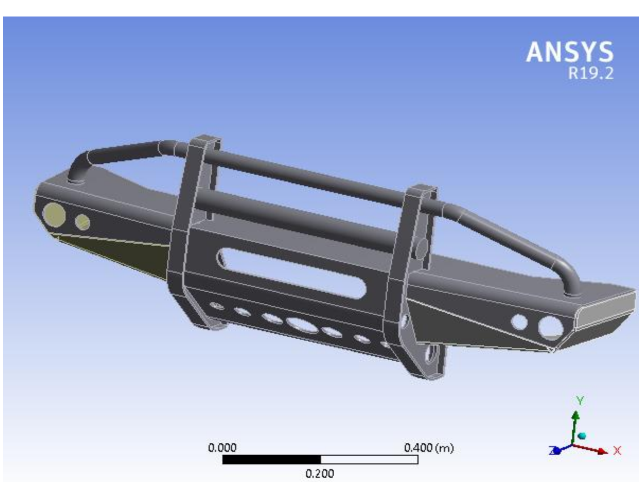

Fig. 13D model of Bumper

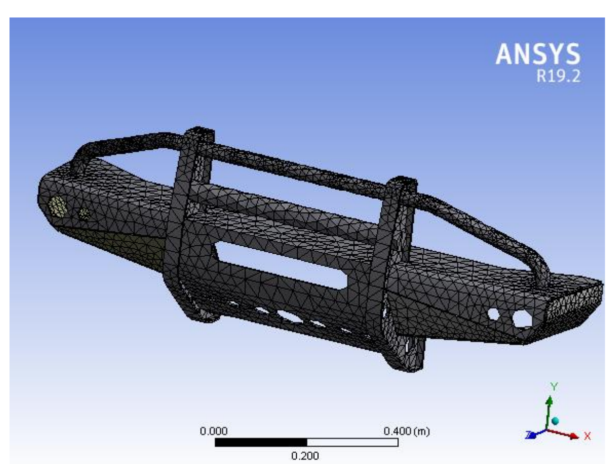

Fig. 2 Meshing with Hexahedral Elements

3. RESULTS AND DISCUSSION

Bumpers play an important role in absorbing the impact energy from being transferred to the passengers and automobile body. Absorbing the impact energy in the bumper to be released in the outside environment reduces the impact of the passengers and automobile. The goal of this work is to design a bumper with minimum weight and cost by employing the SS 304. This bumper either absorbs the impact energy with its deformation or transfers it normal to the impact direction. To reach this aim, a bumper is designed to convert the kinetic impact energy to the spring potential energy and release it to the outside environment in the low impact velocity. In addition, since the residual kinetic energy will be damped with the elastic deformation of the bumper elements, the passengers will sense less impact. It should be noted that in this report, modelling, and result's analysis are done in Solid works and ANSYS software respectively.Fig. 3 shown the deformation of SS-304 bumper. Fig 4 depicts the SS-304 energy curve. Fig. 5 shown the deformation graphof Aluminum 6061

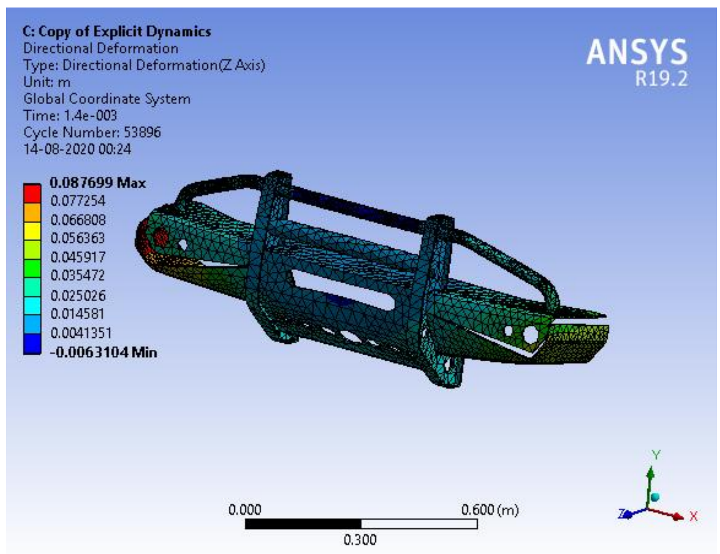

Fig. 3 Deformation of Aluminum 6061 bumper

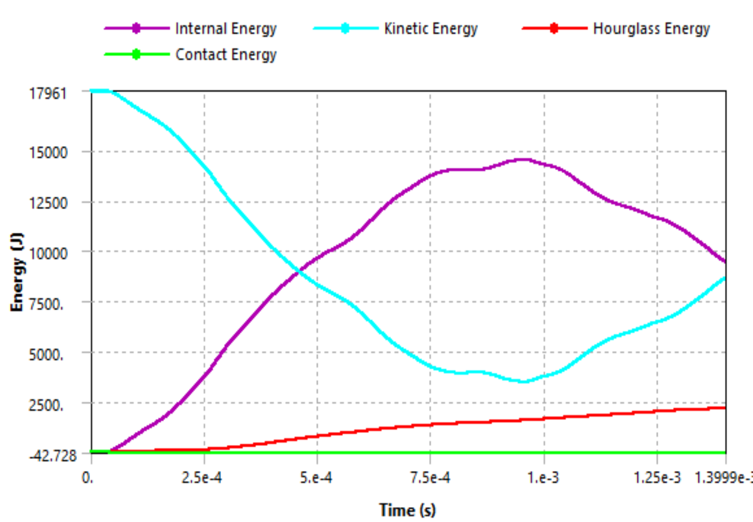

Fig 4 Aluminum 6061 energy curve

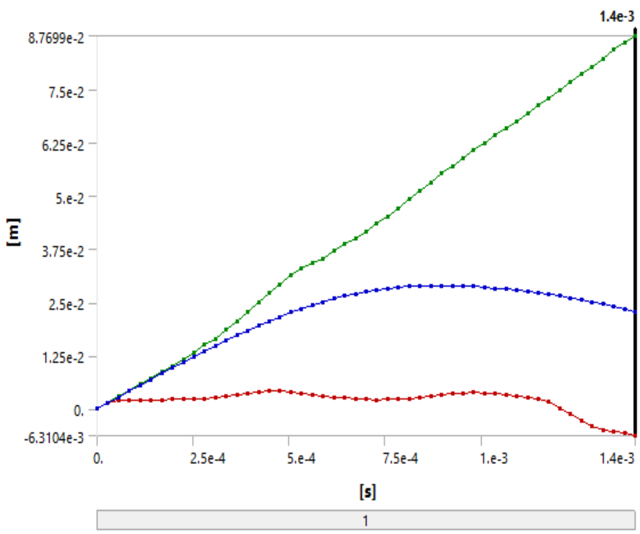

Fig. 5Deformation of Aluminum alloy

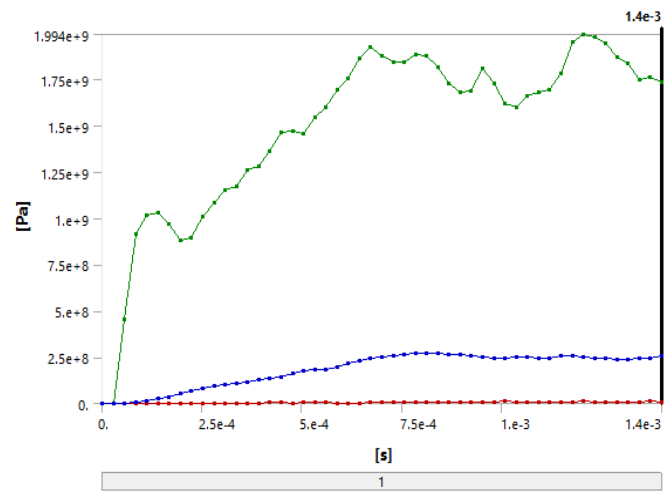

Fig 6 Stress on Aluminum alloy

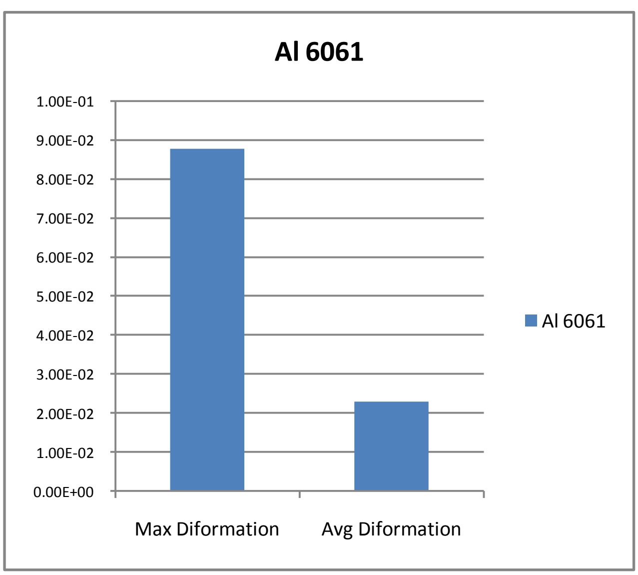

Figure 7 Deformation graph

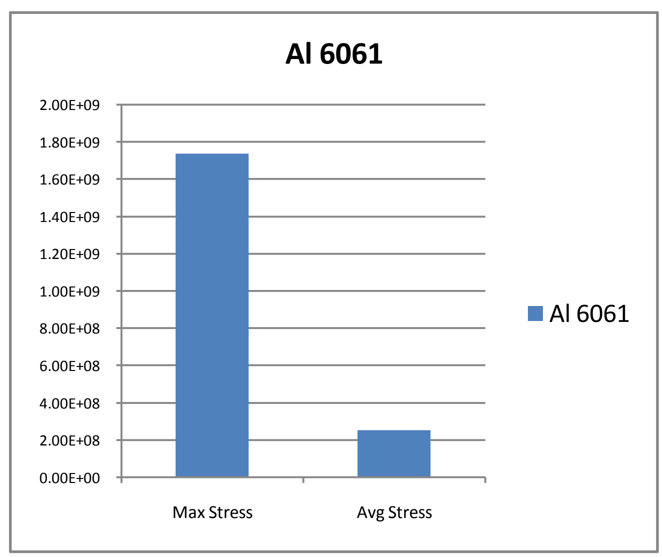

Figure 8 Stressgraph

4. CONCLUSION

In order to design the front bumpers, two major factors considered. First the internal absorbed energy (resilience) by the bumper should be kept high by using material having high yield strength and high modulus of elasticity. In the second place, any plastic deformation of the bumper should be avoided much as possible. Maximum deformation of bumper beam kept within the elastic limit. The maximum stress of the bumper is also below the yield stress of the material. Maximum Deformation 0.087699 m has been recorded.

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