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Design and Analysis of Automotive Bumper by using the Stainless Steel 304

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A B S T R A C T

The present work focuses on methods of how to represent the car in the Ansys crash simulations. 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, stainless steel 304 has been used to develop the bumper.

Keywords: Bumper, Simulation, Stainless Steel, Deformation, Stress

1. INTRODUCTION

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 thesis is to design a bumper with minimum weight and cost by employing the different materials. 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 thesis, modelling, and result's analysis are done in Solid works and ANSYS software respectively. 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. Nitin S. Gokhale, Sanjay S. Deshpande, Dr. Anand N. Thite Manufacturing of a bumper system from aluminium extrusions often involves series of forming operations performed in the soft W-temper condition, and then artificially age-hardening of the components to the material's peak hardness T6 condition. It is probable that proper finite element (FE) modelling of the crash performance of the resulting systems must rely upon a geometry obtained from an FE model following the process route, i.e., including simulation of all major forming operations. The forming operations also result in an inhomogeneous evolution of some internal variables (among others the effective plastic strain) within the shaped components. Results from tensile tests reveal that plastic straining in W-temper leads to a significant change of the T6 work-hardening curves. In addition, the tests show that the plastic preformation causes a reduction of the elongation of the T6 specimens. In the present work, these process effects have been included in a user- defined elastoplastic constitutive model in LS-DYNA incorporating a state-of-the-art anisotropic yield criterion, the associated flow rule and a non-linear isotropic work hardening rule as well as some ductile fracture criteria.

Mahesh Kumar V. Dange Automotive bumper beam assembly plays very important role in absorbing impact. In this 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 behaviour, 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. Current analysis is performed in CAD model using stainless steel SS-304 using two approaches quasistatic method and dynamic analysis. Equivalent stress generated from collision of bumper of vehicle using normal structure by using stainless steel sheet material

2. PROCEDURE OF SIMULATION

2.1 Stainless steel 304

Stainless steel contains Chromium as the principle alloying element other than ferrous. Chromium in the presence of oxygen forms a thin layer around the metal, thus shielding it from outside environment. Stainless steels contain a minimum of 10.5% Chromium. There are over 150+ grades of stainless steel which are divided into 5 types based on internal structure of the metal at room temperature. Austenitic, Ferritic, Martensitic, Duplex and Precipitation hardened are the 5 types of stainless steels. Austenitic grades constitute roughly 70% of the total consumption of stainless steel. Austenitic stainless steels have BCC (Body-Cantered Cubic) structure and are non-magnetic. This grade of stainless steel cannot be hardened by heat treatment but can be work hardened. AISI 304 is one of the most versatile grades within the austenitic grades. The grade finds applications in a variety of industries due to its excellent properties.

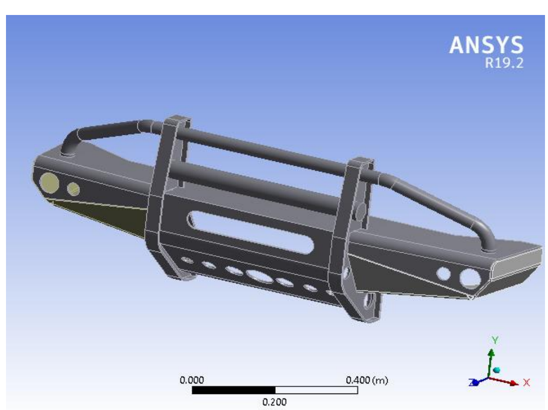


Fig. 13D model of Bumper

2.2 Stainless Steel Characteristics

Corrosion resistant.
High tensile strength.
Very durable.
Temperature resistant.
Easy formability and fabrications
Low maintenance (long lasting)
Attractive appearance
Environmentally friendly (recyclable)

2.3 Composition

AISI 304 is also known as 18/8 Stainless steel. This name has been derived from the composition of Chromium and Nickel elements present in the alloy. Nickel amounts to about 8% and Chromium accounts for about 18%. A few suffixes used with 304 with the major alterations in chemical composition are shown in below table 1

Table 41 Properties of 304/304L Chemical Properties (as per Standard EN 10088-3:2014)

Composition	304/1.4301	304L/1.4307
Carbon (%)	Max. 0.07	Max. 0.03
Silicon (%)	Max. 1	Max. 1
Manganese (%)	Max. 2	Max. 2
Phosphorous (%)	Max. 0.045	Max. 0.045
Sulphur (%)	Max. 0.030	Max. 0.030
Chromium (%)	17.5-19.5	17.5-19.5
Nickel (%) 8.0-10.5	8.0-	10.5
Nitrogen (%)	Max 0.11	Max 0.11

2.4 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.

2.5 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.

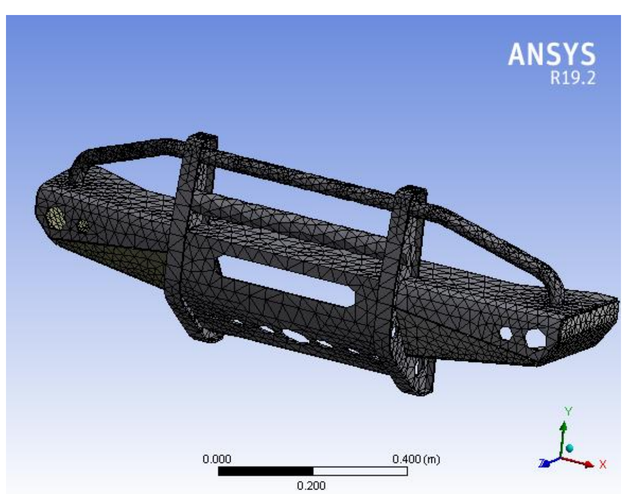


Fig. 2 Meshing with Hexahedral Elements

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 SS-304

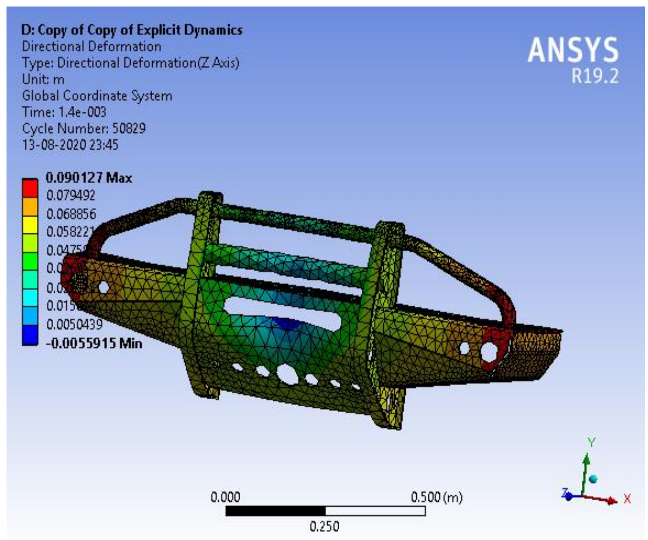


Fig. 3 Deformation of SS-304 bumper

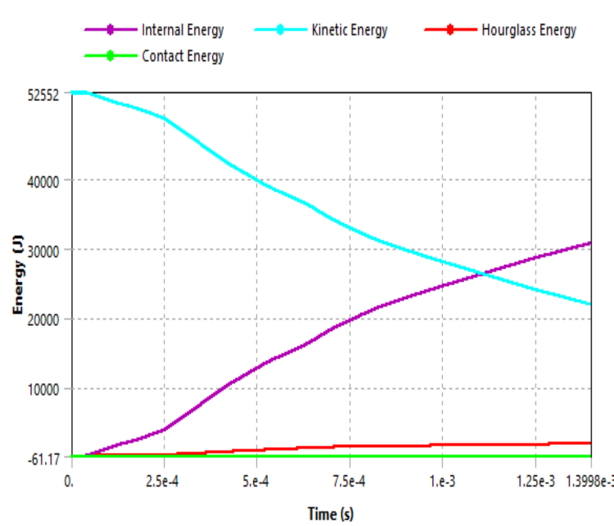
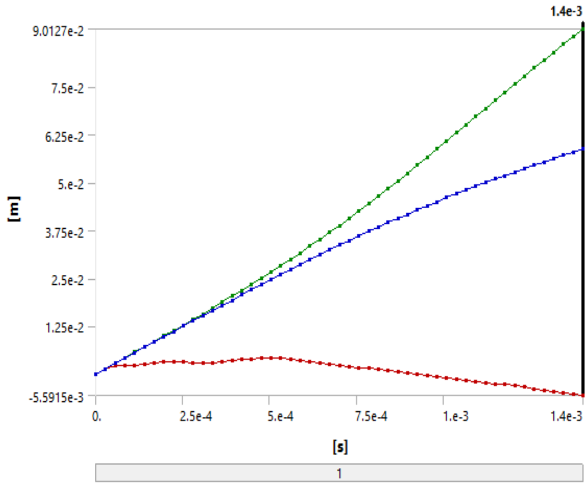


Fig 4 , SS-304 energy curve



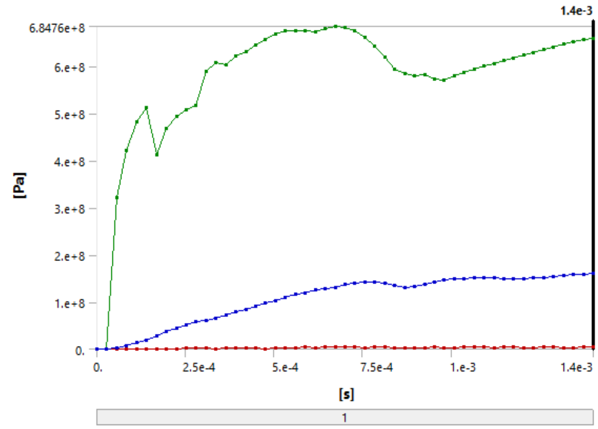


Fig. 5Deformation of SS-304

Fig 6 Stress on SS-304

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 5.3788e-002 m has been recorded with the strength of 2.5e+009 and toughness 228 MPa/m^2.

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