B-PILLAR PANEL SUBJECTED TO SIDE POLE IMPACT ANALYSIS

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ABSTRACT:- In this project the objective is to improve the B-pillar that is made of mild steel (192), in term of specific energy absorption and weight reduction. The conventional material mild steel needs to be change to other material that can absorb more energy during collision and reduce the injury level of driver and occupant. Three Side pole impact test will be conducted using ANSYS simulation software for three materials Mild steel (192), aluminum AA (6060T40) and hot press formed Usibor (1500P). side pole impact test will be carried out according to FMVSS 214 role and regulation car moving at 32.2 km/h (20 mph) at an angle of 75 degrees crashes into a fixed rigid pole that is 254 mm diameter.

The following are the result for the simulation in result of directional deformation

Throughout the tree materials Usibor (1500P) B-pillar had the maximum energy absorption that reach 414.07 KJ/Kg. aluminum AA B-pillar (6060T4) comes in second place with 299.52 KJ/Kg. benchmark model mild steel (MAT192) had the lowest energy absorption with result of 212.48 KJ/Kg. Using Usibor (1500P) in B-pillar lead to reduction in weight that reach about 53.27%. in the other hand aluminum AA (6060T4) weight reduction reached 51.54% compared with commercialize B-pillar mild steel (MAT192).

Usibor (1500P) showed great energy absorption and helped in reducing the weight of Bpillar and it will be the perfect selection in replacing the benchmark model B-pillar mild steel (MAT192).

Keywords: B-Pillar, Panel, Side Pole.

I. INTRODUCTION

With the development of society, people have more and more stringent demands for automobile passive safety and fuel economy, which requires the improvement of automobile structure crashworthiness and light weighting degree. The automobile body light weighting can be achieved by structure modification or material replacement. The automobile body structure modification requires the changes of forming, welding and assembling systems which is costly, while material replacement needs fewer such changes.

High strength steel sheet can be used in automobile body to improve the B-pillar component'simpactenergyabsorbingcapacityandresistancetoplasticdeformation.The B-pillar is an essential load-carrying element in any automobile framework. It functions as a primary supporting structure for the roof. It is characterized by a thin- walled,seam-welded,closed-sectionedstructuremadefromsteels.TheB-pillarislocated between the front and rear doors of vehicle. It consists of three components, named as B- pillarinnerplate,B-pillarreinforcementplate,andB-pillarouterplate.Atpresent,forthe B-pillar of most vehicles, the metal is the preferredmaterial.

The finite element model of B-pillar is shown in Fig. 1.1 The B-pillar is usually designed to achieve the high resistance and rigidity in the region door hinges and door locks. It can guarantee the living space of the driver and reduce the direct damage of occupantinasideimpact. It also should have enough strength to resist deformation in the case of the roofcrush.

Figure1: B-Pillar Locations

Hot press forming–also known as press is hardening–is are latively new forming process. It was recently developed particularly for the application of high strength steels in car body manufacturing in the automotive industry. Hot forming is a unique metal forming processing technique. In this process the material is heated up to a sufficiently hightemperaturetoprovideausteniticmicrostructurethenitiscooleddownrapidlyinthe formingtool.

At certain cooling rate diffusion less, martensitic phase transformation occurs leading to significant increase of the strength parameters. Since the martensitic transformation – i.e. the hardening process – occurs in the forming tool, this is thereason that this process is often termed as press hardening. Press hardening allows raising the strength level up to around 2000 MPA enabling weight reduction of 20 to 30% without safetycompromiseandcostincrease.Examplesofmaterialsusedinhotpressformingare mild steel, aluminum, magnesium and high strengthsteel.

Crashworthiness features includes air bags, seat belts, crumple zones, side impact protection interior padding and headrests. These feature sareup dated when the reis a new safer and better design. The impotence of Crashworthiness features, which are designed to minimize occupant injuries, prevent ejection from the vehicle, andreduce the risk offire, include: seat belts; crumple zones; and, airbags (including side impactprotection).

ProblemStatement

Demand for automobile passive safety and fuel economy requires improvement of automobile structure crashworthiness and light weighting degree. The conventional material (mild steel) need to be improved and changed with material that can absorb more energy during collision to reduce the injury level of driver and occupant. Also, the continues need for improving the B-Pillar crashworthiness in term of specific energy absorption and weightreduction.

Objectives of the study

The aim of this project is to:

a. To compare Aluminum (AA6060 T4) and hot press form (HPF Usibor® 1500P) with benchmark model B-pillar mild steel (MAT192) in term of specific energy absorption by using finite elementmodel.

b. To improve the material type for the B-Pillar system to achieve minimumweight.

Scope of the study

a. Literature study on hot press forming (HPF) specifically onB-pillar.

b. Selection of materials used in this project such as benchmark model Mild steel (MAT 192), Aluminum (AA6060 T4) and hot press form (HPF Usibor®1500P).

c. Crashworthiness of the B-pillar specifically on specific energy absorption (SEA) and weightreduction.

d. Conductsidepoleimpacttestsimulationbyusingfiniteelementanalysissoftware.

II. LITERATURE REVIEW

The AutomobileStructure:

Safety engineers design and manufacture vehicle body structures to withstand static and dynamic service loads encountered during the vehicle life cycle. Exterior shapes provide low aerodynamic drag coefficient. The interior provides adequate space to comfortably accommodateitsoccupants.Thevehiclebodytogetherwiththesuspensionisdesignedto minimize eroad vibrations and aero dynamic noise transfer to the occupants. In addition, the vehicle structure is designed to maintain its integrity and provide adequate protection in survivable crashes. (Farley et al, 1992)

Thebody-overframestructureofapassengercarorasportutilityvehicleconsists of a vehicle body, frame, and front sheet metal. Alight duty truck consists of a frame, cab, andbox.Thevehiclebodyprovidesmostofthevehiclerigidityinbendingandintorsion. In addition, it provides a specifically designed occupant cell to minimize injury in the event of crash. The chassis frame supports the engine, transmission, power train, suspension and accessories. In front a impact, the frame and front sheet metal absorb most of the crash energy by plastic deformation. The three structural modules are bolted together to form the vehicle structure. The vehicle body is attached to the frame by shock absorbing body mounts, designed to isolate from high frequency vibrations. Figure 2.1 is a photograph showing a typical vehicle with this type ofstructure.

Figure 2: Typical Body-on-Framevehicle

B-pillar systemliterature:

The B-pillar is an essential load-carrying element in any automobile framework. It functions as a primary supporting structure for the roof. It is characterized by a thin- walled, seam-welded, closed-sectioned structure made from high strength steels **(**Jambor and Beyer, 1997).

B-Pillar is the pillar presents on both sides of a given vehicle between the rear and frontdoors.TheB-Pillarmountedonavehicleforlatchingofthefrontdoorsandinstalling hinges for the rear doors is a steel structure welded firmly on one end to the rocker panel and floor pan at the bottom of a vehicle while the other to the roof rail for rigidity and support to the roofpanel

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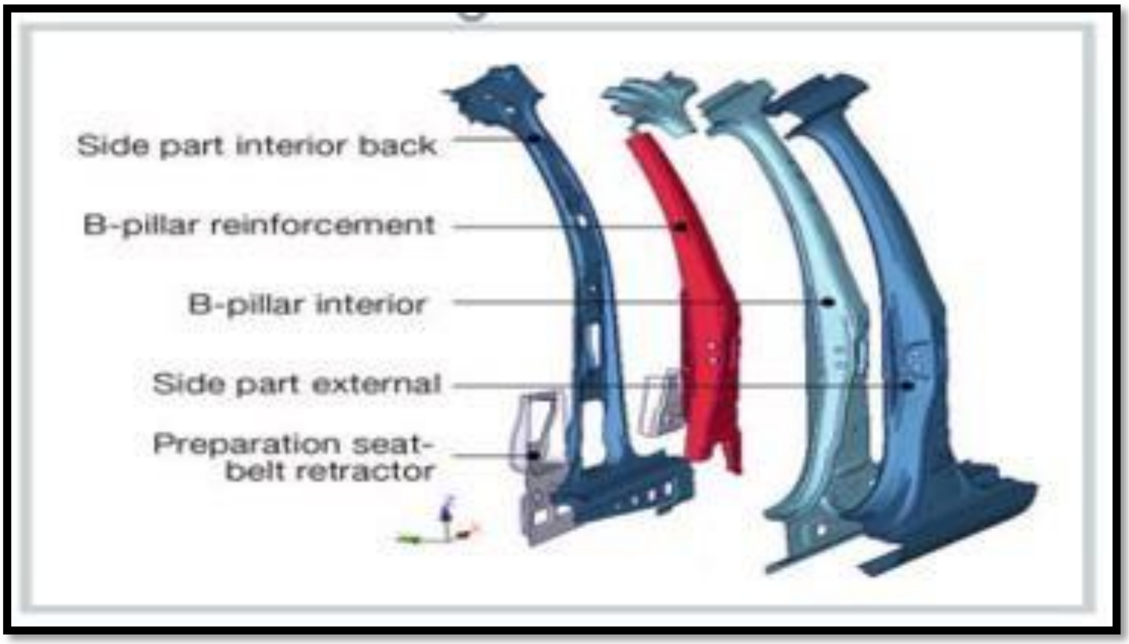

Figure3: B-pillar component

Figure3: show the component of B-pillaritgoes as the following sidepartinterior back, B-pillar reinforcement, B-pillar interior, side part external and preparation seat belt retractor.

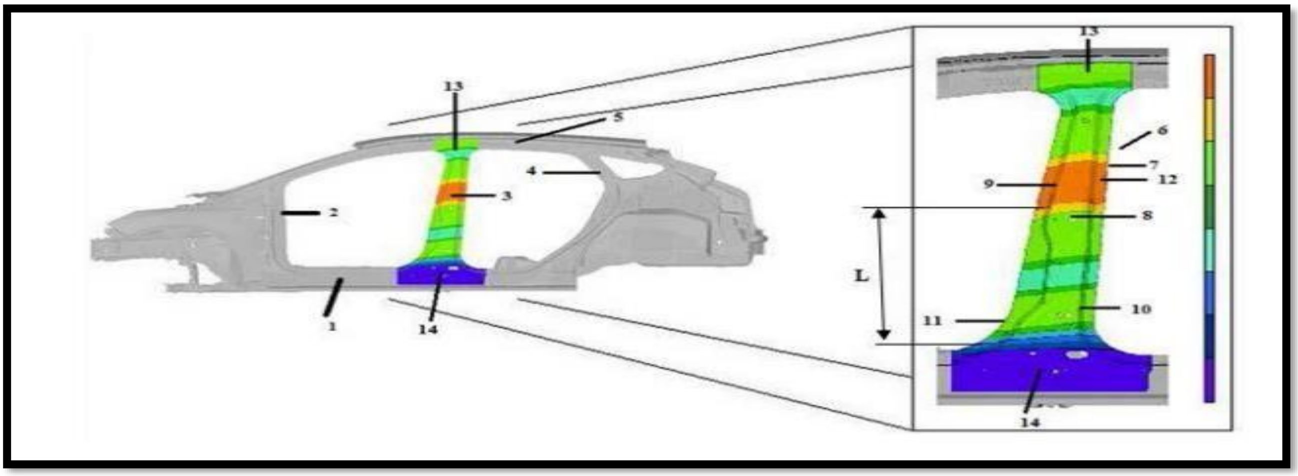

Figure4: B-pillar component and arrangement to vehicle (Z. Yang, Q. Peng, J. Yang)

The A, B and C Pillars are designated (2), (3) and (4) and are attached together by the process of welding to the floor panla belled as(1).Also, theroofrailorpanellabeled (5) is welded to the upper mostend of the B-pillar. Furthermore, other part soft he B-pillar labelled. 6, this consist of a curved-like member labelled (7), while the center flange is labelled (8), the two web-like segments labelled (9) and 10 and both side flanges designated as (11) and(12).
The lower and upperendsectionlabelled(13)and(14)are the segments connecting the floor pan and the roof rail. Moreover, the length (L) signifies the softer area of lateral flanges11and12oftheB-pillar.Itisabout50%oftheentirelengthoftheflangesonthe side (Z. Yang, 2012).

III. CRASHWORTHINESS:

The ability of the vehicle to absorb energy and to prevent occupant injuries in the event of an accident is referred to as “Crashworthiness” (Farley,1992). The vehicle must be designed such that, at higher speeds its occupants do not experience a net deceleration greater than 20 g. Crashworthiness can be categorized into three basic areas, materials engineering and design, combustion and fire and finally medical engineering (biomechanics).

It covers civil, automotive, military, marine and aerospace oriented applications, where the automotive sector is probably the most prominent area in this respect. Crashworthiness features includes air bags, seat belts, crumple zones, side impact protection,interiorpaddingandheadrests.Thesefeaturesareupdatedwhenthereisanew safer and better design. Crashworthiness is not the same as vehicle safety, and the two topics must be distinguished.

The safety of a vehicle depends on crashworthiness and as well as the accident avoidance features, which might include ABS, good handling characteristicsorevenoversizetires.Onevehiclemightbesaferstatisticallythananother and still have a significant crashworthiness defect. It could even conceivably be less crashworthy overall while still being a "safer" vehicle. Structural crashworthiness involves absorption of kinetic energy by considering designs and materials suitable for controlled and predictive energy absorption. In this process, the kinetic energy of the colliding bodies is partly converted into internal work.

Crash events are non-linear and may involve material failure, global and local structural instabilities and failure of joints. In addition, strain-rate and inertia effects may play an important role in the response of the structures involved.

The Hot Forming Process:

As it was very shortly described in the Introduction section, hot press forming is a complex forming and tempering operation when the materials heated first up to the austeniticzone and holding until the carbon fully dissolve producing homogeneous austenite microstructure. The forming operation is performed in this state, and then the part is cooled down rapidly in the tool with the critical cooling rate to prevent the carbon diffusion, thus resulting in martensiticmicrostructure.

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Throughthecombinationofheating,holding,formingandrapidcooling,complex parts can be produced with excellent strength properties. The usual process cycle of hot press forming can be seen inFigure 5.

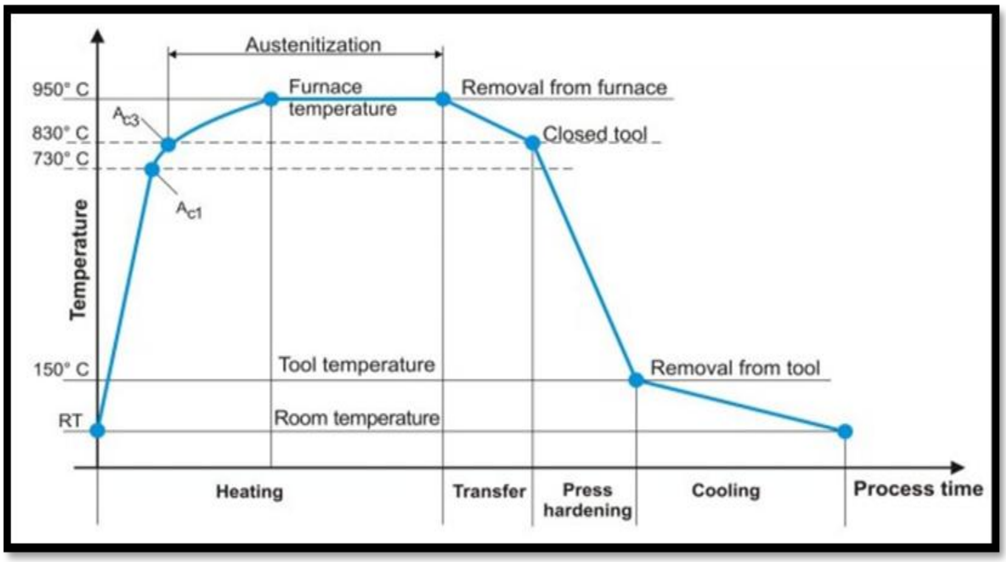

Figure 5: Temperature vs. Process time for Hot Press Forming

Here are two main technological process variantsappliedin hot press forming: one of them is called direct hot forming, the other is the indirect hot forming as shown in FiguresIn direct (or often termed as single stage) hot press forming the blanksheetisdirectlyausterities,transferredtothe Stampingtoolandcooleddownrapidly with the forming tool, thus providing the excellent strengthproperties.

Design and analysis of B-pillar in low speed pole impacttest:

Its importance to occupant safety makes the B-pillar an essential component in the crash worthiness of vehicle side impact. However, this necessitates the complex nature of a B-pillar design with respect to high impact resistance against unforeseen side collision of vehicles. The position of the B-pillar in a vehicle makes it very important in the provision of high impact resistance and safety to vehicle occupants in crash events that involve side impact.However, strengthening or reinforcing structural members is more advantageous thansubstitutingwithneworredesignedmembersassufficientresistanceagainstexternal load can be achieved (Karbasian,H, Tekkaya, 2010).

Mostsideimpactscanbeclassifiedintotwotypes;car-to-broad-objectandcar-to- narrow-object. B-Pillars are often designed to withstand side impact forces and remain elastic after the impact hasoccurred.

Crash impact analysis usually unravels the effects of linear static forces acting on vehicular structures in terms of energy absorption and deformation upon low and high- velocity impacts.

Research Methodology:

This chapter explains the scientific method and technique used to carry out the thesis projectanalysis.Firstthingtodoistoselectnewmaterialtoimprovethecrashworthiness ofB-Pillarinthevehicle.Asabenchmarkmodelbeentakenforexaminationandanalysis which is the B-Pillar CAD of the vehicle will be extruded based on the exact dimension

All the information must be clearly obtained especially the dimension of the current mild steel B-Pillar model. It is important to identify the problem to avoid any failure in this project so that the project can be successfully done and completed. For the literaturereviewpart, alltheinformationwillbewritteninourresearchprogressasitwill help in producing the material replacement effect onB-Pillar.

Steps of Carrying thesimulation:

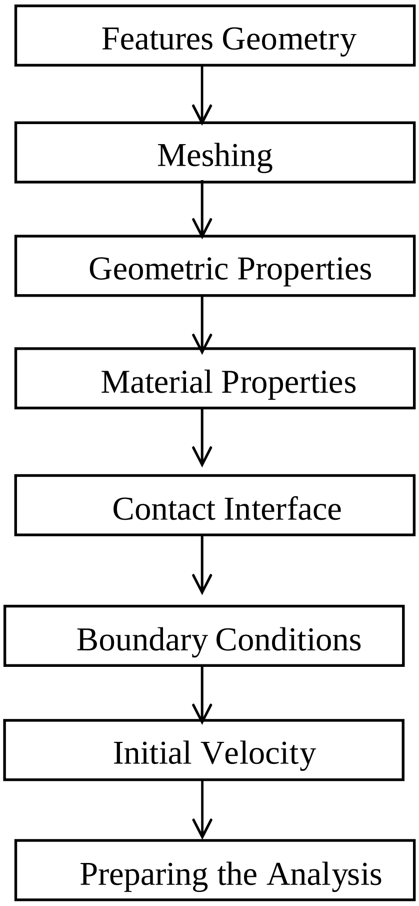

Figure 6: steps of preparing model

Feature geometry:

This section normally talks about development of model feature, since in this project model is imported and not developed from zero. The model consists of B-pillar (inner layer, outer layer, reinforcing plate) that was provided solid works drawing software was used to draw the rigid pole by student.

Meshing:

Once the geometry is in an appropriate state, a mesh will be created to approximate the geometry this meshing step is crucial to the finite element analysis as the quality of the meshdirectlyreflectsonthequalityoftheresultsgenerated.Atthesametimethenumber of elements (number of nodes) affects the computationtime.

Geometricproperties:

The section type of shell is assigned to the geometry, the analysis is then carried out as 3D analysis. Complete key in the material manager, Section manager (section manager>shell category>mass part> thickness > material). Complete the information about the section assignment (material manager > parameters> density> Young Modulus> Strain > Poisson Ratio).

Preparing foranalysis:

For the last step in solution part insert deformation directional in X axis >Total deformation> Equivalent stress >Solve. After a finite element model has been prepared and checked, boundary conditions have been applied, and the model will be solved, it is time to investigate the results of the analysis. This activity is known as the post- processing phase of the finite elementmethod.

3DModeling:

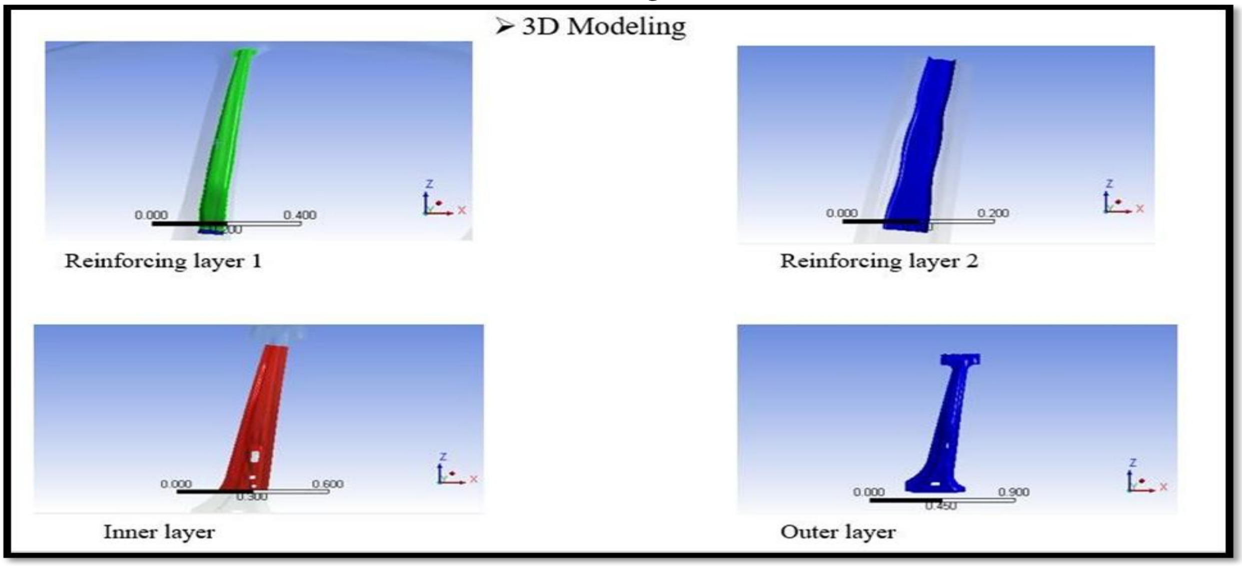

Figure 6: 3D modeling of B-pillar

Figure 6: show parts that B-pillar contain, and they are inner layer, reinforcement plate and outer layer. And all the parts were provided.

IV. RESULT AND DISCUSSION:

The table show the number of node and element in all parts including inner layer1, inner layer 2, outer layer, reinforced 1, reinforced 2 and the main structure, the total number nodes is 9992, for elements its 9030.

Table1 Number of Node and Element in Simulation

Part name	Node	Element
Inner 1	879	774
Inner 2	990	736
Outer	1580	1436
Reinforced 1	488	422
Reinforced 2	197	163
Main structure	5858	5499

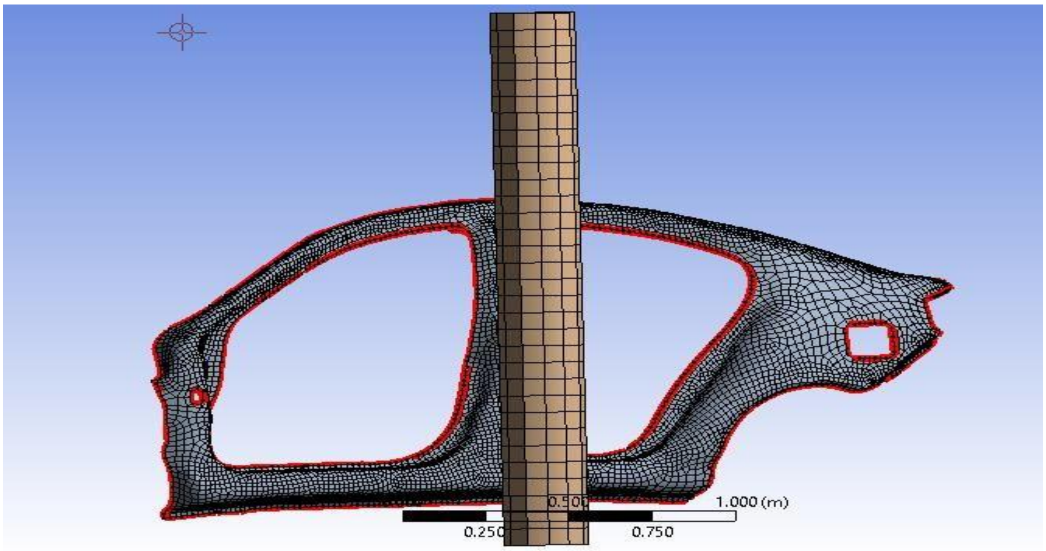

Figure 7: Mesh of B-Pillar and Rigid Pole

The finite element analysis depends on the accuracy of meshing, a coarse mesh is chosen for this simulation to ensure the accuracy of the result, Rigid pole mesh type is Quad/Tri.

Result of Directional Deformation in XAxis:

Figure 8: Ansys simulation results (X Axis directional deformation)

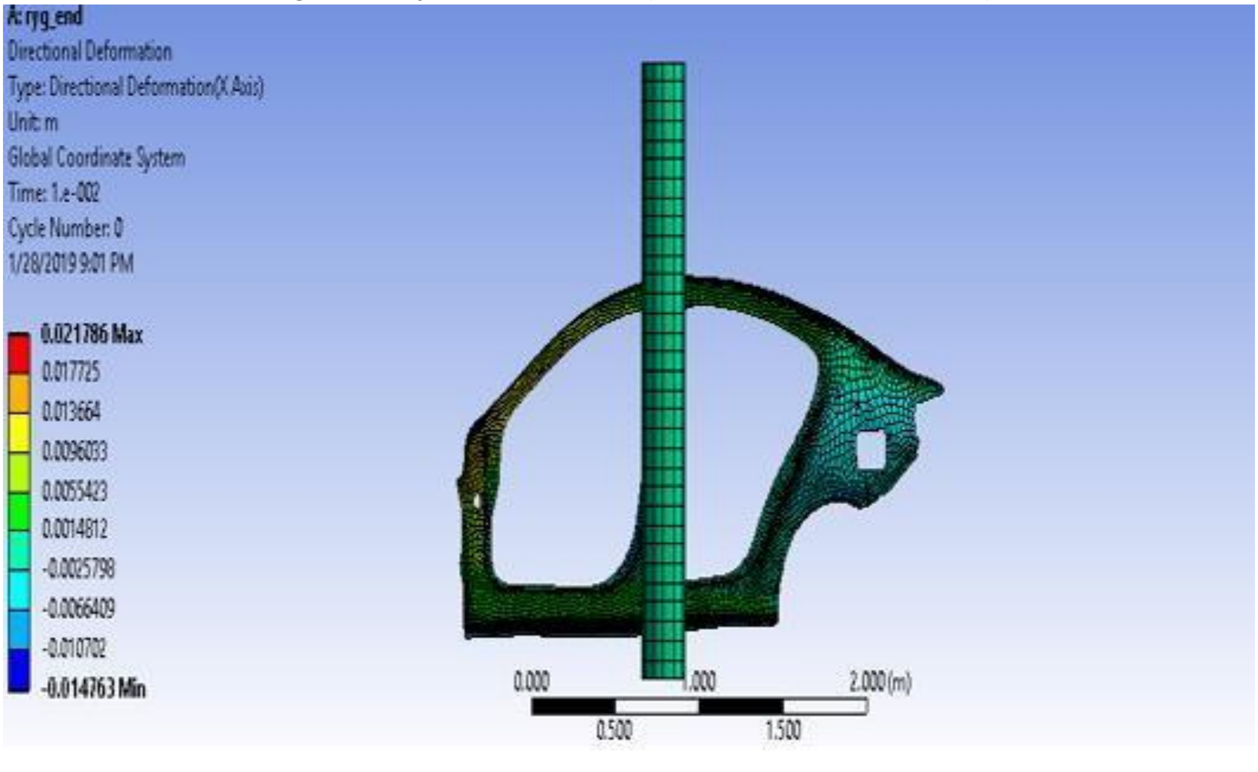

Figure 8 show the result of directional deformation for the commercialize B-pillarMild Steel (MAT192). reinforcement layer with thickness of 1.6 mm, first simulation run according to FMVSS214 regulation, the speed was set up to 32.2 km/h. the maximum directional deformation B-pillar was 0.021786m and minimum was -0.014763 m, the calculation time was0.01s.

V. CONCLUSION AND RECOMMENDATION

In this study, the objective was to improve current benchmark model B-pillar mild steel (MAT 192) in term of specific energy absorption and weight reduction. Side pole crash simulation was conducted to see which material will absorb more energy during the crash, FMVSS 214 role and regulation were followed during conducting the simulation, the following points are the conclusion of thisstudy.

a. In result of directional deformation Usibor (1500P) showed slight improvement with result of 0.021403m, where commercialize mild steel (MAT192) and aluminum AA (6060T4) had the same directional deformation of0.021786m.

b. Intermoftotaldeformation,Usibor(1500P)hadthelowestdeformationcompared with rest of the materials, with deformation of 0. 11186m. in second place comes mildsteel (MAT192) with deformation of 0.11355m.aluminumAA(6060T4) had the heights deformation in all materials that reached0.11426m.

c. ThroughoutthetreematerialsUsibor(1500P)hadthemaximumenergyabsorption thatreach74.71KJ/Kg.aluminumAA(6060T4)comesinsecondplacewith55.66

Recommendation

The following recommendation for future work can be noted:

a. Material other thenUsibor (1500P) can be used to improve specific energy absorption and reduce weight ofB-pillar.

b. The speed used in side pole crash simulation can increased to see how materials will react athighspeed.

c. Experimental tests can be carried out to find the accuracy of the resultobtained

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