Stress Distribution Behaviour of Car Bumper Bracket

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**Abstract**—The bumper bracket is a metal piece which connects the bumper to the reinforcement or frame. This paper describes the design and analysis approach used for the bumper bracket for car. The study shows that the maximum von misses stress of the new material, High Strength Low Alloy (HSLA), was 0.054x10⁹ mN/mm² lower than grey cast iron. The comparison of material strain also shows that the bracket bumper made from HSLA, it can reduce the maximum strain up to 0.8x10⁴ of its original material. Then, the comparison of displacement also prove that, the bracket bumper that made from grey cast iron displaced 52% further than the HSLA’s. The Proton Wira bumper bracket that was manufactured years ago still can be improved. The bumper bracket made from HSLA can withstand more force and pressure that the existing bumper bracket. Thus, can reduce the damage of the car and increase the safety of the vehicle if it meet with any collision.

**Keyword** —Bumper bracket, High Strength Low Alloy, Material, Stress.

I. INTRODUCTION

The whole car assembly includes many important systems and components. All these that make up the vehicle are vital to its overall operation and performance. A defect in any of these will certainly affect the entire operation, thus causing discomfort and inconvenience on the part of the driver as well as its passengers. That is why it is important that these car systems and components be taken care of at all times to maintain their good running condition. However, there are instances when damage on vehicle parts is caused by accidents and collisions. And one of the parts that can be damaged is the bumper bracket.

A. Introduction of Bumper Bracket

The bumper bracket is a metal piece which connects the bumper to the reinforcement or frame. However, there are some bumpers which connect directly to the frame without the need for bumper brackets. But most vehicles have but only different terms are used to refer to the bumper bracket.

There are different bumper brackets that compose the entire bumper bracket assembly.
1. Bracket mounting which is usually rectangular in shape.
2. Bracket support which is the bracket for mounting other bracket types.
3. Bracket stay which holds the bumper ends or the side of the bumper.
4. Bracket arm or the bracket stay side which holds the bumper.
5. Bracket reinforcement which holds the frame of the car.

![Fig. 1. Bumper bracket for Proton Satria.](image)

But just like any other car parts, the bumper brackets can also get damaged due to impact of collisions. Refer to the Figure 1, due to material that to be used to manufacture bracket bumper usually cannot last longer than 8 years. That is why if the brackets defective, the driver have to do replacement at once because these can certainly affect the entire metal bumper assembly. Not only that, the bumper can falls off if there are a lack of bumper brackets and if some are damaged.

Bumper bracket for Proton Wira had been choose for this research. It was chosen because of feedback issued by consumer and mechanic regarding the Proton Wira bumper that easily fall down from its chassis body. Besides, the availability of the product was the factor why it was chosen to be the subject of this research. It is easy to do the research for the part of this model because, Proton Wira is claimed to be one of the national car. So, the car is widely use throughout the country.

Different than other bumper bracket, this bracket only consists of 2 main parts, as shown in Figure 2. The first part is the thin bar that welded to 2 other connector bar which is connect the bracket to the car chassis. The design is too simple.
**B. Problem Statement**

Fig. 2. Proton Wira bracket bumper.

Fig. 3. The thickness of bracket.

Figure 3 shows the bar is too thin (0.7 mm) till, any impact that subject to this bar will result the absolutely damage.

Fig. 4. Dimension of the Bracket.

Figure 4 shows that connector length was 24 cm and bar length was 145 cm.

**C. Material of the Bumper Bracket**

Fig. 5 Automotive part of grey cast iron.

Gray iron, or grey iron, ASTM A48, is a cast iron alloy that has a graphitic microstructure. It was named after the gray color of the fracture it forms, which is due to the presence of graphite. It was the most common cast iron and the most widely used cast material based on weight. A typical chemical composition to obtain a graphitic microstructure is 2.5 to 4.0% carbon and 1 to 3% silicon. Gray iron is a common engineering alloy because of its relatively low cost and good machinability, which results from the graphite lubricating the cut and breaking up the chips [2].

The graphite also gives gray iron an excellent damping capacity because it absorbs the energy. It also experiences less solidification shrinkage than other cast irons that do not form a graphite microstructure. It has a density of $7.3 \times 10^3$ kg/m$^3$ and the Young's modulus is $97 \times 10^9$ Pa. The silicon promotes good corrosion resistance and increase fluidity when casting. Gray iron is generally considered easy to weld. Compared to the more modern iron alloys, gray iron has a low tensile strength and ductility; therefore, its impact and shock resistance is almost non-existent. Figure 5 shows an automotive part that is made from gray cast iron [2].

**II. Finite Element Method**

Finite element method is a numerical analysis technique for obtaining approximate solutions to many types of engineering problems. The need for numerical methods arises from the fact that for most practical engineering problems analytical solutions do not exist. While the governing equations and boundary conditions can usually be written for these problems, difficulties introduced by either irregular geometry or other discontinuities render the problems intractable analytically [3].

In the finite element method, the region of interest is divided up into numerous connected subregions or elements within which approximate functions (usually polynomials) are used to represent the unknown quantity. The finite element method is one of the most powerful approaches for approximate solutions to a wide range of problems in mathematical physics. The method has achieved acceptance in nearly every branch of engineering and is the preferred approach in structural mechanics and heat transfer. Its application has extended to soil mechanics, heat transfer, fluid flow, magnetic field calculations, and other areas [4].

**III. Design and Analysis**

**A. Bumper Bracket Design**

Fig. 6. The CAD drawing of the bumper bracket.

In this research project, the bumper bracket was made by using CATIA V5, as shown in Figure 6. The bracket bumper was designed by the Proton and released with Proton Wira model in 1993. It consists of 2 connector, 2 sheet components, and 1 bar. This datum is very critical for this proton model car. It said as one of the factors, why the Proton Wira bumper was always fall off from the body chassis. The length of the main bumper bracket was 145 cm and the connector length was 24 cm. The thickness of the bumper bracket design was 0.7 mm.
As refer from the Figure 7, this part was the main part of the Proton Wira bumper bracket. This part is where the bumper was attached with. This important part also the part that play the role to withstand the force or the pressure that act when the collision is happen.

Plate connector in Figure 8, was the part that connect the main plate to the chassis. This part is prevent the bumper from falling off. There are 2 of them in the design. The several holes in the end of the figure show that, it is screwed to the car chassis.

The sheet plate is almost unseen in the bumper bracket. It connects the main plate to the connector plate. This thin plate is welded to the main plate and the connector plate. Figure 9 shows desig of sheet plate.

### IV. ANALYSIS

The tool that used to analyze this project was ABAQUS. All analysis in this project done by using the ABAQUS CAE software. The bracket bumper was analyzed with both material, grey cast iron and the High Strength Low alloy (HSLA). The comparison done by comparing the different material selection from the same bumper bracket design. The parameter that was used in the comparison wee stress, strain and displacement. The magnitude of highest stress was critical because can lead to failure. Thus, it is important to take note to reduce stress magnitude at this point.

### V. RESULT AND DISCUSSION

#### A. Comparison of Material

<table>
<thead>
<tr>
<th></th>
<th>Density</th>
<th>Young modulus</th>
<th>Poisson ratio</th>
<th>Conductivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Datum (Grey Cast Iron)</td>
<td>7.3e-6kg/m³</td>
<td>97GPa</td>
<td>0.26</td>
<td>46</td>
</tr>
<tr>
<td>New Design (HSLA)</td>
<td>7.8e-6kg/m³</td>
<td>200GPa</td>
<td>0.3</td>
<td>46</td>
</tr>
</tbody>
</table>

Table 1 shows the material properties for both materials, HSLA and grey cast iron.

#### B. Von Misses stress

Figure 10 shows the maximum von misses stress for bumper bracket that made of grey cast iron. The maximum stress was 2.825x10⁹ mN/mm² at node 4397.

Figure 11 shows the maximum von misses stress for bumper bracket that made from HSLA. The maximum stress was 2.771 x10⁹ mN/mm² at node 4397.

Figure 12 shows that the bumper bracket that made from HSLA had lower maximum stress than the bracket bumper that used grey cast iron. The HSLA had maximum stress of 0.054x10⁹ mN/mm² lower than the Grey Cast Iron.
C. Strain

Figure 13 shows the maximum strain for bumper bracket that made from Grey cast iron. The maximum strain was $2.4664 \times 10^4$ at node 4397. The minimum strain was $18.0748 \times 10^{-3}$ which occurred at node 194.

Figure 14 shows the maximum strain for bumper bracket that made from HSLA. The maximum strain was $1.66574 \times 10^4$ at node 4397. The minimum strain was $18.0748 \times 10^{-3}$ which occurred at node 194.

Both material used the same design to avoid any miscalculation or error that can be occurred if the different simulation design were used. From the Figure 15, it shows that the HSLA relatively had lower maximum strain compare to grey cast iron. The maximum strain of grey cast iron was $2.4664 \times 10^4$ which was higher than HSLA, which was $1.66574 \times 10^4$. Bumper bracket was made from HSLA, it can reduce the maximum strain up to $0.8 \times 10^4$ of it original material.

D. Displacement

Figure 16 shows the maximum displacement for bumper bracket that made of grey cast iron. The maximum displacement was $14.0102 \times 10^6$ at node 1453. The minimum displacement was 0 occurred at node 12883.

Figure 17 shows the maximum displacement for bumper bracket that made from HSLA. The maximum displacement was $6.66808 \times 10^6$ at node 1453. The minimum displacement was 0 occurred at node 12883.

Figure 18 shows the different displacement of the critical point of the bumper bracket that HSLA and grey cast iron. The HSLA’s displacement lower than the grey cast iron’s displacement. The displacement different was $7.34 \times 10^6$ mm. It mean that the
bumper bracket that made from grey cast iron displaced 52% further than the HSLA’s bumper bracket.

Fig. 18. Bar Chart of the Maximum Displacement (HSLA VS GCI).

VI. CONCLUSION

The main goal of this research was to investigate the effect of relative changes in the material selection of the bumper bracket in term of stress, strain and displacement. Any changes in the material selection will influence the result of the system. The study shows that the maximum von misses of bumper bracket that made from HSLA was $0.054 \times 10^9$ mN/mm² lower than grey cast iron. The comparison of material strain also show that the bracket bumper was made of HSLA, it can reduce the maximum strain up to $0.8 \times 10^4$ of its original material. Then, the comparison of displacement also proved that, the bracket bumper that use grey cast iron displaced 52% further than the HSLA’s.

REFERENCES