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Investigation of Reliability on Structural Analysis on Oil Pan Bolt Feeder Machine: A Short Review

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Abstract: The aim of this work is to investigate the reliability of the structural model of oil pan bolt feeder machine in the industry. Generally, oil pan bolt feeder machine is a custom-made machine by Double One Precision Engineering Sdn. Bhd. that is used to feed bolt and at the same time it can fasten to a component automatically. The work will apply finite element method (FEM) by using SolidWorks2018. The model will be drawn according to its Computer aided-design (CAD) data then apply some load to the model to get the factor of safety of the model. Next, repeat the same procedure by applying different types of aluminium alloy to get the best kind of aluminium frame for the model. The result from the test indicates the reliability and level of user friendly of the model. It helps the industry in increasing the quality of their products which also guaranteed the lesser expense. The result obtained also indicates the tensile strength, the weight and the price of the aluminium alloys on today's market.

Keywords: Oil Pan Bolt Feeder Machine, Finite Element Analysis, Aluminium Alloy

1. Introduction

The study will focus on the industry generally due to the importance of studying the reliability of a model. This work will require SolidWorks2018 Simulation to simulate the Finite Element Analysis (FEA) into the desired model. FEA aids in the visualization of stiffness and strength in structural simulations, as well as the reduction of weight, material and prices. FEA allows researchers to visualize structures flex or twist in detail, and the distribution of loads and displacements. In short, FEA's advantages includes increased precision, improved design and greater visibility into crucial design

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Corresponding author: ahmadh@uthm.edu.my criteria, virtual prototyping, less iteration of the hardware, a quicker and less costly design cycle and increased efficiency [1].

The main factors that were affecting the tensile strength and ductility of aluminium alloy are the temperature of the material during the test and the alloy used in the material[2]. Manganese-containing alloys are the most essential and versatile system of high-strength wrought aluminium-copper magnesium alloys used in industry. Tensile strength rises with independent or simultaneous increases in magnesium and manganese, and yield strength rises to some extent. Manganese and magnesium additions reduce the fabricating qualities of aluminium-copper alloys, and manganese also reduces ductility; as a result, manganese concentrations in commercial alloys do not exceed roughly 1%. Thus, the higher the weight percentage Mg-Mn in aluminium alloy the higher the tensile strength of the aluminium alloy[3].

Table 1: The composition of aluminium alloy

Aluminium alloy	Al	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Ni	Ga
6061-T4	96.00-97.36	0.40-0.80	0.70	0.15-0.40	0.15	0.80-1.20	0.04-0.35	0.25	0.15	-	-
6061-T6	98.08	0.63	0.30	0.31	0.02	0.51	0.06	0.06	-	0.03	0.01
6063-T6	98.952	0.412	0.090	0.002	0.002	0.525	0.001	0.002	0.014	-	-
6063-T83	97.5-99.4	0.2-0.6	0-0.35	0.15	-	0.45-0.9	0-0.1	0.15	0.15	-	-
7075-T6	89.89	0.07	0.16	1.50	0.05	2.30	0.21	5.80	0.02	-	-

Note. Data are from [4],[5],[6],[7] and [8]

The mechanical qualities of the material will add to the design's strength; the material must have the required strength and stiffness for proper application in the engineering industries. Another consideration while designing is material wear: manufacturing procedures can put a product under stress. Thus, more wear resistance is necessary.

There are many types of aluminium alloy [2]. A study has found that many researches proposed aluminium alloy for lightweight model construction structures as it prompted them to look for new material [9]. The usage of aluminium alloy is mentioned an excellent material to use in a structural model, especially for industrial purposes, as aluminium alloy has very high tensile strength despite pricing at a low price and lightweight. As we know, they are many kinds of aluminium alloy which are used for different applications. Each kind of aluminium alloy has different alloying element that distinguish the alloy’s characteristics, so the alloying element’s nominal composition will dictate the functionality of the aluminium alloy [10].

The aim of the work is to investigate the reliability of the structural model of the oil pan bolt feeder machine that is custom-made by Double One Precision Engineering Sdn. Bhd. The issue with this system is weighty, and not all workstations can support it over time. To tackle this problem, we need to construct a workstation that can support the machine and calculate the workstation’s maximum weight so that the machine has to fasten a component and the workstation can hold it all without issue.

2. Experimental Setup

This study pre-processing begins with the design and ends with the meshing of the model.The external load, contacts, bolt connectors, and fasteners throughout the FEA process is known as the analysis phase. After the simulation has completed, post-processing takes place. The required data is obtained from the graph and animation at this point.

2.1 Pre-Processing Phase

The initial phase in this research is to design the frames and planes according to the measurements provided. Each structure assigned to its own specific material for both frames and planes, which is aluminium alloy 6061-T4 (as shown in Figure 6). After that, put together all of the pieces and join them together according to the Figure 1, Figure 2, Figure 3 and Table 2. Figure 4 and Figure 5 show the manufactured machine and the critical area that needs to be investigated.

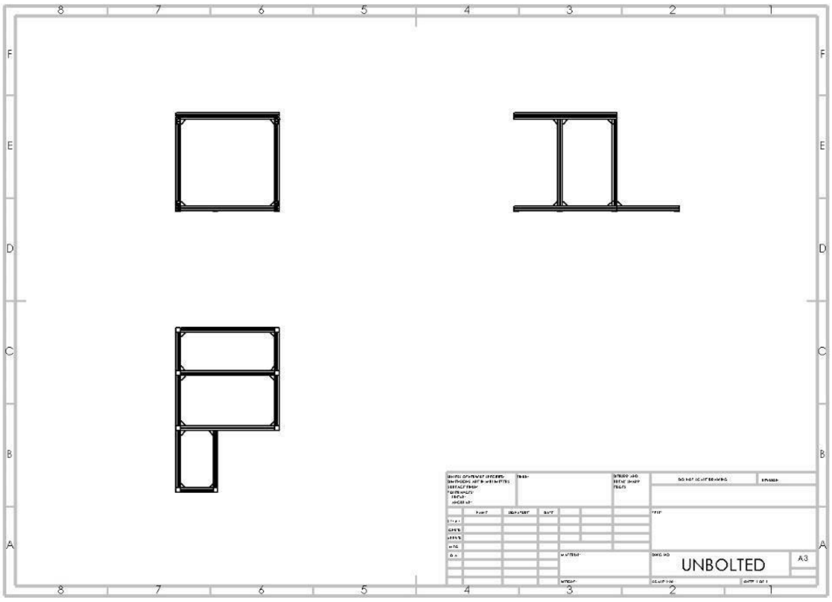


Figure 1: A3 drawing of the model

Figure 2: 3D drawing of the model

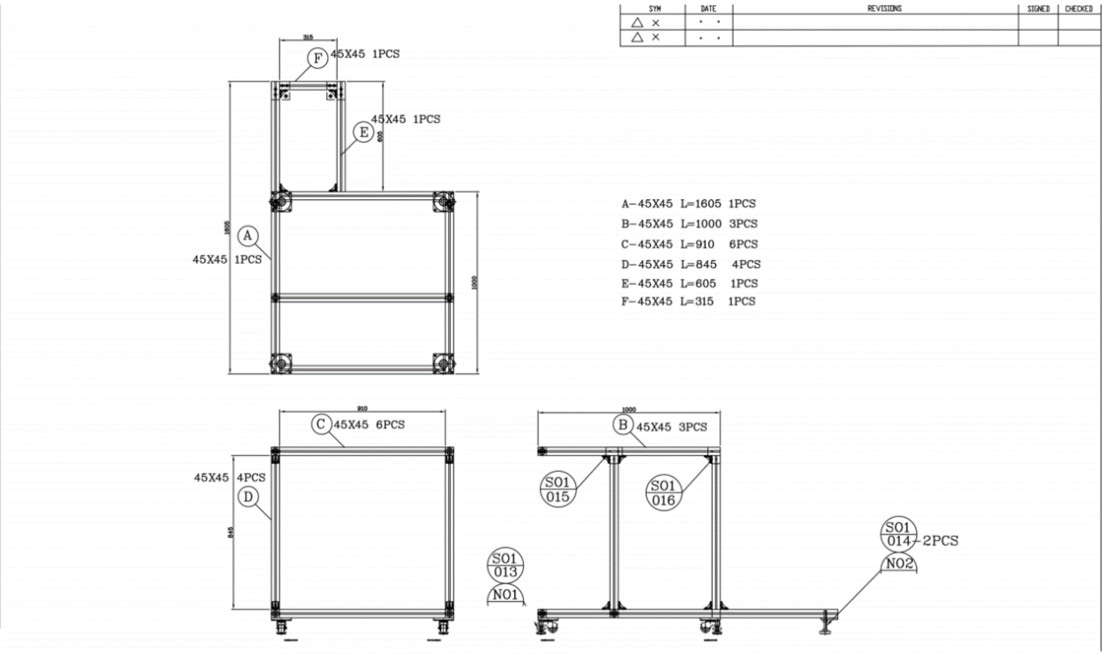


Figure 3: Dimension of the model

Table 2: Dimension of the model

Frame	Length (mm)	Pieces
A	1605	1
B	1000	3
C	910	6
D	845	4
E	605	1
F	315	1

Figure 4: Original model of the structure

Figure 5: The red circle indicates the critical spot

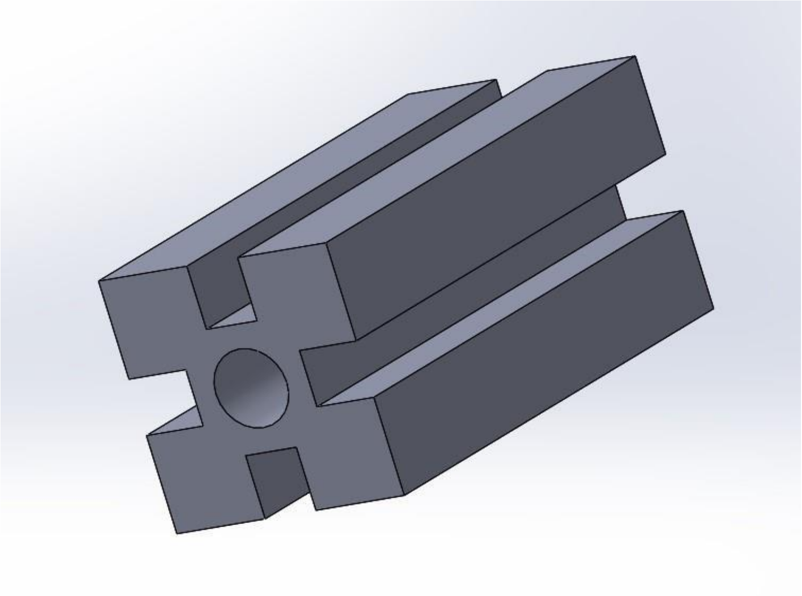


Figure 6: 45x45 aluminium alloy frame

2.2 Analysing Phase

To keep the structure from moving, start by applying fixed geometry to it (as shown in Figure 7). Figure 8 shows the applied load to the structure in the proper direction. Apply any amount of force to the chosen load. The force range was set at 2000lb because it reached its maximum safety factor at 2000lb and discovered the maximum bending stress that the structure could bear. Figure 9 shows the application of bolt as the structure's connector. To support the structure, subject the bolt to the appropriate amount of force. After that, connect the connectors with the contact set and component contacts. Run the simulation under static study condition after the analysing phase was completed.

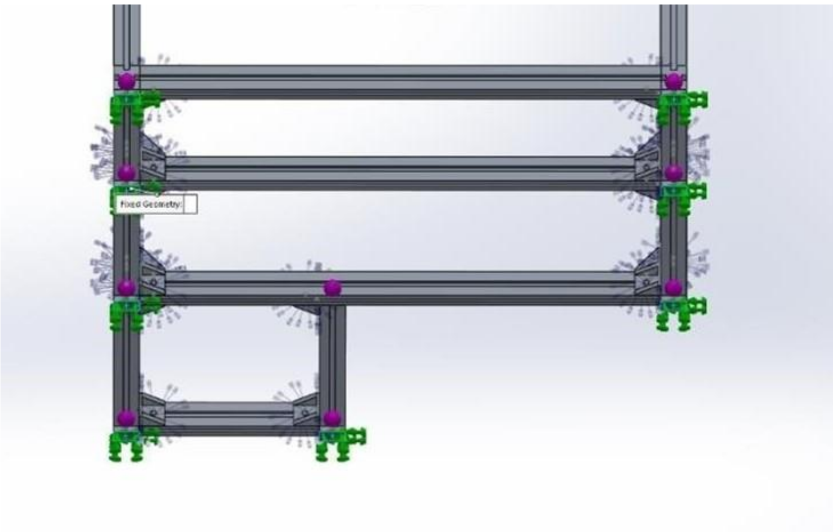


Figure 7: The application of the fixed geometry to the model structure

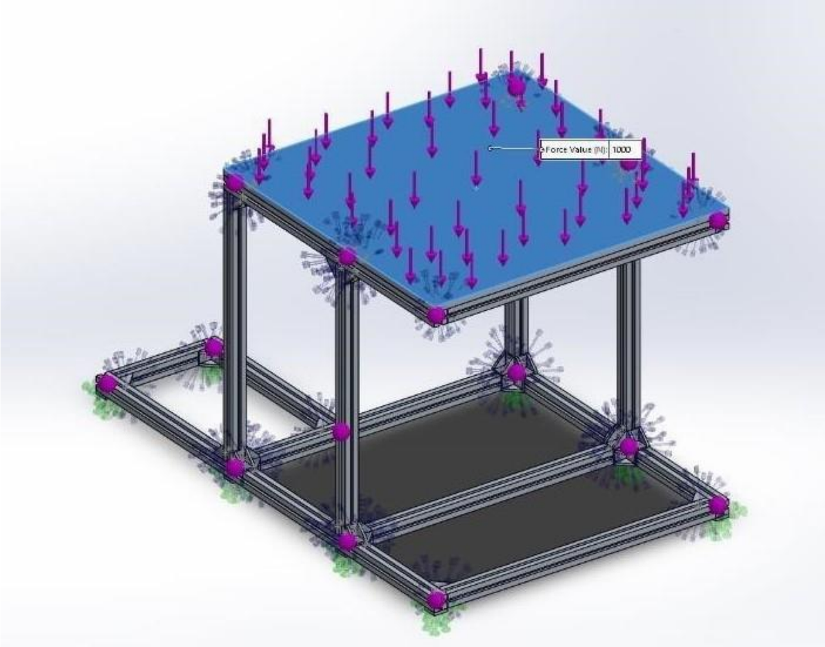


Figure 8: The application of external load to the model structure

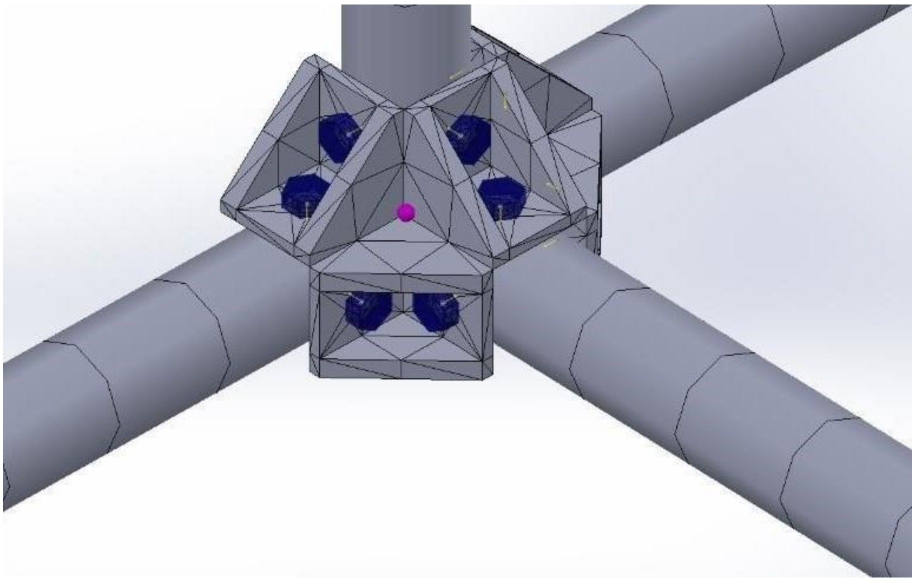


Figure 9: The application of connectors to the model structure

2.3 Post-Processing Phase

Select the Simulation study tree and click Run to run a study. After the simulation have successfully obtained the result, click Report from the toolbar, then right-click the result plot icon and select Save As. Repeat the Analysing phase by changing the material to another aluminium alloy.

3. Results and Discussion

3.1 Comparison of each material

This section evaluates the score according to the material quality on the tensile strength and weight. The higher material's tensile strength, the higher the possibility of the material to getting a high score, but if the material has a weight the point deducted is high. This section prioritizes the balance of the two main factors which are high tensile strength but lightweight. Figure 10, Figure 11, Figure 12 and Figure 14 show the result of FEM analysis on the different aluminium alloy. Each figure shows the displacement plot of the model. The higher the percentage of magnesium-manganese in the material, the lesser the area plotted in red. The score evaluation for each material is tabulated in Table 3.

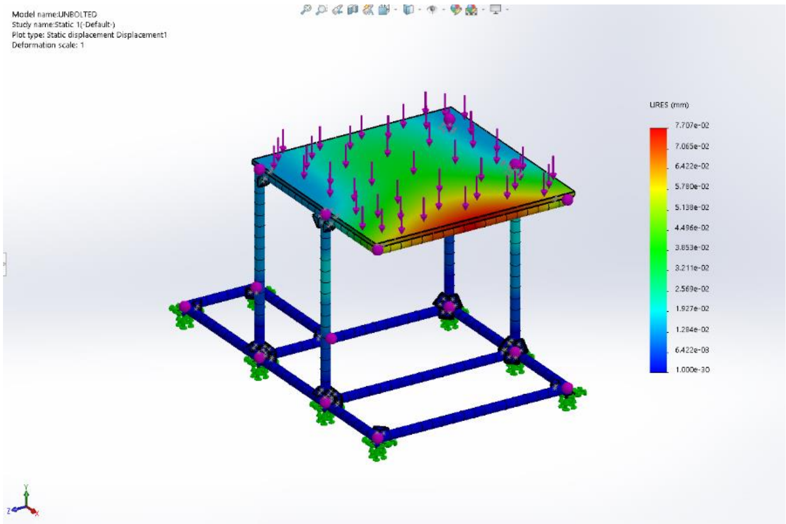


Figure 10: The result for aluminium alloy 6061-T4

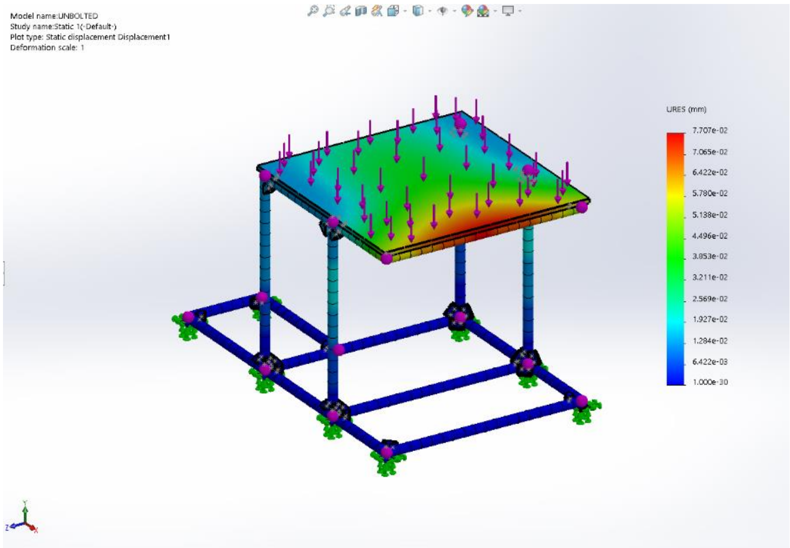


Figure 11: The result for aluminium alloy 6061-T6

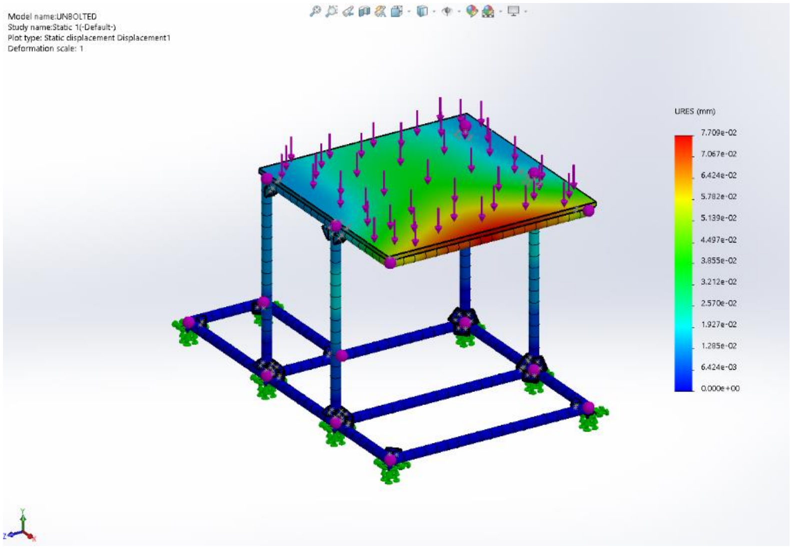


Figure 12: The result for aluminium alloy 6063-T6

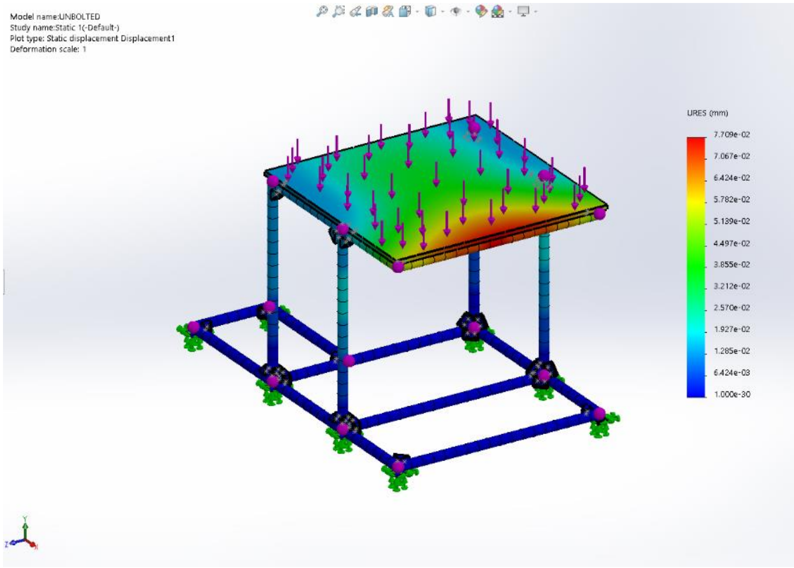
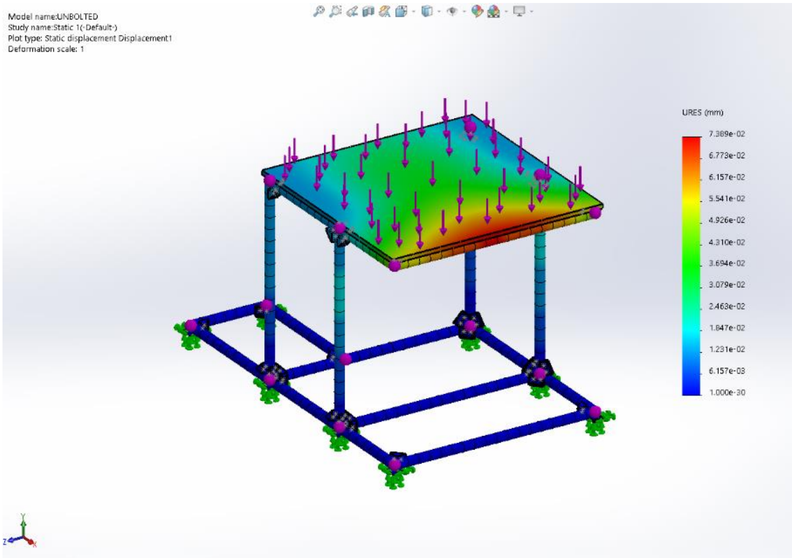


Figure 13: The result for aluminium alloy 6063-T83



Model name:UNBOLTED
Study name:Static 1(-Default-)
Plot type: Static displacement Displacement1
Deformation scale: 1

Figure 14: The result for aluminium alloy 7075-T6

Table 3: Comparison of the tensile strength and weight of each matter

Material	Tensile strength, MPa	Weight,g (per $1cm^3$)	Score
6061-T4	207.0	2.70	4
6061-T6	290.0	2.70	5
6063-T6	190.0	2.69	2
6063-T83	186.0	2.70	1

7075-T6	510.00	2.81	3

**The higher the score of the matter, the better the matter*

Aluminium alloy 6061-T6 has the highest score among all the alloys tested because the alloy has the second-highest tensile strength among the five and has a lighter weight than aluminium alloy 7075-T6 which has higher tensile strength. Ignoring the weight of the alloy above its tensile strength will result in overkill in the design of our model, as the model should also be user-friendly rather than focusing just on performance.

The aluminium alloy 6061-T4 received the second-highest score among the alloys since it is a light material with a tensile strength that is not excessive. The goal of this research is to create a model that is both usable and performs well.

Due to their poor tensile strength, aluminium alloys 6063-T83 and 6063-T6 receive the lowest and second-lowest scores, respectively. In addition to usability, the alloy's performance is critical in creating a user-friendly model. Both aspects are crucial when building a model. However, maintaining a balanced and optimal specification should take precedence.

3.3 Economy Factor

This section investigates the pricing by surveying Malaysia’s current market online at The Metal Merchant. Figure 11 shows the price of various type of aluminum alloy aluminum alloy 6061-T4 stands at the most expensive of the five priced at RM34.08 per kg coil. The second most expensive matter is aluminium alloy 7075-T6 which priced at RM28.40. The third most expensive is aluminium alloy 6063-T83 which priced at RM15.62. Both aluminium alloy 6063-T6 and 6061-T6 priced at RM13.06.

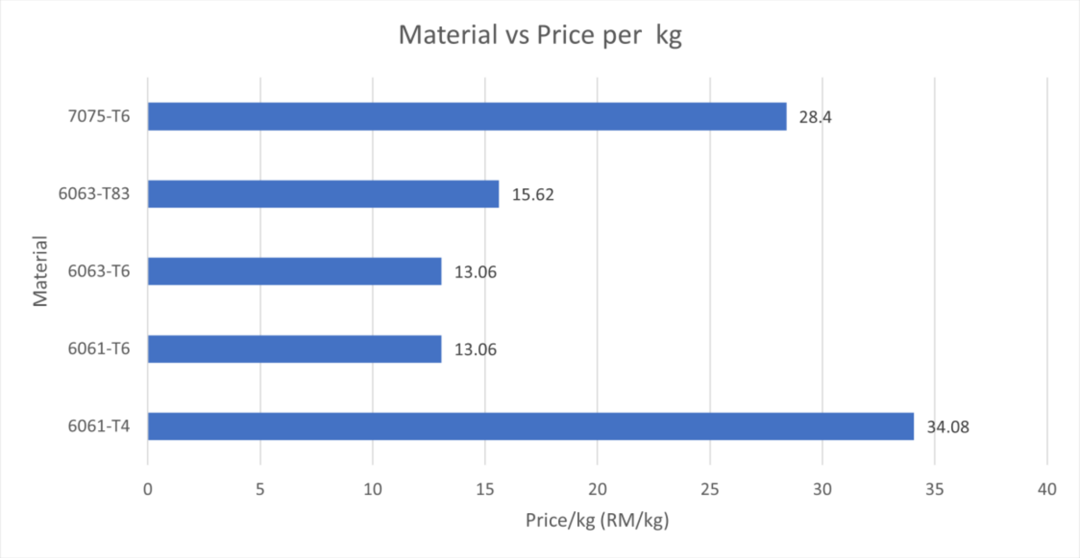


Figure 11: Price of each material per 1kg coil

Because it is the most expensive alloy of the alloys examined, aluminium alloy 6061-T4 is the least acceptable alloy for use in the model. The alloy is inconvenient to utilize. Some engineering research at universities cannot be supported because extra money is spent on the material to make a model.

The aluminium alloys 6061-T6 and 6063-T6 were the most cost-effective and user-friendly. Many engineering studies are employing cheaper materials. Furthermore, because the alloy has a low cost for a finished product, it can be employed for commercial applications. In summary, after considering different factors, the best material among the five aluminium alloys is 6061-T6.

4. Conclusion

The objective of the study has been achieved. It is proven that aluminium alloy 6061-T6 is the best material to use to construct the structural model because of its reliability, durability and user-friendly material, especially for the industry. The material has a very high tensile strength because it has very high weight percentage of manganese and magnesium composition in its alloy. Generally, as the weight percentage of manganese and magnesium in aluminium alloy composition increase separately or simultaneously, the higher tensile strength of the alloy hence the higher the yield strength and ultimate tensile strength.

By obtaining the same result aligned with the same explanation from different data that this study has collected, Finite Element Analysis, which was employed in this study, has verified the accuracy of prior scientific discoveries.

The material itself is very cheap for only RM13.06/kg and very light which only $2.70 g/cm3$ is. These characteristics can help the industry build more model structures with high reliability and durability at a tight budget.

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