Strength simulation of power window panel components design using ABS material

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Abstract. This study aims to simulate the strength of the design of car power window panel products using ABS plastic material. Strength obtained from this simulation will be used as a reference in the development of power window panel products in cars using bamboo fiber composite materials. The method used is to design the power window panel components and simulate loading using software. The results of strength simulation using software show that the strength of ABS plastic material produces good strength with loads 250 N, 500 N, 750 N, and 1000 N. The simulations produce data on safety factors, Von Mises, first principal, third principal and displacement. These results become a reference in the development of further power window panel components. Keywords: strength simulation, ABS plastic material, power window panel component.

1. Introduction
Power window panel is one component that is widely used in car interiors. The power window panel is not only as an accessory, but also as a place for the power window button even to the door lock button. The power window panel itself has a composite material which is the main choice in product development because it has several advantages over other materials used conventionally [1-5]. Composite is a material that is composed of a mixture of two or more materials with different chemical and physical properties, composite materials are composed of two types of constituent materials namely matrix and fiber (reinforcement). Both have different functions, fiber functions as the frame material that composes composites, while the matrix functions to glue the fiber and keep it from changing positions. A mixture of the two will produce a hard, strong, but lightweight material [6-9].

Today many power window panel components are made of special plastic material, known as ABS plastic. This research focuses on the design of power window panel components and strength simulation of power window panels made from ABS plastic material. The results of this study will be one of the references in the development of new materials made from natural fiber composite materials. Design and simulation of strength using Autodesk Fusion 360 software [10-13].

2. Method
This methodology is carried out in several stages, namely manual measurement of power window panels, 3D design and simulation that has been done on Autodesk Fusion 360 software with 4 load force variations, namely 250 N, 500 N, 750 N and 1000 N to get several results namely safety factor, Von Mises, 1\textsuperscript{st} Principal, 3\textsuperscript{rd} principal and displacement. ABS plastic
material characteristics are obtained from references commonly used by industrial components made of ABS plastic.

3. Result and Discussion

The power window panel component design was developed from the power window panel components used in Fortuner cars. The design begins with the measurement of finished components made of ABS plastic. Based on the measurement results of dimensions, then made designs using CAD software, as shown in Figure 1.

![Figure 1. Power window panel](image)

| Table 1. Properties of ABS plastic |
|------------------------------------|
| **Density**                        | 1.06E-06 kg/mm³ |
| **Young Modulus**                  | 2240 MPa        |
| **Passion’s Ratio**                | 0.38            |
| **Yield strength**                 | 20 MPa          |
| **Ultimate Tensile Strength**      | 29.6 MPa        |
| **Thermal Conductivity**           | 1.6E-04 W/(mm°C) |
| **Thermal Expansion Coefficient**  | 8.57E-05°C      |
| **Specific Heat**                  | 1500 J/(kg°C)   |

The purpose of this study is to develop new materials as materials for making power window panel components to become an alternative material to replace ABS plastic. Therefore, a mechanical output simulation is performed from the power window panel components commonly used on the market, which are made of ABS plastic material. The results of the strength simulation due to the load received by the power window panel, can be seen the durability of the original material from the power window panel against workloads including both hand loads when driving, loads opening and closing car doors (Figure 2). The following test data are test results obtained from the Autodesk Fusion 360 software with 4 load variations, namely 250 N, 500 N, 750 N, and 1000 N, which have several results, namely safety factor, Von Mises, 1st Principal, 3rd Principal, and displacement [12-17].
Figure 2. An example of a load on the power window panel

Von Mises test results
The Von Mises test aims to predict the height of the material's yield strength to the loading conditions. Based on simulation testing, the results of Von Mises are as follows:

| Force (N) | ABS | Force (N) | ABS |
|-----------|-----|-----------|-----|
| 250       |     | 500       |     |
| 500       |     | 750       |     |
| 1000      |     |           |     |

From the Von Mises (Table 2), it can be concluded that the lowest Von Mises value in ABS is 4.64 MPa at 250 N load and the highest Von Mises value in ABS is 19 MPa at 1000 N load.
1st principal test results
1st principal testing aims to predict the high shear stress with maximum tensile stress. Based on testing the 1st principal results are obtained as follows:

![Figure 4. Chart of 1st Principal stress results](image)

From the 1st principal stress (Figure 4), it can be concluded that the lowest 1st principal value in ABS is equal to -2.002 to 3.27 MPa at 250 N load and the highest 1st principal value at ABS is -9.86 to 13.07 MPa at 1000 N load.

3rd principal test results
The 3rd principal testing aims to predict high shear stresses with maximum stresses. Based on testing, the results of the 3rd principal are as follows:

![Figure 5. Chart of 3rd Principal stress results](image)
From the 3rd principal stress (Figure 5), it can be concluded that the highest 3rd principal value in ABS is -24.45 to 2.4 MPa at 1000 N load, and the lowest 3rd principal value in ABS is -4.741 to 0.6 MPa at 250 N load.

**Displacement test results**
Displacement testing aims to find out about the shift with the dimensions that have been determined. Based on testing, the displacement results are as follows:

| Force (N) | ABS | Force (N) | ABS |
|-----------|-----|-----------|-----|
| 250       | ![Image](image1.png) | 500       | ![Image](image2.png) |
| 750       | ![Image](image3.png) | 1000      | ![Image](image4.png) |

From the above displacement table data, it can be concluded that the lowest displacement value on ABS is 0.1917 mm at 250 N load and the highest displacement value at ABS is 0.767 mm at 1000 N load.

**Safety factor test results**
Safety factor testing aims to find out about the safety with the dimensions that have been determined. Based on testing, it can be concluded that the safety factor value in ABS with all the load given, namely at 250N, 500N, 750 N, and 1000 N is as follows:

| Force (N) | Yield Strength (MPa) | Von Mises (MPa) | Safety Factor |
|-----------|----------------------|-----------------|--------------|
| 250       | 20                   | 4.63            | 4.31         |
| 500       | 20                   | 9.5             | 2.1          |
| 750       | 20                   | 14.25           | 1.4          |
| 1000      | 20                   | 19              | 1.05         |

**4. Conclusion**
This study aims to obtain the characteristics of power window panel products made of ABS plastic material. The test is carried out by performing a loading simulation to obtain the strength of the car power window panel products made of ABS plastic material. Loading simulation using software at a load of 20 N, 500 N, 750 N and 1000 N. Based on this simulation, has been obtained the characteristics of the power window panel product which will be one of the references in developing alternative materials to make power window panels.
5. References

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