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Design of Plastic Waste Processing Extrusion Machines

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ABSTRACT

Plastic waste remains a significant unresolved issue due to extensive usage and lack of public awareness. It continues to be a problem in both rural and urban areas. The difficulty in eradicating plastic waste means that it will continue to accumulate if not addressed seriously. This study aims to develop equipment for processing plastic waste, including the main frame, component holder, heating tube, and screw extruder. This type of research falls under research and development (R&D) and involves the following steps: identifying potential and problems, gathering information, product design, design validation, and design improvement. The study findings are as follows: 1) The main frame is constructed using black hollow iron 30x30x1.6 mm; 2) Design drawings for the main frame, tube holder, heating tube, and screw extruder in both 2D and 3D formats are provided. These drawings include dimensions and work symbols in accordance with drawing rules; 3) The Von Mises Stress test on the main frame, conducted with a 100 kg load, indicates that the highest tension is located above the end of the middle support, with a value of 73.09 MPa. This value is far from the melting point. The part with the lowest stress is the lower frame, with a value of 0.02 MPa; and 4) The Von Mises Stress test on the tube holder, conducted with a 50 kg load, shows that the highest stress is at the bottom, with a value of 1.813 MPa. This value is far from the melting point. The part with the lowest stress is the lower seat of the side, with a value of 0.001 MPa.

Keywords: Extrusion, Plastic Waste, VON Mises Stress

INTRODUCTION

Plastic waste remains an unresolved issue due to extensive use and lack of public awareness. It continues to be a problem in both rural and urban areas. This type of waste is challenging to eliminate, and without serious intervention, it will persist and increase over time [1]. According to the National Waste Management Information System (SIPSN) of the Ministry of Environment and Forestry in 2022, plastic waste is the second most disposed type of waste [2].

The waste management breakthrough is outlined in Presidential Decree No. 97/2017, which addresses national policies and strategies for managing household and similar waste [3]. The Presidential Regulation requires the involvement of all stakeholders in carrying out integrated waste management from the source to the final processing. The goal is to promote the improvement of the environment's quality, making it clean and sustainable to enhance competitiveness. One of its implementations is to promote the recycling or utilization of hazardous and toxic materials (B3) as resources in the production process, including raw materials and energy. Nationally, the aste management performance index is still relatively low, with only 8 districts/cities falling under the good category in waste management [4]. In the Subang district, waste processing still involves open dumping. This means that after the waste is disposed of at the Final Processing Site (TPA), it is only compacted and left open. Ideally, waste processing should involve sanitary landfills, where the waste is covered with soil after compaction to prevent odor and the attraction of flies. It's important to note that waste, aside from its negative impact, also holds significant economic potential[5]. Recycling is the process of reprocessing items that are no longer considered economically viable through physical or chemical processes, or both, so that the materials can be reused or traded [6] A plastic waste processing device is needed to recycle plastic waste into a cylindrical shape (filament) so that it can be reused and traded. The process involves heating the plastic waste in a room to produce filament. Before creating the device, a design of the plastic waste processing equipment should be made to minimize errors in manufacturing. The study aims to design the equipment, including the main frame, component holder, heating tube, and screw extruder.

RESEARCH METHOD

This type of research involves development research, which includes data collection through observation and documentation of practical work. Data analysis is conducted using qualitative description. This type of research encompasses research and development (R&D)[7]. R&D research is a method used to develop and test new products [8] Research completion methods include:

1. Potential and Problems

The waste processing in Subang district still involves open dumping, where garbage is disposed of at the Final Processing Site (TPA), leading to odors and attracting numerous flies. However, waste also holds significant economic potential in addition to its negative impact. One way to capitalize on this potential is by recycling waste.

Field observations were conducted to gather information and data related to waste processing in the field. The information collection took place at the Environmental Office of Subang Regency, West Java. The field observations revealed that the amount of plastic waste in Subang regency, particularly in household waste, is still quite high and has not been recycled to its full potential. Therefore, the need for a plastic waste processing machine is essential to minimize plastic waste.

Figure 1. Observation of the availability of plastic waste processing equipment at the Subang regency environmental service

2. Product Design

To address the issue of recycling plastic waste, one approach is to develop plastic waste processing equipment. This process begins with conducting a search for relevant literature sources such as journals, books, or articles. Following this, the equipment is sketched to visualize its initial design and dimensions [9]. The design is created using CAD software after the sketch is made [10]. The design components consist of the main frame, tube holder, heating tube, and screw extruder.

3. Design Validation

This validation is an assessment of the design by experts who are competent in their fields, testing the strength of the design structure using CAD software. The validated designs include the main frame, tube mount, heating tube, and screw extruder. The structures tested were the Von Mises stress in the main frame and tube mount. Von Mises stress is used to predict the strength limit of a material under any loading condition based on the results of a simple uniaxial tensile test [11]. For the heating tube and screw extruder, only visual inspection is conducted by experts.

4. Design Improvements

Design improvement is the final stage of refining plastic waste processing machines. This phase is necessary if the CAD software tests and validations reveal design errors and deficiencies [12].

RESULT AND DISCUSSION

1. Main Frame

The main frame is constructed in a square shape to support all parts with a width of 500 mm and a height of 315 mm. At the top, there are two supports measuring 440 mm, made of black hollow iron material.

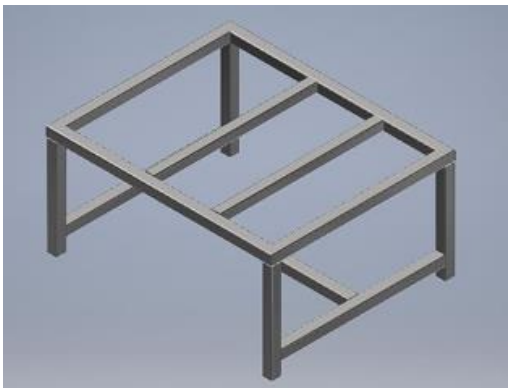

Figure 2. Main frame

The material selected for the frame and other components needs to be strong and resistant to corrosion. The main frame is made of black hollow iron, which is weather-resistant, corrosion-resistant, anti-rust, and free from termites, insects, fleas, and rodents. It has a size of 30x30x1.6 mm. The Von Mises Stress test using CAD software with a load of 100 kg shows that the highest stress is above the middle support end at 73.09 MPa, well below the melting point, while the part with the lowest stress is in the lower frame at 0.02 MPa. Based on this test, the frame design is considered safe.

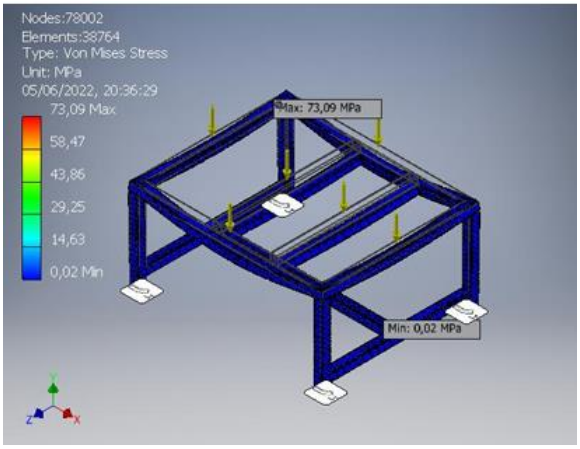

Figure 3. Von mises stress

2. Tube Mount

The tube holder is made using plate iron material. Iron plates are often made from low carbon steel, so they have good flexibility. This allows the plate to be drilled or shaped according to construction needs. The size of the tube holder is 200x160x4 mm. This stand has eight holes with a diameter of 10 mm and one hole with a diameter of 20 mm.

I have noted the following information: The heating tube holder undergoes Von Mises stress testing with a load of 50 kg applied to the stationary part, specifically at the base of the plate. The test results indicate that the load power limit ranges from a minimum of 0.001 MPa to a maximum of 1.813 MPa. Based on these results, the tube holder is still considered safe.

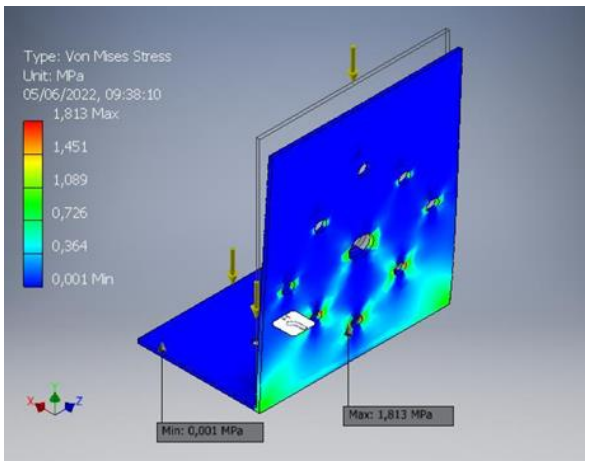

Figure 4. Tube mount

3. Heating Tube

The heating tube is designed as a reservoir for melting plastic waste, using an iron pipe with the following specifications: 350 mm in length, 90 mm in outer diameter, and 80 mm in inner diameter. Iron pipes are chosen for their ability to conduct both gases and fluids[13]. Furthermore, ductile iron exhibits strength, pressure resistance, and corrosion resistance [14].

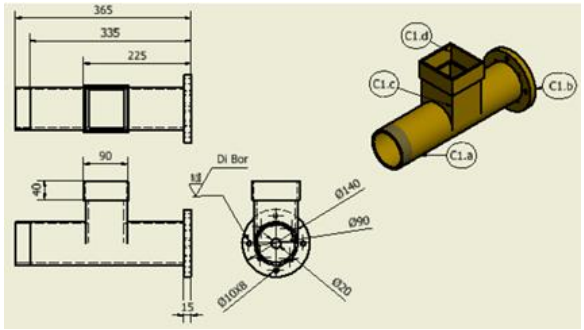

Figure 5. Heating tube

The tube cover is made of a 15 mm thick iron plate with a diameter of 140 mm. The circular plate has eight 10 mm diameter holes and one 20 mm diameter hole. The material entry point uses a 4 mm thick iron plate formed into a square with dimensions of 90x90 mm. Based on the results of the image validator, the drawings meet the requirements, with 2D drawings containing image dimensions and 3D drawings.

4. Screw Extruder

The screw extruder functions as a mechanism for melting plastic waste in paste form. It is made of solid iron, with a length of 505 mm and a diameter of 87.30 mm. The circular section is made of a 4 mm thick iron plate, formed into a circle with a diameter of 87.30 mm, and has 40 mm between each circle [15]. Based on this, the screw is expected to remove the maximum amount of plastic melt (paste).

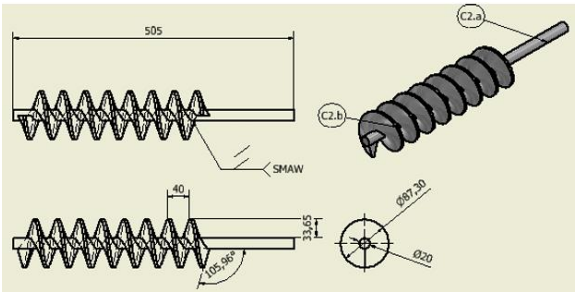

Figure 6. Screw extruder

Based on the results of the image validator, the drawings meet the required standards. Both 2D and 3D drawings are provided, with dimensions and work symbols.

CONCLUSION

The key points of the plastic waste processing machine plan are as follows:

1. The main frame will be constructed using black hollow iron measuring 30x30x1.6 mm. This material is chosen for its strength against weather changes, resistance to

corrosion and rust.

2. Design drawings of the main frame, tube holder, heating tube, and screw extruder in both 2D and 3D will be provided for use in the manufacturing process. These drawings will include dimensions and work symbols according to the rules of working drawings.
3. The Von Mises Stress test results on the frame using CAD software, with a load of 100 kg, indicate that the highest stress occurs above the middle support end with a value of 73.09 MPa, which is far from the melting point. The part that receives the lowest stress is on the lower frame, with a value of 0.02 MPa.
4. The results of the Von Mises stress test on the tube holder using CAD software with a load of 50 kg show that the highest stress is at the bottom, with a value of 1.813 MPa, which is far from the melting point. The part that receives the lowest stress is on the lower side seat, with a value of 0.001 MPa.

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