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Design Of Styrofoam Waste Treatment Equipment For Recycling Crafts Industry

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Abstract – People often use styrofoam as packaging for food products and electronic goods. After using styrofoam, it can be used for various purposes, such as basic materials for children's toys, craft materials, and materials for making glue or adhesives. But most of it becomes waste that can pollute the environment. Styrofoam waste can be recycled into raw material for styrofoam products. The design of this Styrofoam waste treatment machine uses the Pahl and Beitz method which is carried out in four stages, namely planning and explanation, concept design, product design, and detailed design. This Styrofoam waste processing machine is designed based on the need for waste treatment which can later be used by small industries to minimize Styrofoam waste. The results of the design of the styrofoam waste processing machine based on the calculation obtained a capacity of 19526 kg/hour with a rotation of 550 rpm for the counter shaft, 150 rpm for the forming shaft and 1 kW of power. The transmission system uses a v-belt with belt length 1 is type A-73 with L = 1854 mm and belt 2 is type A-78 with L = 1981 mm, pulley d2 is 550 mm d3 145mm, pegs with size 6 mm x 6 mm , bearing type numbered 6204, and on the chopping and forming shafts using SC35C material with a diameter of 20mm each.

Keywords – Machine design, Styrofoam waste, Pahl and Beitz method.

I. Introduction

Development of technology basically aims to answer the need for something useful for society, both existing and to be designed. Effective technology development efforts, first of all, must be based on market demand, whether existing or starting to be needed by the market. This capability must be complemented by the ability to translate the development of market needs with the ability to conceive of a spectrum of technologies that can respond to the observed needs. However, the level of success is still determined by the effectiveness of the technology produced. The success rate will be higher if the element of efficiency can be met. The term usability is a term that has a vague meaning, if it is not followed by a statement of usability, the latter is very contextual, depending on the community environment in which the technology will be used. Humans do not realize that every day must produce waste, both organic waste and inorganic waste. Organic waste is waste that can be decomposed by nature. Meanwhile, inorganic waste is waste that is difficult to decompose or even cannot be decomposed by nature. Inorganic waste has become part of society. Examples are styrofoam, plastic, PVC, and others. Styrofoam is widely used by the public as food wrappers and as a buffer material in packaging or packing electronic goods. After use, Styrofoam is thrown away, resulting in the accumulation of Styrofoam waste. Basically the nature of styrofoam is stiff, light and odorless so it is widely used by the public. The use of styrofoam only once makes the styrofoam life cycle short. In addition, there are still few craftsmen who process Styrofoam into products. Some people who have used the styrofoam waste to make it into various purposes such as basic materials for children's toys, craft materials, and materials for making glue or adhesives. Most glue manufacture is only used for patching carpet, vinyl or roof leaks, damaged household appliances or using it as an adhesive. The lack of styrofoam waste treatment is one of the reasons why this research is carried out. Therefore it is necessary to do research on the design of processing machine Styrofoam and objectives of this study are:

1. Designing a waste processing machine styrofoam by modifying the method of Pahl and Beitz.
2. Designing a waste processing machine styrofoam for small industries.
3. Designing machine components used in Styrofoam waste treatment machines.

II. RESEARCH METHODS

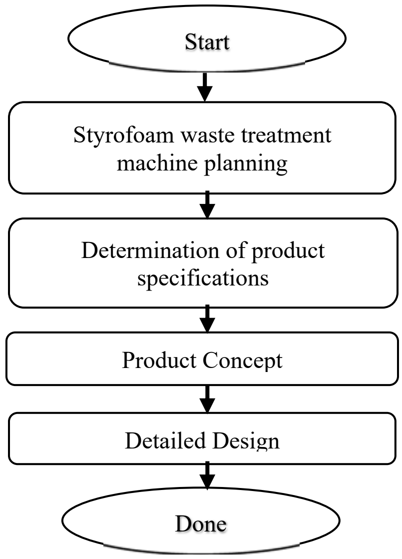

Figure 1. *Flow chart*

Design is the main and important stage of a process of making objects/products. In making objects/products, it is necessary to describe the right steps to be a guide in doing work. Flowcharts can be used to describe the steps in work. To facilitate the design of the styrofoam waste treatment machine, the author uses the Pahl and Beitz design method. Pahl and Beitz have 4 phases in product design, as follows:

1. Planning and explanation (Planning)
2. Product concept design (Conceptual Design)
3. Product shape design (embodiment Design)
4. Detail design (Detail Design)

Final layout in detail design stage is the result of invention design after doing several design phases before it becomes a finished product. In the final layout design, the arrangement of gears, form, dimensions, exterior levelness and substantial of each factor is resolute. Likewise, the opportunity of manufacturing methods has been analyzed and the projected cost has been considered. The output or final outcome of this stage is a comprehensive design illustration and invention conditions for manufacture which are commonly called product manufacturing documents.

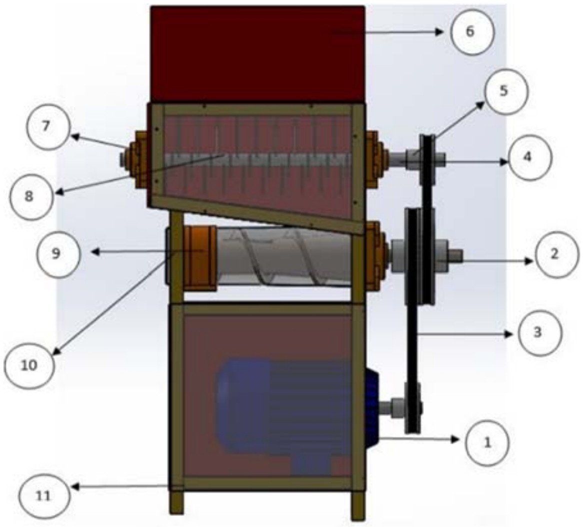

Figure 2. Final layout of the Styrofoam Waste Processing Machine

Description:

1. Engine

2. Pulley

3. Belt

4. Shaft

5. Pully

6. Hopper

7. Base Bearing and Bearing housing

8. Chopping knife

9. Heater bolt

10 Threaded shaft

11. Body

The hope is that the tool/machine can operate in accordance with the wishes and economical manufacturing costs. Machine specifications are absolutely necessary as a description of a product to be made. The description of the expected Styrofoam waste treatment machine design demands as shown in Table 1 is as follows:

1. Demands (D), is an absolute requirement that must be owned by the tool, if it is not fulfilled then the tool cannot be accepted.
2. Wishes (W), is a condition that can still be considered, so that if possible it can be fulfilled by the product made.

Table 1 Plan Demands Data Recapitulation

No	Plan Demands	Requirements	Level of Need
1	Kinematics	a. The mechanism is easy to operate b. Using the transmission system c. Direction of rotation CW	D D D
2	Material	a. Easy to get and cheap b. Has good mechanical properties c. According to general standards d. Long service life	D D D D
3	Geometry	a. Length ±610mm b. Width ±200 mm c. Height ±750 mm	D D D
4	Energy	a. Energy source using electric motor	W
5	Ergonomics	a. As needed b. Not noisy c. Easy to operate	D W D
6	Signal	a. Measuring motor speed b. Understandable manuals	W D
7	Safety	a. Strong construction b. Cover the rotating part	D D
No	Plan Demands	Requirements	Level of Need
8	Production	a. Can be made by small industry b. Low cost & easy to find spare parts c. Low cost	W D

			W
9	Mainte-nance	a. Low cost maintenance b. Easy maintenance	D D
10	Transport	a. Easy to move	D

III. Results And Discussion

In the design can be taken some data which is the assumption of the designer. In the design of the styrofoam waste treatment machine the assumptions made are:

1. Styrofoam in the form of sheets with a maximum size that can be processed is 330mm x 1000 mm x 160 mm.
2. The chopping blade has a diameter of 160 mm.
3. The enumerator house has dimensions of 165 mm x 200 mm x330 mm.
4. Chopper blade shaft rotation is 550 rpm.
5. The forming shaft has a diameter of 90 mm and a length of 300 mm.

Dimensions of the Enumerator Box

From the assumptions above, the dimensions of the enumerator house are planned to be 330 x 200 x 165 mm and Figure 3 is the design of the box.

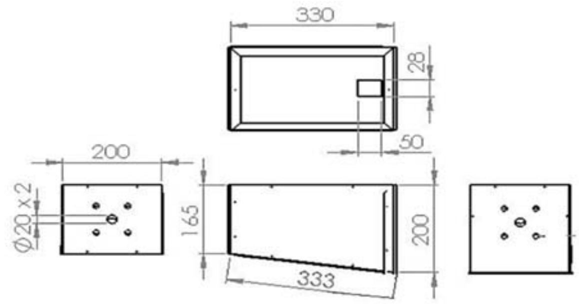

Figure 3. Chopping Box

Dimensions Chopping Blade Dimensions

From the assumption, it can be planned that the chopper blade diameter is 160 mm, with Figure 4 being the design drawing of the chopper blade. The chopping knife is planned to be single with 3 rows of blades with 11 blades per row so that the total number of blades is 33 blades.

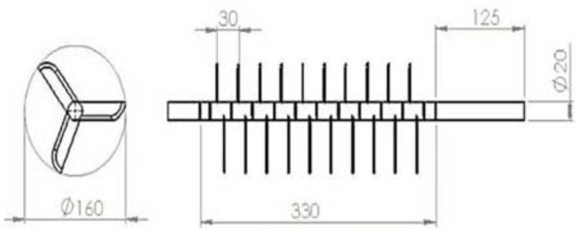

Figure 4. Dimensions of Counter Blades

The Planning for Screw Shaft

forming shaft is planned to have a length of 300 mm, with a diameter of 90 mm which is adjusted to the materials available in the market. The design of the shaft is as shown in Figure 5:

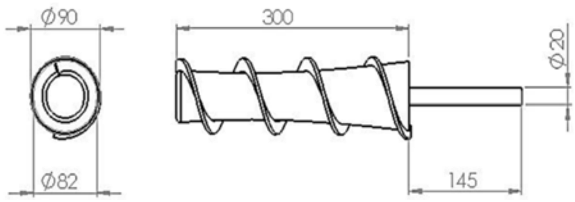

Figure 5. Dimensions of the Screw Shaft

The forming chamber is planned to be conical in shape with the size adjusted to the dimensions of the machine. The forming chamber is a container or space for the threaded shaft, so that it is planned to have a diameter of 50.8 mm and a length of 300 mm.

The Enumer Unit Capacity

Initial planning of the Styrofoam waste treatment machine is planned as follows:

Feeding area:

$A = 2 \times L_{mp}$

$= 2 \times 80$

$= 160 \text{ mm}^2$

Information:

A = feeding area

L_{mp} = blade length

Styrofoam density 0.05 gr/cm^2. Plastic cutting speed with HSS blade is 36 m/min. It is planned that the rotation of the chopping blade shaft is 550 rpm. Then the feeding speed can be as follows:

Feeding speed:

$S = S_z \text{ xnxz}$

$= 0.245 \times 11 \times 550$

$= 1482.25$

From the above calculation, the engine capacity can be calculated with the following formula:

$Q = P \times A \times S$

$= 50 \text{ kg/m}^3 \times 160 \text{ mm}^2 \times 1482.25 \text{ mm/min}$

$= 1.1858 \text{ kg/min}$

$= 71.148 \text{ kg/hour}$

Shaft

Calculation Calculating the torsional moment (designed torque moment) experienced by the shaft, the design torsional moment is the magnitude of the torsional moment exerted on the shaft. If the diameter of the shaft is determined to be 20 mm, the torsional moment (also known as the design moment) is T (kg.mm), then:

$$d_s = \left[\frac{5.1}{\tau_\alpha} Kt.Cb.T\right]^{1/3}$$
$$d_s = \left[\frac{5.1}{2.88}\ 1.5\ x\ 2.2\ x\ T\right]^{1/3}$$
$$d_s = [5.84\ x\ T]^{1/3}$$
$$T = \frac{8000}{5.84}$$
$$= 1\ 369.86 \text{ kg.mm}$$

Motor Power Planning

Styrofoam waste processing machines work by rotating the shaft driven by an electric motor. The rotation of the electric motor is transmitted by the help of pulleys and v-belts then to the shaft. In this styrofoam waste processing machine there are two shafts, namely:

1. Shaft 1 is the shaft of the forming unit with a diameter of 20 mm which serves to move the shaft of the forming unit.
2. Shaft 2 is the chopping knife shaft with a diameter of 20 mm which functions to move the chopper blade.

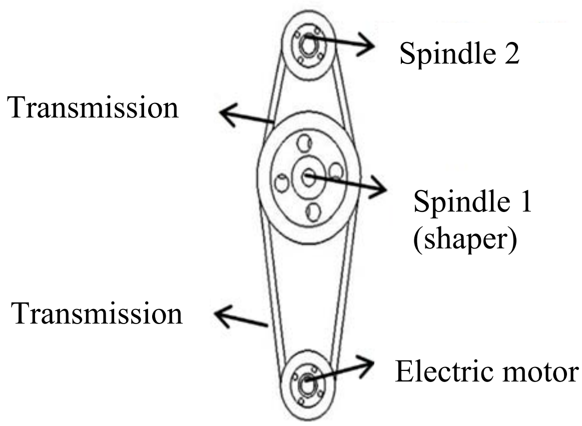

Figure 6. Power transmission of styrofoam waste processing machine

Shaft Power 1

Calculating the power of the first shaft where the rotational speed of the screw shaft (n1) is planned to be 466 rpm and the torque (T) 1 is 369.86 kg.mm. Then the rotational power of the first shaft (Pd1) is as follows:

$$P_{d1} = \frac{(\frac{T}{1000})(\frac{2\pi n1}{60})}{102}$$
$$= \frac{(\frac{1369.86}{1000})(\frac{2\pi.150}{60})}{102}$$
$$= \frac{(1.36)(15.7)}{102}$$
$$= 0.20 \text{ kW}$$

Shaft Power 2

Calculates the power of the second shaft where the rotational speed of the counter shaft (n2) is planned to be 550 rpm and the torque (T) 1 is 369.86 kg.mm. Then the rotation of shaft power one (Pd2) is as follows:

$$P_{d2} = \frac{\left(\frac{T}{1000}\right)\left(\frac{2\pi n2}{60}\right)}{102}$$

$$= \frac{\left(\frac{1369.86}{1000}\right)\left(\frac{2\pi.550}{60}\right)}{102}$$

$$= \frac{(1.36)(57.5)}{102}$$

$$= 0.76 \text{ kW}$$

Total Motor Power

From the calculation of the shaft power, the results of the first shaft power (Pd_1) are 0.20 kW and the second shaft power (Pd_2) the results are 0.76 kW. Then the required motor power (P) is:

$$P = Pd_1 + Pd_2$$

Description:

P = Motor power (kW)

Pd_1 = Shaft power rotation 1 (kW)

Pd_2 = shaft power rotation 2 (kW)

Then:

$$P = Pd_1 + Pd_2$$

$$= 0.20 + 0.76$$

$$= 0.96 \text{ kW}$$

According to the motor available in the market, the motor power of 1 kW is used.

Design of Shaft Bearings

In the Styrofoam waste processing machine, rolling friction occurs between the rotating shaft and the stationary element, in this case the ball (bullet) in a bearing. Based on the diameter of the shaft used, the bearing number used is 6204 because the specific nominal capacity affects the life of the bearing. The bearing type is Single row radial groove ball bearing.

Counter Bearing Planning

In the Styrofoam waste processing machine, rolling friction occurs between the rotating counter shaft and the stationary element, in this case the ball (bullet) on a bearing. Because of this, the designer plans to use a ball bearing type. The bearing number used is 6204 because the specific nominal capacity affects the bearing life.

IV. DECISION

Constructed on the consequences of the design of the Styrofoam waste treatment machine, the following conclusions can be drawn:

1. The method used in the design, namely Pahl and Beitz, is carried out in four stages, namely planning and explanation, concept design, product design, and detailed design. The design chosen is the 3rd variant with a value of 7.44 because it has the best value compared to variant 1 with a value of 7.02 and variant 2 with a value of 7.16.

2. The results of the design of the Styrofoam waste treatment machine from the calculation obtained a capacity of 71,148 kg/hour with a power of 0.1 kW.

3. The engine components used are SC35C type shafts with a diameter of 20 mm each. The transmission system uses a v-belt with a belt length of 1 is type A-73 with L = 1854 mm and belt 2 is type A-78 with L = 1981 mm, pulley d2 is 550 mm d3 145mm, pegs with a size of 6 mm x 6 mm , Project bearing type numbered 6204.

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