

Plastic Shredder Machine Design Using Quality Function Deployment (QFD) Method

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Abstract- Plastic waste is one of the causes of environmental problems faced by the people of Indonesia and the world. The characteristic of plastic waste is that it is difficult to break down in the soil, so it takes tens or hundreds of years for it to be completely degraded. The negative impact of plastic waste can damage the environment systematically. The first thing that is done in the plastic recycling process is chopping plastic or destroying plastic. Not a few bottles or plastic cups used for mineral water come from households. The objectives of this research are as follows: 1). To find out the attributes that according to the wishes/needs of consumers in designing an ergonomic plastic Shredder Machine based on a home industry using the Quality Function Deployment (QFD) method; 2). Designing an ergonomic plastic Shredder Machine model as an alternative to Appropriate Technology. Based on the results of the House Of Quality (HOQ), 2 alternatives were obtained, and 2nd alternative was chosen, because there are several components that are useful for work safety and the height is adjusted according to customer need.

Keywords- Shredder Machine, Quality Function Deployment (QFD), House Of Quality (HOQ)

I. INTRODUCTION

Every year, Surabaya's population is always increasing. The increasing population of the City of Surabaya is not only influenced by the high birth rate, but also the movement of residents from other areas to the City of Surabaya who want to try to find work (Kunhadi, et al., 2018). With the increasing number of residents in the city of Surabaya, it can be correlated with the increasing amount of waste generated. The consumption pattern of Surabaya City residents contributes to producing various types of waste. Based on data from the Office of Cleanliness and Green Open Space, Surabaya noted that the amount of waste entering the Benowo Disposal Site in 2016 reached 1,500 tons per day, in 2015 with 2,000 tons per day and 2014 at 1,400 tons per day (Amaluddin, 2017).

Various sources of plastic waste. One fact, the use of plastic in Indonesia which is used as packaging mentions around 43.4%. In addition, another fact that is obtained is that every person in Indonesia throws away 700 plastic bags per year. One more fact, consumption of bottled drinking water

continues to increase by 10 percent per year. Indonesia is in second place after China as the largest plastic waste contributor in the world. The amount is 3.2 million tons. "Plastic waste has proven to be bad for marine biota. On the East Coast of Surabaya, thousands of mangrove children died wrapped in plastic waste (Cahyono, 2018). Not a few bottles or plastic cups used for mineral water come from households. One application of a new paradigm in community-based waste management through waste banks is by empowering communities at the RT and RW levels.

Lack of tools that can treat plastic waste, resulting in less than optimal handling of plastic waste. The manufacture of plastic waste chopping machines can help overcome the problem of existing plastic waste so that it can be used as raw material for recycled plastic so that it can reduce plastic waste that pollutes the environment (Almukti & Purkuncoro, 2018).

The problems faced by the RT and RW in the Surabaya area are as follows:

1. The management of the waste bank has limited storage space, so that they feel confused in placing plastic bottles or cups that come from the community, because they have light weight and moderate volume.
2. The management of the waste bank usually use sacks as containers for used plastic bottles or cups before being transported to collectors, so they need a lot of wrapping containers with a few scales in one sack.
3. Selling prices for plastic bottles and cups is cheaper than those that have been chopped.

II. RESEARCH DESIGN

A. Research Problems

1. What attributes are in according to consumer desires in designing a plastic Shredder Machine.
2. How to design a plastic Shredder Machine as an alternative to Appropriate Technology.

B. Problem Scope and Limitation

1. The design of this plastic Shredder Machine is in accordance with consumer desires.

- The data used in this research use primary data and secondary data. Primary data used were interviews and questionnaires, while secondary data were found in the publication of scientific articles and journals.
- Analysis of the data used in this research using the Quality Function Deployment (QFD) method.

C. *Research Goals*

- Knowing and identifying the attributes used in designing a plastic Shredder Machine in accordance with consumer desires.
- Designing a plastic Shredder Machine in accordance with consumer desires

III. THEORETICAL FRAMEWORK

A. *Garbage*

Garbage is material or residual material from human activities that is no longer used, disliked or something that must be thrown away. Waste management needs to be done, because the more waste humans produce, with the aim of processing waste that is harmful to the environment into materials that have economic and useful value (Fadhilah, et al., 2011).

Plastic waste is dangerous because it is difficult to degrade, plastic is difficult to decompose in the soil because it takes up to 100 years or more. The use of plastic waste pollutes soil, groundwater and underground creatures. The plastic particles toxins enter the soil and can kill animals and decomposing bacteria in the soil. Plastics interfere with waterways that are absorbed in the soil and reduce soil fertility because blocking air circulation in the soil and the space for creatures that play a role in soil fertility. Plastic waste is a serious disruption to environmental sustainability (Hardiatmi, 2011; Setyowati & Mulasari, 2013).

B. *Quality Function Deployment (QFD)*

QFD is a method used for structured product planning and development that allows the development team to clearly define consumer needs and wants, and evaluate each desired product or service capacity provided systematically in order to meet the wants and needs of consumers (L. Cohen, 1995; Rahman & Supomo, 2012).

By definition, Quality Function Deployment (QFD) is a practice for designing a process in response to customer needs. Quality Function Deployment (QFD) translates what the customer needs into what the organization produces. Quality Function Deployment (QFD) enables organizations to prioritize customer needs, find innovative responses to those needs and improve processes to achieve maximum effectiveness. Quality Function Deployment (QFD) is also a practice towards process improvement that can enable organizations to exceed customer expectations (Jaelani, 2012).

C. *Shredder Machine*

Shredder Machine is a tool used to chop or crush plastics. Starting from beverage bottles, oil bottles, jerrycan, and other

plastic wastes. Lack of tools that can treat plastic waste, resulting in less than optimal handling of plastic waste. By making this automatic plastic waste Shredder Machine, it is hoped that it can help overcome the problem of existing plastic waste so that it can be used as raw material for recycled plastic so that it can reduce plastic waste that pollutes the environment (Almukti & Purkuncoro, 2018). The main components used in designing a Shredder Machine include: a. Motor drive, b. Shaft, c. Pulley, d. Belt (Belt), e. Chopping knife, f. Plastic filter (Suartika, et al., 2015).

IV. RESULT AND DISCUSSION

A. *Voice of Customer*

At this stage, identification of customer needs is carried out by conducting interviews and distributing questionnaires as many as 30 plastic bottle collectors who know and understand the Shredder Machine. Based on the questionnaire, related information and consumer wants and needs were obtained, so that several attributes can be formulated in the planning and manufacturing of a Shredder Machine. The attributes used include: 1) Attractive Design; 2) Rotary knife speed; 3) Production capacity; 4) Easy to maintain; 5) Easy to operate; 6) Safety for operators; and 7) Affordable prices.

B. *Relationship Stage*

On the stage consists of 2 stages, namely: relationship technical response, and relationship between customer needs and technical response. According Widiasih and Murnawan (2016) explain that technical response is a stage to transform non-technical customer needs and desires into technical data to meet these needs and desires. Technical response is also often referred to as the developer’s voice as a technical answer to what customer want. The preparation of technical responses can be seen in the table 1 below.

TABLE I. THE PREPARATION OF TECHNICAL RESPONSE

No	Attribute	Technical Response
1	Attractive Design	Shape
2	Speed of rotary knives	Motor & Gearbox
3	Production capacity	Chopping knife
4	Easy to care	Easy to dismantle and assemble
5	Easy to operate	Holder of the sack clamp
6	Safety against to operator	Safety sensor
7	Affordable prices	Raw material

C. *Planning Matrix Stage*

In determining the planning matrix, several processes are carried out, including: Importance to customer, Current Satisfaction Performance, Goal, Improvement Ratio, Sales Point, Raw Weight and Normalized Raw Weight. The improvement ratio value is obtained from the goal divided by Current Satisfaction Performance. These results are to find out how big improvement or enhancement must be made in developing the product which can be seen in table 2.

TABLE II. IMPROVEMENT RATIO VALUE

Customer Needs	Goal	Curent Satisfaction Performance	Improvement Ratio	Decision
1	2	3	4 = 2/3	5
Attractive Design	4	2,939	1,361	Moderate improvement
Speed of Rotary knives	4	2,727	1,467	Moderate improvement
Production capacity	4	3,424	1,168	Moderate improvement
Easy to care	4	4,242	0,943	No changes
Easy to operate	4	3,121	1,282	Moderate improvement
Safety against to operator	4	2,818	1,419	Moderate improvement
Affordable prices	3	2,394	1,253	Moderate improvement

Technical matrix used to determine the priority of the technique in the process of developing engineering characteristics. The result technical matrix can be seen in table 3 below.

Based on the results of the technical matrix, the priority to product in shredder machine design is: 1) Safety sensor; 2) Shape; 3) Motor & Gearbox; 4) Chopping knife; 5) Easy to dismantle and assemble; 6) Holder of the sack clamp; 7) Raw material.

TABLE III. TECHNICAL MATRIX

Attribute	Technical Response							Importance Customer	Current Satisfaction Performance
	1	2	3	4	5	6	7		
Attractive Design	9	0	0	0	3	3	0	3	2.939
Speed of Rotary Knives	0	9	9	1	0	0	1	3	2.727
Production Capacity	0	9	9	1	1	0	3	3	3.424
Easy to Care	1	0	0	9	1	0	0	4	4.242
Easy to Operate	1	1	1	3	9	9	0	4	3.121
Safety against to Operator	9	1	0	0	0	9	0	3	2.818
Affordable Prices	3	0	0	0	0	0	9	3	2.394
Contribution	3.303	2.861	2.709	2.033	2.332	3.435	1.491	18.16	Total
Normalized Contribution	0.182	0.157	0.149	0.112	0.128	0.189	0.082		
Priority to Produk	2	3	4	6	5	1	7		

D. Product Concept Design

Based on the desires and needs of consumers, can be described in the Hous Of Quality (HOQ) in the shredder machine design which can be seen in figure 3.

Based on the HOQ result above, there are 2 alternatives in designing and manufacturing a shredder machine according to consumer wants and needs, namely:

1. The first alternative to the product specifications used is: the frame material uses 4cm x 4cm angle iron because it is strong and easy processing. The electric motor uses a ½ hp 1 phase induction motor with a 100 rpm gearbox. The chopping knife uses steel material as ST 90 and the shaft uses the material as ST 90 because its hard and not easily worn or crushed. The machine funnel uses galvanized steel plate material because its stronger and doesn't rust easily.

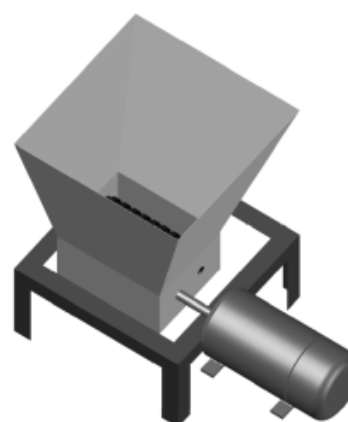


Figure 1. The First Alternative

2. The second alternative product specifications are used, namely: material using 4cm x 4cm angle iron because its strong and easy processing. The foot of the machine uses M16 x 40cm stut so that the engine can be adjusted to the height according to the wishes of the operator. The electric motor uses an induction motor 2800 rpm ½ hp 1 phase. The gearbox is separate from the motor, using a 50:1 gearbox which has an output of 100 rpm. The chopping knife uses steel material as ST 90 and the shaft uses the material as ST 90 because its hard and not easily worn or crushed. The machine funnel uses galvanized steel plate material because its stronger and doesn't rust easily. The safety system uses a pear sensor which when any part of the body enter the engine funnel or approaches the engine blade, it will automatically stop.

Based on the selection of the Shredder Machine concept, the selected design product is the second alternative. The dominant reason for the second alternative chosen is because it has several components that have important uses for work safety and can be adjusted according to customer need.



Figure 2. The Second Alternative

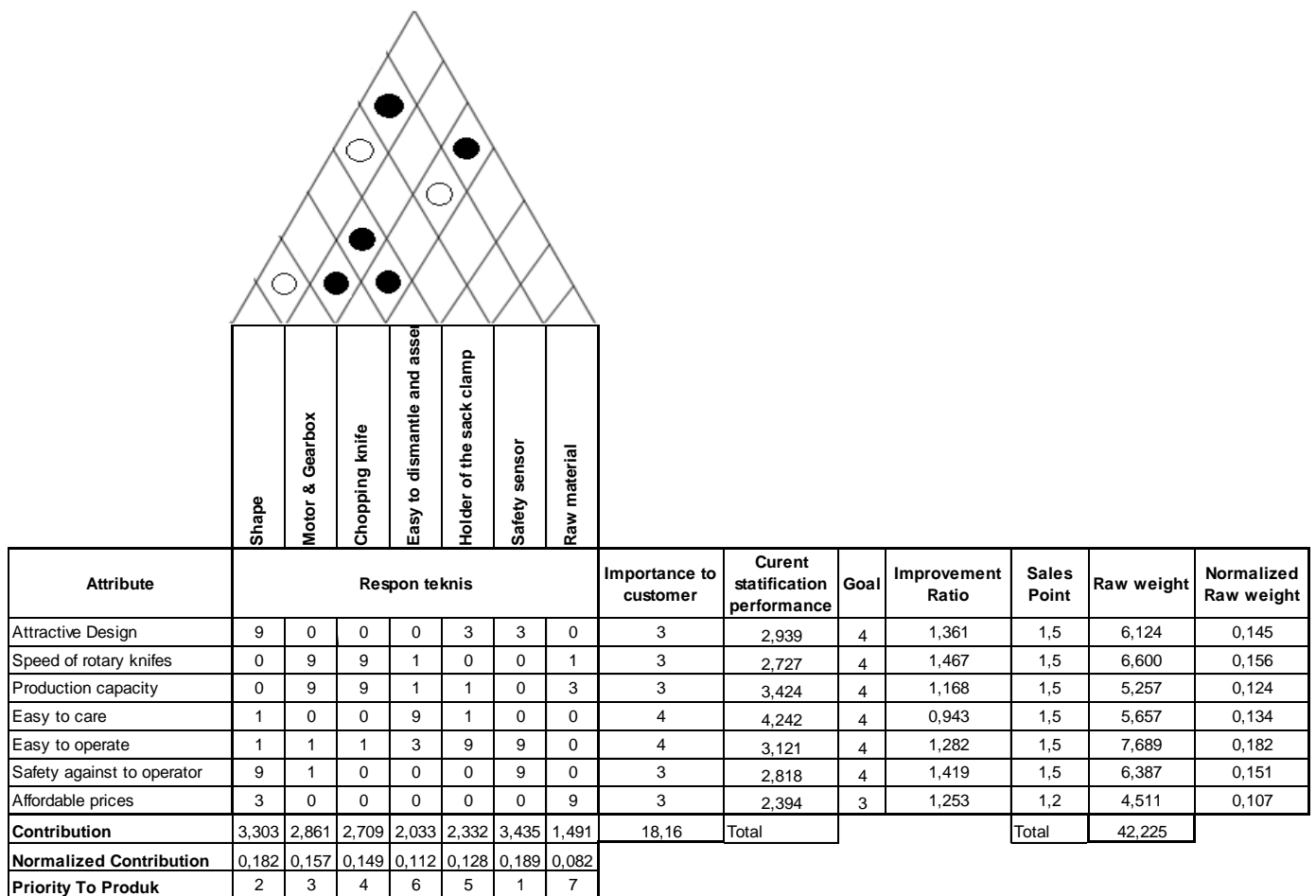


Figure 3. House Of Quality (HOQ)

V. CONCLUSION AND SUGGESTION

A. Conclusion

The conclusions of this research are:

1. Based on the above analysis, the following conclusions can be drawn: The attributes in accordance with the desires of consumers in designing a plastic Shredder Machine, namely: attractive design, speed of rotary knives, production capacity, easy to maintain, easy to operate, safety for operators, and affordable prices.
2. In designing the chosen shredder machine is the second alternative, because there are several components that are useful for work safety and the height is adjusted according to consumer needs.

B. Suggestion

For the development and improvement of the shredder machine, the following suggestions can be given :

1. This Shredder Machine is designed only to chop plastic bottles, therefore for further research it is hoped that the shredder machine design can be used for multi-functions.
2. This Shredder Machine has a relatively heavy load of 85 kg, it is hoped that for further research it can be lightened and made portable so that it is easy to carry and move places.

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