

Prototype Design of Plastic Waste Processing Equipment



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Introduction:

- Plastic waste is one of the biggest contributors to environmental problems. There are several alternatives that can be done to process plastic waste, namely by 3R (Reuse, Reduce, Recycle). Previous plastic recycling activities have been carried out by changing plastic waste into fuel oil [5] and making a plastic ore [3].

Objective:

- To develop plastic waste processing equipment products by integrating the shredder and heating machine into one tool, that can produce various kinds of plastic recycle products

Literature Review



STATE OF THE ART

ULRICH-EPPINGER :

Product Development Process, here are phases of Product Development:

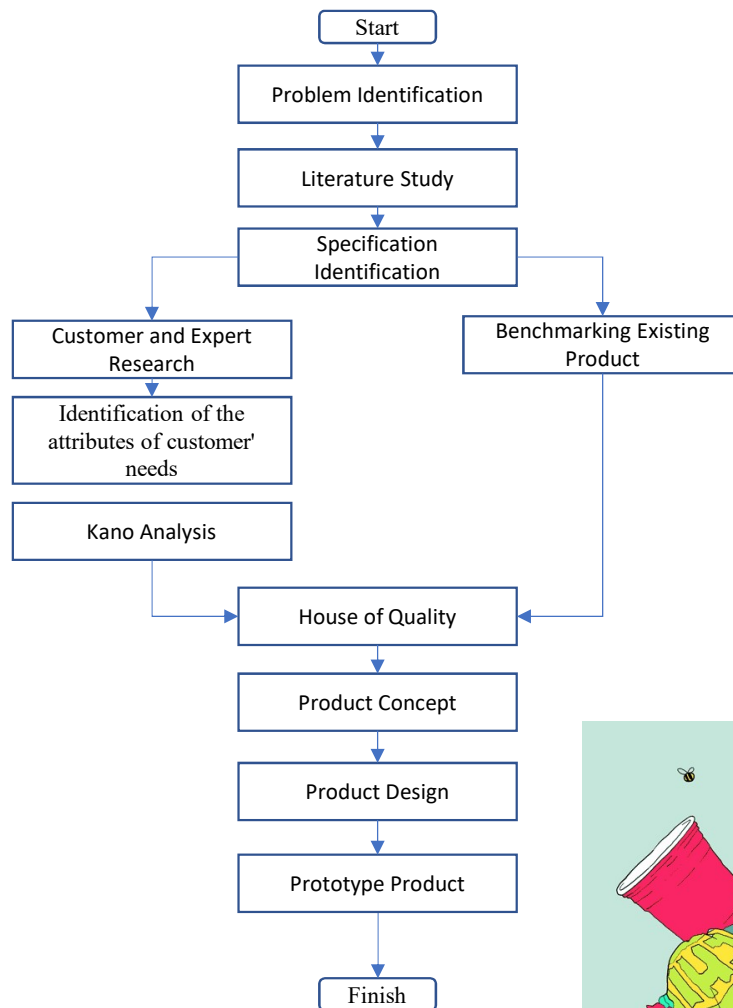
- Product planning
- Identifying customer needs
- Product Specifications
- Concept Generation
- Concept Selection Concept Testing
- Product Architecture
- Industrial Design
- Design for Manufacturing
- Prototyping

Kano model was made to understand the important factor from the customer point of view. There are 5 categories of Kano:

1. **Must-be Quality:** the requirements that must be included and are the price of entry into a market.
2. **One-dimensional Quality:** These attributes result in satisfaction when fulfilled and dissatisfaction when not fulfilled.
3. **Attractive Quality:** These attributes provide satisfaction when achieved fully, but do not cause dissatisfaction when not fulfilled
4. **Indifferent Quality:** These attributes refer to aspects that are neither good nor bad, and they do not result in either customer satisfaction or customer dissatisfaction.
5. **Reverse Quality:** These attributes refer to a high degree of achievement resulting in dissatisfaction and to the fact that not all customers are alike.
6. (from Wikipedia)

Methodology	Plastic Waste Processing Machine Output		
	Plastic Shreds	Liquid	Recycle Product
Without Product Development Methodology	Yamin, Satyadarma, Naipospos (2008)	Latief, Suparjo, Muis (2015)	
	Nur, Nofriadi, Rusmandi (2014)	Wicaksono & Arijanto (2017)	
	Kolontoko (2013)	Landi & Arijanto (2017)	
	Yetri, Sawir, Hidayati (2016)		
	Almukti & Purkuncoro (2018)		
	Anggraeni & Latief (2018)		
With Product Development Methodology	Syaka dkk (2016)		
	Parwati dkk (2018)		
	Research Area		

Research Methodology



3 stages:

1. Identification of the attributes of consumers' needs for products into the Kano category by formulate the Kano quadrant diagram.
2. Find out the attributes of consumer needs that must be prioritized and applied or not.
3. Determine product concept, specifications until prototype using Ulrich methodology.



3. Result and Discussion

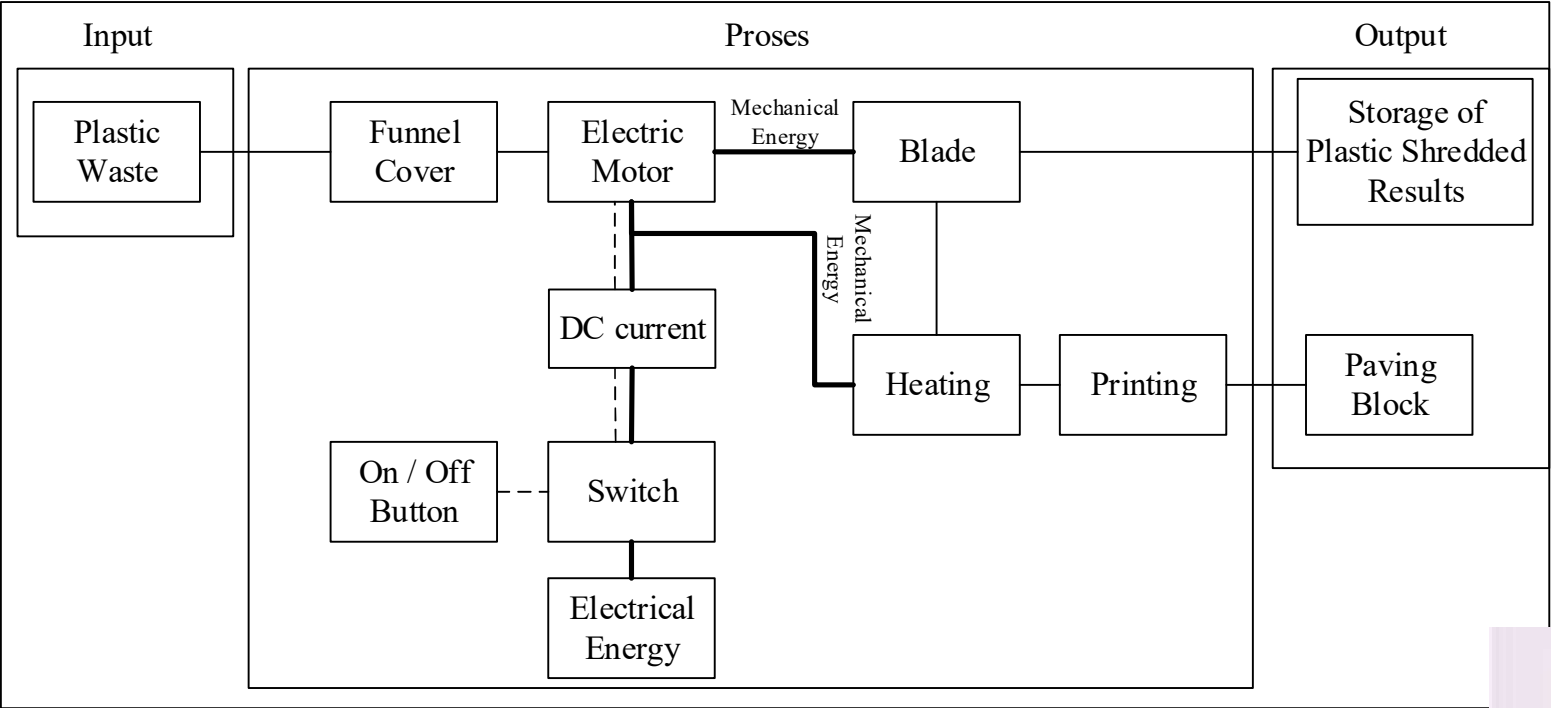
- *3.1 Data Collection*
- For this data collection, our team studying the existing plastic waste processing equipment, then we discuss, analyze the implementation to the new equipment. Then we made the *Operation Process Chart (OPC)* that describes the work elements, work sequence, and division of work elements in the production process of plastic waste processing equipment. Based on OPC drawings, it can be seen that there are 22 operations and 2 inspection activities with a total total time of 175 minutes .
- Then we made the Bill of material to the definition of the final product which consists of a list of items, materials, or materials needed to assemble, mix or produce the final product. In this BOM consists of various levels of the level of needs of a product section. The plastic waste processing equipment consists of 4 levels .

Part of Bill Material

Table 1. Bill of Material

Part Number	Level				Information	Amount	Units	Decision
	0	1	2	3				
A000					Recycling Plastic Machine	1	Units	Make
	A1100				Electric Motor	1	Units	Buy
	B1100				Gear Box	2	Units	Buy
	C1100				Poelly	2	Units	Buy
	D1100				V-Belt	1	Units	Buy
	E1100				Shedder	1	Units	Make
		E100			Hopper	1	Units	Make
			E110		Iron plate	4	Cm	Buy
			E200		Blade	1	Units	Buy
				E210	Bolt	1	Units	Buy
	F1100				Extrution	1	Units	Make
		F100			Barrel	1	Units	Buy
			F110		Screw Barrel	1	Units	Buy
				F111	Steel	1	Cm	Buy
				F120	Nozzle Heater	4	Units	Buy
				F130	Bearing	3	Units	Buy
				F131	Iron	1	Cm	Buy
				F140	Gear	2	Units	Buy
		F200			Controllor Temperatur	1	Units	Buy
			F210		Solid State Relay	1	Units	Buy
	G1100				Iron plate	1	Cm	Buy
	H11000				Framework	1	Cm	Make
		H100			Galvaniz Ram Wire	2	Units	Buy

Product Scheme

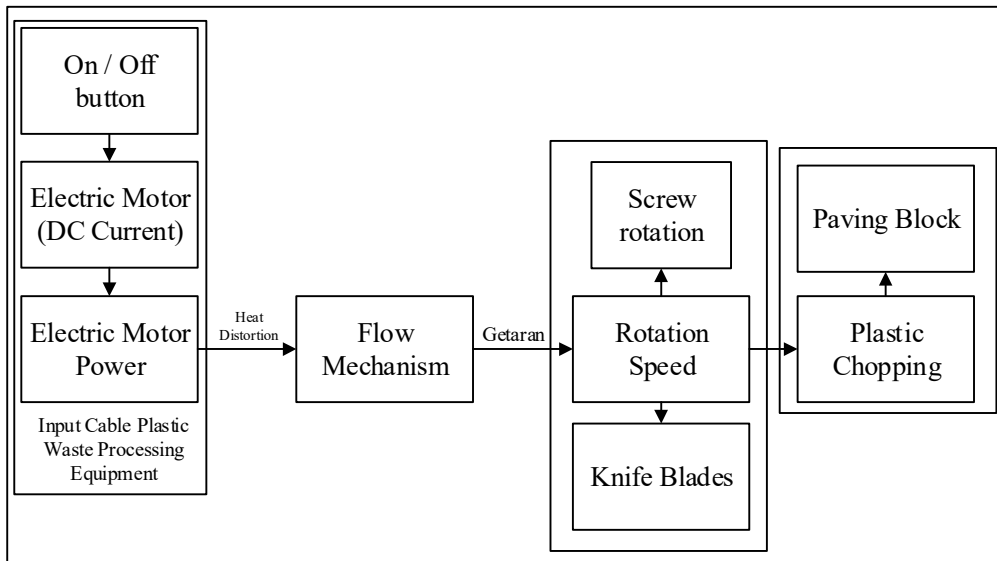


- Then we made the Product Architecture, starting from the Product Scheme.
- The scheme for plastic waste processing equipment products has physical elements as well as energy and material flow



3.2.1.2 Fundamental and Incidental Interactions

Fundamental interactions are interactions that have been planned and known from the start that occur suddenly, unplanned and have risks.



3.2.1.3 Concept Drafting

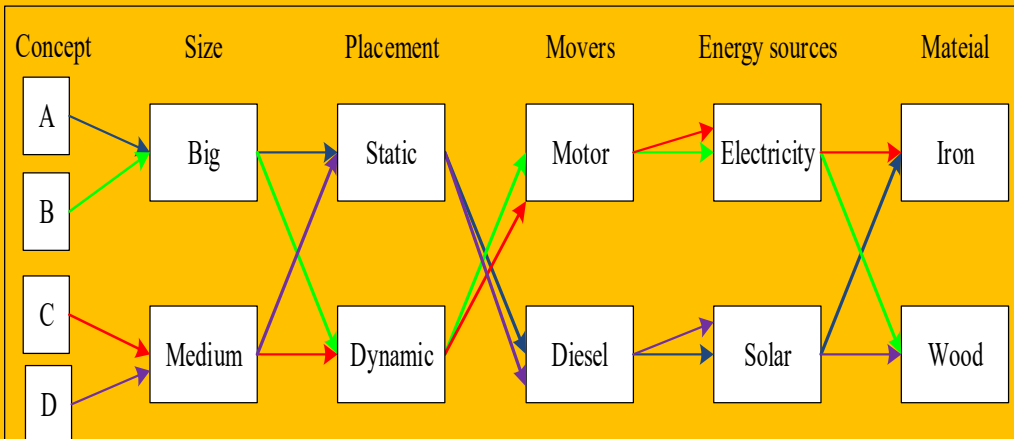
The product concept is a picture or estimate, the working principle and shape of a product. In addition, the product concept is also a brief description of how the product can satisfy the needs and wants of customers.

- Classification Tree



- Combination Table

After make a classification tree, we choose the feasible and optimum condition than we made the classification tree.



Based on the Figure 3 there are 4 kinds of concept variations

Concept A

the product has a large size that is 2 m long, 8 m wide, and 2 m high, the product placement is static, the engine drive uses diesel and uses iron-based materials.

Concept B

the product has a large size of 2 m long , width 8 m, and height 2 m, product placement is dynamic, the engine drive uses a motor,, and uses wood-based materials.

Concept C

the product has a medium size of 1 m long, width 6 m, and height 1 m, the product placement is static, the engine drive uses a motorand uses iron-based material.

Concept D

the product has a medium size of 1 m long, width 6 m, and height 1 m, the product placement is static, the engine drive uses diesel, and uses wood-based materials.

3.2.1.4 Concept Selection

Concept selection helps the development team in refining the concept.

- Screening Concept

Concept screening : narrowing down the alternatives. The score were 0, positive (+), and negative (-) assessments for each selection criteria.

Selection Criteria	Concept			
	A	B	C	D
Product Size	0	0	+	+
Product Placement	0	+	+	0
Movers	-	+	+	-
Energy Resources	-	+	+	-
Material	+	-	+	-
Amount +	1	3	5	1
Amount -	2	1	0	3
Amount 0	2	1	0	1
Final Score	-1	2	5	-2
Rank	3	2	1	4
Continue?	NO	YES	YES	NO

- Scoring Concept

Concept evaluation uses weighting selection criteria and a better rating scale. The result was as below:

Selection Criteria	Load	Concept			
		B		C	
		Rating	Value	Rating	Value
Product Size	15%	3	0,45	4	0,6
Product Placement	15%	5	0,75	5	0,75
Movers	25%	4	1	4	1
Energy Resources	20%	4	0,8	4	0,8
Material	25%	2	0,5	5	1,25
Total Value	100%	3,5		4,4	
Rank		2		1	
Continue?		NO		YES	

The highest value is concept C with score 4.4. Concept C in plastic waste processing equipment has a medium product size of 1 m long, 6 m wide and 1 m high, dynamic placement, using dynamo or electric motors as penggeraknya, energy sources which is generated is electricity, and uses iron material.

Then we do the design industry from ergonomic aspects.

Ergonomics			
Category	Level of Importance		
	Low	Medium	High
Ease of Use			●
Ease of Care		●	
Quantity of User Interactions			●
Security			●



3.2.1.2 Aesthetic Aspects

Differentiation that is owned by plastic waste processing equipment can be said to be different (moderate) from similar products.

Aesthetics			
Category	Level of Importance		
	Low	Medium	High
Product Differentiation			●
Prestige of Ownership, Fashion, Impression			●
Team Motivation			●

Prototype based on Kano and Benchmarking



(3)

(2)

(1)



Prototype Product Design

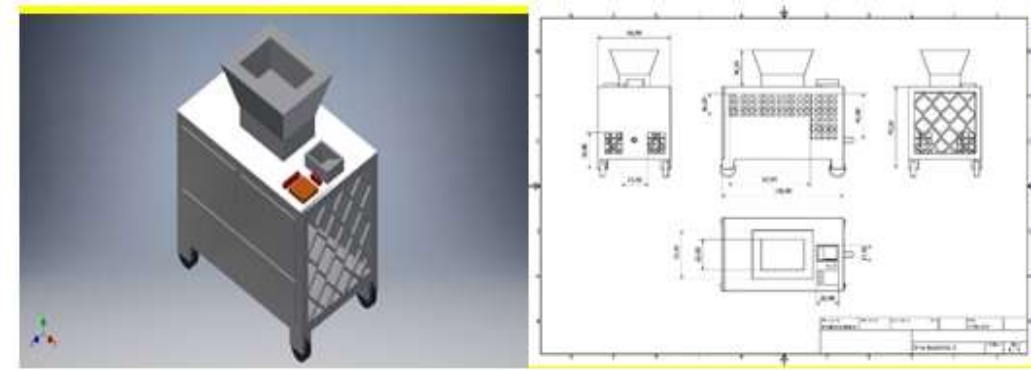


Illustration of a 3D and 2 D Image of a Plastic Waste Processor



Conclusion

- It is possible to make plastic waste processing equipment with the target functions.
- The shredder and heating process could work well.
- the blade does not make noise when the machine is used.
- But in the process of heating the molten plastic produced is still small in number.
- The concept chosen was the C concept, which was a medium-sized device that was 1 m long, 6 m wide, and 1 m height, moved using an electric motor, generated energy sources, and the material used for casing is iron.

