MODIFICATION DESIGN OF SHREDDER MASK WITH DISINFECTANT SPRAYER BY USING REVERSE ENGINEERING AND VDI 2221 METHODS

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Abstract

The Covid-19 pandemic has become a global disaster and not only in Indonesia. The whole world has been negatively affected by the presence of Covid-19, including almost all aspects that were quite affected by the presence of Covid-19. The incidence of the corona virus pandemic or covid-19 is able to paralyze the activities of all people who are carried out outside the home. Corona virus is a large family virus that causes mild to severe illness, such as the common cold or cold and serious illnesses such as MERS and SARS. Transmission from animals to humans (zoonosis) and transmission from humans to humans is very limited. The covid-19 pandemic cannot be controlled quickly so it requires proper management from both the government and the community. The covid-19 virus can easily be transmitted through droplets that come out well when talking, or through airborne droplets, so it doesn't take long for Covid-19 to spread. The spread is quite fast, especially in Indonesia. Various efforts have been encouraged by the government. Wearing a mask can prevent the spread of droplets, because droplets can be caught on the masks used, but droplets that stick to masks can also spread again if they are not handled correctly. The increase in the use of masks and gloves at the household level also needs special attention. Household medical waste has the potential to be mixed with other household waste, thus endangering garbage transport officers who generally work without PPE or use inadequate PPE. According to some estimates, globally, there are 129 billion face masks and 65 billion plastic gloves every month. Which of course will be dangerous if not handled properly and appropriately. Due to the problem, so the main focus is to design a Mask Shredder with Disinfectant Sprayer that will combine a mask destroyer and a disinfectant spray in it. So that the masks that have been used can be immediately destroyed and sprayed with disinfectants to prevent the spread of droplets. This machine modification process uses the reverse engineering method and the VDI 2221 method for the engineering design process.

Keywords: Shredder, Benchmarking, Reverse Engineering, VDI 2221

1. Introduction

The Covid-19 pandemic has become a global disaster and not only in Indonesia. The whole world has been deteroited by the presence of Covid-19, including almost all aspects that were quite affected by the presence of Covid-19. In December 2019, cases of mysterious pneumonia were first reported in Wuhan, Hubei Province. The source of transmission of this case is still not known with certainty, but the first case was linked to a fish market in Wuhan (Rothan, et.al., 2020). From 18 December to 29 December 2019, five patients were treated with Acute Respiratory Distress Syndrome (ARDS) (Ren, et. Al.,2020). From 31 December 2019 to 3 January 2020, this case increased rapidly, marked by the reporting of 44 cases. In less than one month, the disease has spread to various other provinces in China, Thailand, Japan, and South Korea (Huang, et. Al.,2020). The emergence of the corona virus pandemic or covid-19 is able to paralyze the activities of all people who are carried out outside the home. Corona viruses are a large family of viruses that cause mild to severe illness, such as the common cold or colds and serious illnesses such as MERS and SARS. Transmission from animals to humans (zoonosis) and transmission from humans to humans is very limited. The covid-19 pandemic cannot be controlled quickly so it requires proper management from both the government and the community. The covid-19 virus can easily be transmitted through droplets that come out either when talking or through airborne droplets, so it doesn't take long for Covid-19 to spread. So that the spread is quite fast, especially in Indonesia. The increase in the use of masks and gloves at the household level also needs special attention. Household medical waste has the potential to be mixed with other household waste, thus endangering garbage transport officers who generally work without PPE or use inadequate PPE (Prasetiawan,2020).

Many activities encourage or recommend used mask wearers to destroy and dispose of masks specifically to prevent the spread of these droplets. However, in fact there are still many ways to handle used masks that are wrong and seem random. Even though disposable masks that have been used can be dangerous if they fall into the wrong hands and have the potential to be resold by irresponsible individuals, they can become a medium for spreading viruses and spreading diseases such as the Corona virus. According to some estimates, globally, there are 129 billion face masks and 65 billion plastic gloves every month. Which of course will be dangerous if not handled properly and appropriately. Due to the problem, So the main focus is to design a Mask Shredder With Disinfectant Sprayer that will combine a mask destroyer and a disinfectant spray in it. So that the masks that have been used can be immediately destroyed and sprayed with disinfectants to prevent the spread of droplets. This machine modification process uses the reverse engineering method and the VDI 2221 method for the engineering design process.

2. Research Methods

2.1 Benchmarking

In the benchmarking process, for each product, there are 2 machines that are used as benchmarking materials. The 2 machines can be seen in Table 1 and Table 2.

Table 1 Benchmarking Shredder

No.	Differentiator	Gemet 60S Paper Shredder	USB Shredder
1.	Model		
2.	Price	Rp. 475,000	Rp. 120,000
3.	Capacity	9 L	1.6 L.
4.	Material	Body cover and cover: Plastic Blades: Stainless	Body material: plastic
5.	Dimensions	Length: 28.5 cm Width: 14.2 cm Height: 34.4cm	Length: 10.5 cm Width: 6.2 cm Height: 15 cm
6.	Power	53 W.	10 W
7.	Machine Weight	1.27 kg	0.8 kg

Table 2 Benchmarking Sprayer

No.	Differentiator	Zoom Paint Sprayer	Farmtool Mist Sprayer
1.	Model		
2.	Price	Rp. 270..000	Rp. 250,000
3.	Capacity	0.8 L	1L
4.	Material	Plastic	Hose material: Rubber Tube material: Plastic Sprayer material: plastic
5.	Dimensions	Machine height: 10 cm Machine width: 8 cm Machine length: 15 cm Tube height: 18 cm Tube diameter: 0 cm	Machine height: 21 cm Machine width: 5 cm Machine length: 8 cm Tube height: 21 cm Tube diameter: 10 cm
6.	Power	105 W	30 W

7.	Machine Weight	1.8 kg	1.3 kg

2.2 Reverse Engineering Method

Of the 2 shredder machines referred to Table 1, the Gemet 60S Paper Shredder was chosen as the machine to be modified. This is because the information and data about this machine is much more complete, and this product is more powerful and more suitable to be modified into a mask shredder. Also, from the 2 sprayer machines the farmtool mist sprayer was chosen. This machine was chosen because it is more compact and easier to modify, because everything can be customized according to your needs (Daywin, et.al., 2019). This reverse engineering method is divided into 4 stages, including:

1. Disassembly product
2. Assembly product
3. New Design
4. Prototype

Stage 1 and 2 are included in the reverse engineering method, while stages 3 and 4 are included in the design engineering method or VDI 2221. The following is an explanation of the stages of the reverse engineering method for the mask shredder machine with disinfectant sprayer.

1. Disassembly Product
   At the dismantling stage, there are 2 machines that will be dismantled which will be used as benchmarks to be put together, namely the shredder and sprayer machines. For the first, the disassembly of this shredder machine is divided into 3 major parts, namely the container, cover and motor, and the knife. While the disassembly of the sprayer is divided into 4 major parts, namely the container, cover, motor, and hose. The following is a Bill of Material (BOM) from the above machine which can be seen in Figure 1 for the shredder and Figure 2 for the sprayer.

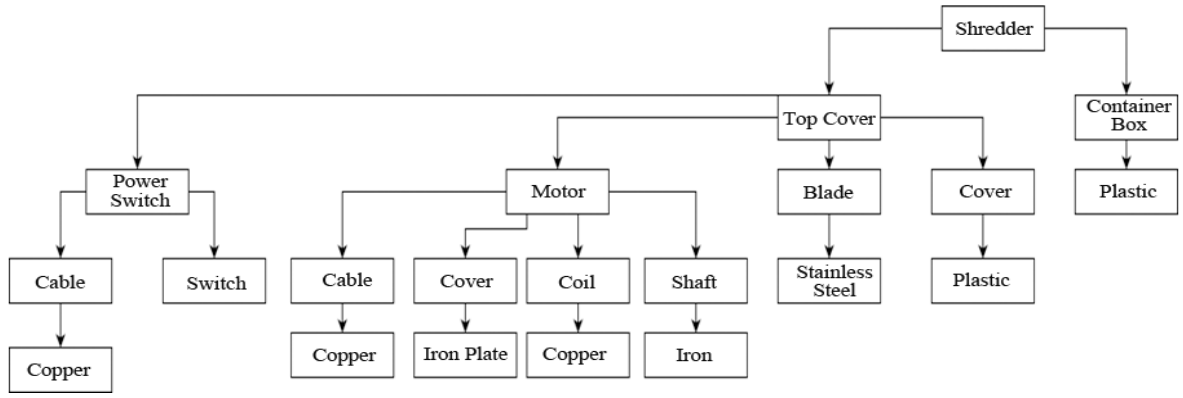


Figure 1 Bill of Material Shredder

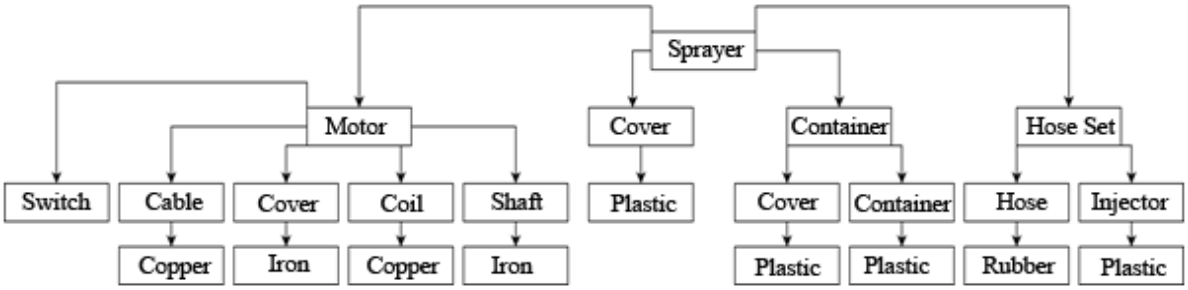


Figure 2 Bill of Material Sprayer

2. Assembly Product
   After knowing the components for the compilers of the machine, the machine will be installed as before to get the Assembly Process Chart (APC) from the machine. APC can be seen in Figures 3 and 4.

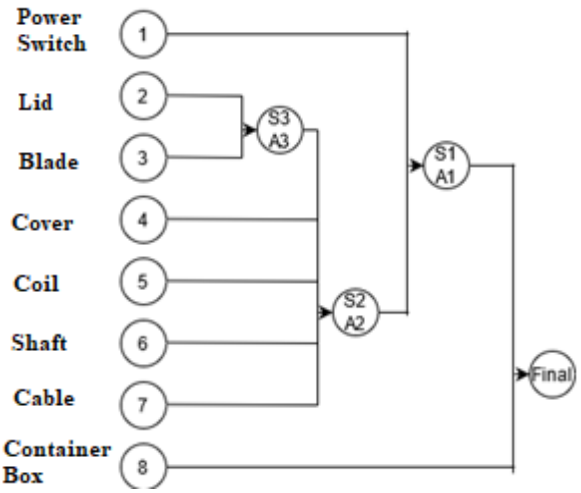


Figure 3 Assembly Process Chart Shredder

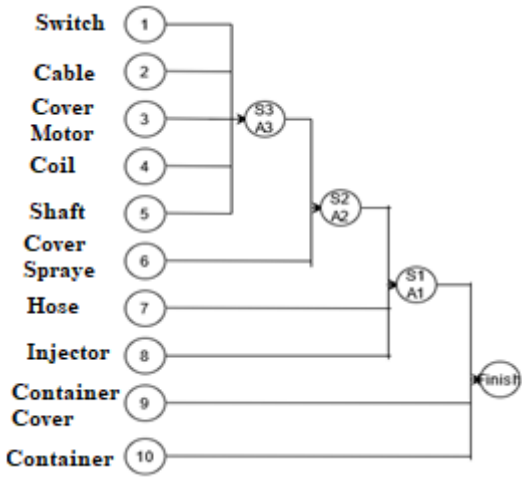


Figure 4 Assembly Process Chart Sprayer

2.3 VDI 2221

In the design stage of a product, a wish list is needed which will be used as a reference and is also used as a limitation in the manufacture of the product (Daywin, et.al., 2019). The following is a wish list of product design.

a. Tools can be operated easily.
b. This tool can break down the covid-19 virus droplets
c. The tools can operate without being harmful to humans
d. Easy tool to do maintenance.
e. Does not require special skills in using this tool.
f. Tools have a simple way of working.

From this wish list, the initial specifications of the machine design can then be determined. In this specification there are 2 answer options for each parameter in the form of demand (D) and wishes (W) / hope. The initial specifications can be seen in Table 3 below.

Table 3 Initial Specifications

Parameter	Specification	D / W
Function	Can break down covid-19 droplets	D
Geometry	Equipment weight does not exceed 5 Kg	W
	Storage capacity that can be changed according to the needs and space available	D
Kinematics	The power required is 200 W	W
	The machine can be maintained easily (easy to assemble and assemble)	W
Material	The tools are made of strong and durable materials	D
	The appliance can withstand the disinfectant compound for a long time	W
	Light material	W
	Tool-making materials can be obtained easily	D
Making	Using standard components	D
	Simple construction and easy to work with	D
Assembly	The tool is easy to assemble and assemble	D
	The component assembly system is easy to understand	W
Operation	Tools can be operated easily	D
	Safe tool when used	D
	Tools can be operated by anyone	D
	Low Noise Pollution	W
Care	Maintenance is relatively easy and cheap	D
	Easy to repair in case of damage	W
	The process of cleaning the tool is easy	D
Marketing	For large and small scale production	W
	Use in public and private places	D
Price	Affordable for the lower middle class	W

From the initial specifications described above, it can be determined some principle solutions for the machine to be designed. The following is the principle of the sub-function solution of machine design which can be seen in Table 4.

Table 4 Principles of Sub-Function Solution

No.	Principle of Solution / Sub Function	Ket	1	2	3
1.	Container Box	For	Stainless steel	Acrylic	
2.	Motorcycle	Buy	53 W.	10 W	
3.	Power Switch	Buy	1 cm	3 cm	5 cm
4.	Distance between blades	For	0.1 cm	0.15 cm	0.2 cm
5.	Cover Width	For	8 cm	15 cm	20 cm
6.	Container Box Height	For	15 cm	19 cm	23 cm
7.	Knife	For	10 cm	12 cm	15 cm
8.	Disinfectant Container	For	Stainless steel	Acrylic	Plastic
9.	Motorcycle	Buy	53 W.	10 W	
10.	Power Switch	Buy	1 cm	3 cm	5 cm
11.	Injector Nozzle Size	Buy	0.1 mm	0.15 mm	0.2 mm
12.	Hose	Buy	¼ inch	½ inch	¾ inch
13.	Disinfectant Capacity	For	1 L	1.5 L.	2 L

After the solution principle is made, the next step is to determine the combination of the solution principle. There are 3 combinations that will be made. The following is a combination of the sub-function solution principles which can be seen in Table 5.

Table 5 Combination of Sub-Function Solution Principles

Number	Solution Principle / Sub Function	Information	1	2	3
1.	Container Box	Made	Stainless steel	Acrylic	
2.	Shredder Motor	Buy	100 W	10 W	
3.	Power Switch	Buy	1 cm	3 cm	5 cm
4.	Distance between Blades	Made	0.1 cm	0.15 cm	0.2 cm
5.	Cover Width	Made	8 cm	18 cm	20 cm
6.	Container Box Height	Made	15 cm	30 cm	23 cm
7.	Blade Width	Made	10 cm	12 cm	15 cm
8.	Disinfectant Container	Made	Stainless steel	Acrylic	Plastic
9.	Motor sprayer	Buy	53 W	10 W	
10.	Power Switch	Buy	1 cm	3 cm	5 cm
11.	Injector Nozzle Size	Buy	0.1 mm	0.15 mm	0.2 mm
12.	Hose	Buy	¼ inch	½ inch	¾ inch
13.	Disinfectant Capacity	Made	1 L	1.5 L	2 L

Judging from the table above, 3 combinations of solution principles can be determined as follows:

a. K1: 1.1 - 2.2 - 3.2 - 4.1 - 5.1 - 6.1 - 7.1 - 8.1 - 9.1 - 10.2 - 11.2 - 12.2 - 13.1
b. K2: 1.1. - 2.1 - 3.1 - 4.1 - 5.3 - 6.2 - 7.2 - 8.2 - 9.2 - 10.1 - 11.1 - 12.1 - 13.2
c. K3: 1.2 - 2.1 - 3.3 - 4.3. - 5.2 - 6.3 - 7.3 - 8.3 - 9.1 - 10.3 - 11.3 - 12.3 - 13.3

Next is the process of selecting the best combination from the 3 existing combinations. This selection process is assisted by a selection diagram. In this selection diagram, there are 6 criteria. These criteria include:

1. In accordance with the overall function
2. According to the wish list
3. In principle, this can be realized
4. Within the constraints of production costs
5. In accordance with the wishes of the maker
6. Knowledge of concepts is adequate

The following is a selection diagram from a combination of the previous solution principles which can be seen in Table 6.

Table 6 Selection Diagram

Industrial Engineering				**Solution Selection Table For Shredder Machine**				
Solution Principle Variations	Selection Criteria (+) Yes (-) No (?) Less information (!) Check Specifications			Decision Sign Solution Variant (SV) (+) The solution looking for (-) Remove Solution (?) Gather Information (!) View Specifications				
	According to the overall function							
		According to wish list						
			Within production cost limits					
				Adequate knowledge of concepts				
					As per the designer's wish			
						Meet safety requirements		
	A	B	C	D	E	F	Information	SV
K1	+	-	-	+	-	+	Unsuitable	-
K2	+	+	+	+	+	+	Suitable	+
K3	+	-	-	+	-	-	Unsuitable	-

From the diagram described above, it can be concluded that K2 was chosen as the best variant to be used in designing the new design. The creation of this new design was assisted by the fusion application. The following in Figure 5 is the modification of the shredder machine according to the results of the selection diagram. Based on the criteria, the shredder is modified according to the needs, namely to become a mask shredder. Where for mask waste it is recommended to do disinfection first by immersing it in a disinfectant / chlorine / bleach solution then changing its shape such as breaking the rope or tearing it (Amalia,2020). Because it will deal directly and continuously with disinfectants, the material of this tool is modified to become stainless steel which is stronger and resistant to corrosion. And also for the size of this shredder, referring to the needs and size of the mask which is quite small, it is determined that the overall product dimensions are only slightly larger to 28.5 cm x 14.2 cm x 37 cm from the original size of 28.5 cm x 14. , 2 cm x 34.3 cm, where there is a change in the height of the object 2.7 cm higher due to the addition of a sprayer component. The following is an explanation of the modified results of the mask shredder with disinfectant sprayer.

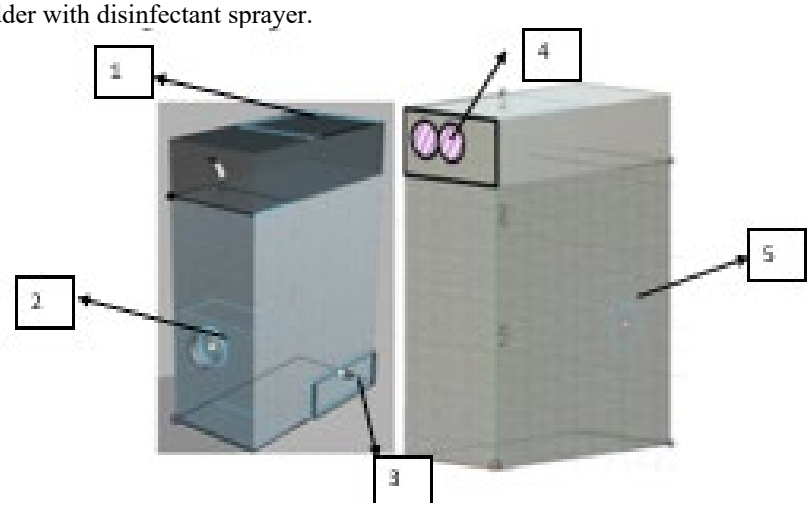
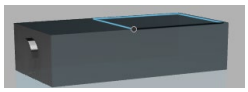
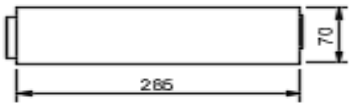
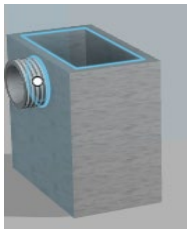
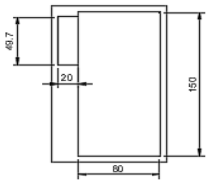
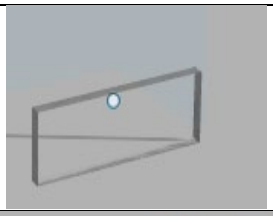
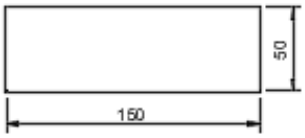
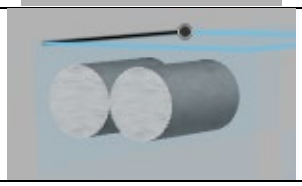
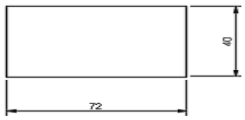
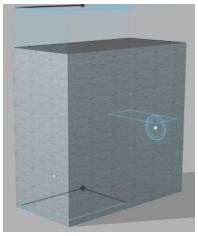
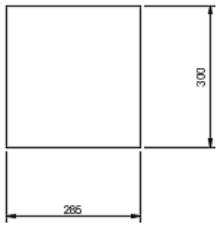


Figure 5 Shredder Machine Modification Results

The following is an explanation of the 5 components of the image above which can be seen in Table 7.

Table 7 Components and Specifications After Modification

No.	Name	Component Drawing	Component Specifications (in mm)
1.	Top Cover		
2.	Disinfectant collection box		
3.	Masks disposal area		
4.	Shredder knife		
5.	Container for masks		

In the design stage of this mask shredder modification, there are several components that are made adjustments such as motor power, container dimensions, knife models and the addition of a sprayer. Some of these adjustments were made to support and match the need to destroy masks and spray disinfectants.

Table 8 Assembly Costs

Type of Fee	**Total cost**
Material Purchase Costs	Rp. 1,877,000
Workshop Equipment Usage Fee	Rp. 352,000
Subtotal (1)	**Rp. 2,229,000**
Assembly Cost (10% of the purchase of materials)	Rp. 187,700
Subtotal (2)	**Rp. 2,416,700**
SME Profits (30%)	Rp. 725,010
Selling Price per Unit	**Rp. 3,141,710**

After knowing the selling price for 1 modified mask shredder unit, this price will be compared with the selling price of the shredder machine which is used as benchmarking. The following is a comparison of the selling prices of the two machines which can be seen in Table 9.

Table 9 Comparison of Benchmarking Shredder Prices and Modified Shredder Machines

Benchmarking Shredder Machine	**Modified Shredder Machine**
Rp. 475,000	Rp. 3,141,710
Difference	Rp. 2,666,710

Judging from the table above, it can be analyzed that this modified mask shredder is more expensive than the shredder used as benchmarking. This price difference occurs because the specifications of this tool must meet the requirements of its new function as a mask destroyer, and must be able to meet Health requirements to prevent the spread of viral droplets.

3. Results And Discussion

After doing research on the shredder machine using benchmarking methods, reverse engineering and VDI 2221, a better engine modification design is obtained than before. The result of this modification made quite a lot of modifications starting from the body material, motor strength, and size. All of these modifications were made to support the results in accordance with the modification objective of this tool, namely to become a mask shredder with a disinfectant sprayer.

4. Conclusion

From the design results of this mask shredder with disinfectant sprayer, several conclusions were obtained:

1. The research method of this study:
   a. Benchmarking method
      Machines that are used as benchmarks for benchmarking are the Gemet 60S Paper Shredder and farmtool mist sprayer.
   b. Reverse engineering method
      The machine chosen as the machine to be dismantled is the Gemet 60S Paper Shredder because of its simple model and extensible capacity and allows minimal structural changes compared to using other types of shredder. However, in the development process, it still uses several other machines as benchmarks. Especially to determine the type of dynamo and shredder blade.
   c. VDI 2221 method
      In this method 3 alternatives are determined based on the wish list and the selected one is variant 1.
2. Machine design results
   a. Machine specifications:
      1) The upper body has a block shape with a size of 8 cm x 28.6 cm x 7 cm
      2) The lower body has a block shape with a size of 8 cm x 28.6 cm x 30 cm
      3) The shredder blade has a length of 12 cm.
      4) Has a disinfectant collection box with a capacity of about 1 liter
      5) Has a shredder motor with a power of 100 W
   b. Machine advantages and disadvantages:
      The advantage of this machine is that it has a greater engine power, which makes it easier to destroy the mask. The disadvantage of this machine is that the price is quite expensive due to meeting needs.
3. Production cost and selling price per unit
   a. The production cost for 1 modified mask shredder machine is Rp. 2,416,700.00
   b. The selling price of the modified mask shredder machine per unit is Rp. 3,141,710.00. In other words, the selling price of this machine is more expensive than the shredder used as benchmarking, with a very significant increase in specifications.

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Biography

Immanuel Beckham was born in Jakarta, Indonesia on 18th of july 1999. He graduated from Mutiara Bangsa 2 Senior Highschool. He is currently on his last year pursuing Industrial Engineering Bachelor Degree at Tarumanagara University, Jakarta. In 2020, had an internship at PT. Mitra Mika Cipta with the topic of Occupational Health and Safety (K3)

Frans Jusuf Daywin was born in Makasar, Indonesia on 24th November 1942. is a lecturer in the Department of Agricultural Engineering at Faculty of Agricultural Technology Bogor Agricultural University since 1964 conducted teaching, research, and extension work in the field of farm power and machinery and become a professor in Internal Combustion Engine and Farm Power directing and supervising undergraduate and graduate students thesis and dissertation and retired as a professor in 2007. In 1994 up to present as a professor in Internal Combustion Engine and Farm Power at Mechanical Engineering Program Study and Industrial Engineering Program Study Universitas Tarumanagara, directing and supervising undergraduate student's theses in Agricultural Engineering and Food Engineering Desain. In 2016 up to present teaching undergraduate courses of the introduction of concept technology, research methodology, and seminar, writing a scientific paper and scientific communication, and directing and supervising undergraduate student's theses in Industrial Engineering Program Study at the Faculty of Engineering Universitas Tarumanagara. He got his Ir degree in Agricultural Engineering, Bogor Agricultural University Indonesia in 1966, and finished the Master of Science in Agricultural Engineering at the University of Philippines, Los Banos, the Philippines 1981, and got the Doctor in Agricultural Engineering, Bogor Agricultural University Indonesia in 1991. He joined 4-month farm machinery training at ISEKI CO, AOTS, Japan in 1969 and 14 days agricultural engineering training at IRRI, Los Banos the Philippines, in March 1980. He received the honors "SATYA LANCANA KARYA SATYA XXX TAHUN" from the President of the Republic of Indonesia, April 22nd, 2006, and received appreciation as Team Jury from the Government of Indonesia Minister of Industry in Industry Start-Up 2008. He did several research and surveys in farm machinery, farm mechanization, agricultural engineering feasibility study in-field performance and cost analysis, land clearing and soil preparation in secondary forest and alang-alang field farm 1966 up to 1998. Up till now he is still doing research in designing food processing engineering in agriculture products. Up to the present he already elaborated as a conceptor of about 20 Indonesia National Standard (SNI) in the field of machinery and equipment. He joins the Professional Societies as a member: Indonesia Society of Agricultural Engineers (PERTETA); Indonesia Society of Engineers (PII); member of BKM-PII, and member of Majelis Penilai Insinyur Profesional BKM-PII.

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