Design of an organic waste biogas crushing blower with a capacity of 200 liters

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A B S T R A C T

The development of machine technology has made things easier and faster for people, encouraging the public and the business community to use waste, especially organic waste, as a feedstock for biogas. When using waste as feedstock for biogas, a waste grinder is needed to speed up the decomposition process in the digester. When designing a biogas organic waste crusher, several planning methods should be adopted, namely: data research, data processing, design and production, machine planning, calculation of the machine, the manufacture of the machine, the production of trials and the writing of reports. So the required motor power is 0.342 kW, and is chosen according to what is on the market with a power of 0.373 kW or the equivalent of 0.5 HP. Determined in each chopper the machine is capable of chopping (m) 10 Kg (each chopping), and the number of blades in the shaft (z) 12 Blades, and (n2) Motor Rotation. The crushing drum is 420mm, the total height is 750mm, using a shaft with a diameter of 25 mm and a shaft length of 810 mm, it can cut up to 56 kg of mango skin per hour requires a motor power of 0.5 horsepower (0.373 kilowatts) at a speed of 2800 rpm.

I. INTRODUCTION

Waste that is deemed obsolete and subsequently disposed of by previous owners or users can still be repurposed effectively if managed through appropriate procedures (Tiwari, and Kumar., 2024). Among the various types of waste, organic waste presents a particularly promising opportunity for resource recovery due to its inherent properties and relatively rapid decomposition process. Organic waste is derived from living organisms, encompassing a wide range of materials produced by humans, animals, and plants (Yusron, et all., 2024) The disposal of organic waste is an issue of significant public concern, especially considering that households, cottage industries, and other sources generate substantial quantities of organic material on a daily basis (Ahmad., 2024). Unfortunately, many of these entities do not adequately address the management of their waste, leading to environmental degradation and lost opportunities for resource recovery. In Indonesia, for instance, organic waste has predominantly been utilized solely as a raw material for compost production (Zubair, and Khan., 2024). This limited application is largely attributed to a general lack of awareness among the public regarding the potential benefits of effectively managing organic waste, as well as the insufficient availability of technology and infrastructure necessary for converting organic waste into biogas (Kharisov, and Kharissova., 2024). The underutilization of organic waste as a resource not only represents a missed opportunity for sustainable waste management but also contributes to ongoing environmental challenges, such as pollution and greenhouse gas emissions. By fostering greater public understanding of the value of organic waste and investing in the development of appropriate technologies for biogas production, it is possible to transform this waste stream into a valuable energy source (Liu, and Zhang., 2024). This shift not only enhances waste management practices but also supports broader sustainability goals, including energy security and reduction of waste-related environmental impacts. Therefore, it is imperative to promote educational initiatives and technological advancements that facilitate the effective management of organic waste, paving the way for its utilization in biogas production and contributing to a more sustainable future (Rybak, et al., 2023). All forms of organic waste possess the potential to be utilized for biogas production; however, certain types, particularly fruit scraps such as mango peels, have been identified as the most economically viable feedstocks. Research indicates that organic waste serves as an excellent raw material for biogas generation due to its capacity to produce methane gas, which can be harnessed for various applications, including cooking and heating. The effective conversion of organic waste into biogas is contingent upon the physical and chemical properties of the feedstock (Rojas, and Valenzuela., 2024). In this context, it is essential to preprocess the organic material by shredding or grinding it into smaller particles. This mechanical treatment significantly enhances the surface area of the waste, thereby accelerating the decomposition process during anaerobic digestion (Santos, and Lima., 2024). By increasing the efficiency of microbial activity, the shredding process facilitates a more rapid breakdown of organic matter, ultimately leading to improved biogas yields. Moreover, the utilization of fruit scraps, such as mango peels, not only contributes to the production of renewable energy but also addresses waste management challenges associated with organic refuse. By diverting these materials from landfills and employing them in biogas production, it is possible to reduce environmental pollution while simultaneously generating a sustainable energy source (Omer, 2023). The strategic use of organic waste, particularly fruit scraps, as a feedstock for biogas production presents a dual opportunity: it enhances waste management practices and fosters the development of renewable energy solutions. Continued research and investment in technologies that optimize the preprocessing and digestion of organic materials will be critical in maximizing the potential of biogas as a clean energy alternative (Li, and Zhang., 2024).

In the above cases, observation and research are needed to deal with the use of organic waste to minimize the expense of daily cooking or other needs. In this way, a machete of a 200 liter organic waste production machine is made. It is hoped that this step can be carried out optimally and promote the recovery of organic waste.

II. Literature review

A. *Definition of Biogas*

Biogas is defined as a gaseous mixture generated by methanogenic bacteria during the anaerobic decomposition of organic materials (Sari., and Harahap., 2023). This renewable energy source serves as a viable alternative to conventional fossil fuels, including kerosene and natural gas, thereby contributing to energy diversification and sustainability. The production of biogas occurs through a closed fermentation process that involves the breakdown of organic waste, animal manure, and other biodegradable materials (Muliarta, and Yulianto., 2024). Despite its potential as an alternative energy source, the utilization of organic waste for biogas production remains relatively underexplored compared to its application as raw materials for organic fertilizers. This discrepancy may be attributed to several factors, including a lack of public awareness regarding the benefits of biogas, insufficient technological infrastructure, and limited access to information on effective waste management practices (Rojas, and Valenzuela., 2024). The advantages of biogas production extend beyond energy generation; it also plays a crucial role in waste management by reducing the volume of organic waste that would otherwise contribute to landfill accumulation and environmental pollution (Yusron et all., 2024). Additionally, the digestate resulting from the anaerobic digestion process can be utilized as a nutrient-rich organic fertilizer, thereby closing the nutrient loop and promoting sustainable agricultural practices. To fully realize the potential of biogas as a sustainable energy source, it is imperative to enhance public understanding of its benefits and to invest in the development of technologies that facilitate the efficient conversion of organic waste into biogas. By fostering a greater appreciation for biogas and its applications, stakeholders can encourage the adoption of biogas systems, thereby contributing to a more sustainable energy future (Ochoa, and Marquez., 2024).

Biogas technology offers a transformative approach to waste management by enabling the conversion of organic waste into a renewable energy source that can fulfill various energy needs, including cooking, lighting, transportation, and other applications that require significant energy input. The process of biogas production primarily involves fermentation, which is the biochemical transformation of organic matter facilitated by anaerobic bacteria within a biogas digester under anaerobic conditions (Akinmoladun, and Ojo., 2024). During this fermentation process, methane gas (CH_4) and carbon dioxide (CO_2) are generated as the primary products. Notably, the concentrations of these gases are relatively high, with methane being the principal component of biogas, while the volumes of hydrogen (H_2), nitrogen (N_2), and hydrogen sulfide (H_2S) are comparatively lower. The fermentation process typically spans a duration of 7 to 10 days, during which optimal conditions must be maintained to maximize biogas production. The ideal temperature for this process is approximately 35°C, and the pH level should be maintained within a range of 6.4 to 7.9 to support the metabolic activity of the anaerobic bacteria involved (Elgharbawy, and Fathy., 2024).

The specific microbial communities responsible for biogas production predominantly consist of anaerobic bacteria, including genera such as Methanobacterium, Methanococcus, and Methanosarcina. These microorganisms play a crucial role in the degradation of organic substrates and the subsequent generation of methane, thereby contributing to the overall efficiency of the biogas production process.

In summary, biogas technology not only provides an effective means of managing organic waste but also offers a sustainable energy solution that can significantly reduce dependence on fossil fuels. By harnessing the biochemical processes of anaerobic bacteria, biogas production can be optimized to meet diverse energy demands while simultaneously addressing environmental concerns associated with waste disposal.

B. *Component of Planned Biogas Generator*

The figure below is the design and construction drawing of our planned 200 liter biogas generator for organic waste.

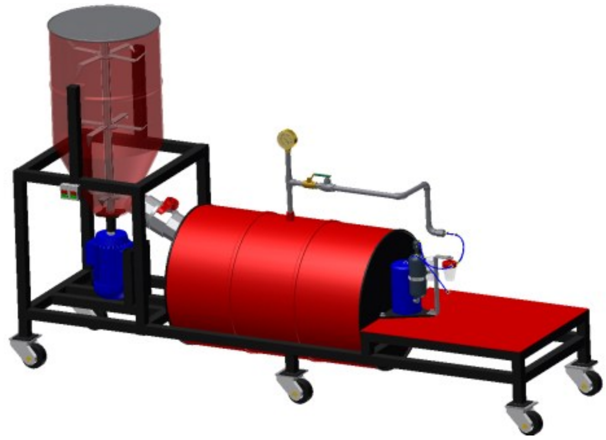


Fig 1. Organic Waste Biogas Generator

C. *Chopper Container or Mixer Tube Planning*

The Chopper Container, also referred to as the Mixer Tube, is an essential component designed to receive organic waste that requires grinding prior to further processing. This mixer tube is available in two distinct geometric configurations: tubular and conical. The construction of this mixer tube necessitates the secure connection of its two sides through soldering, ensuring structural integrity during operation (Hossain, and Rahman., 2024). The mixing pipe serves the primary function of shredding or crushing the organic waste, facilitating its subsequent decomposition in the biogas production process. The dimensions of the mixing pipe are specifically designed for optimal performance, featuring a diameter of 42 cm and a height of 75 cm. The thickness of the mixing tube is 2 mm, which provides adequate durability to withstand the mechanical stresses associated with the grinding process.

In terms of configuration, the mixer tube comprises both tubular and conical sections. The tubular section has a height of 40 cm, while the conical section measures 35 cm in height and is designed with an angle of 60°. The conical section transitions into the bottom tube, which serves as the outlet of the digester, measuring 10 cm in length with a diameter of 7.62 cm. The geometric shapes present in the mixing cylinder include both a cylinder and a cone. The planning formula for determining the volume and surface area of these shapes is critical for ensuring the effective design and functionality of the mixing cylinder. A tube or cylinder is defined as a three-dimensional geometric shape characterized by two identical parallel circles (the bases) and a rectangle that surrounds these circles. This geometric understanding is fundamental in calculating the capacity and efficiency of the mixing cylinder, thus contributing to the overall effectiveness of the biogas production system. The design and dimensions of the Chopper Container or Mixer Tube are pivotal in enhancing the processing of organic waste, thereby optimizing the conditions for biogas production. The careful consideration of geometric shapes and structural integrity ensures that the mixer tube functions efficiently within the biogas system, ultimately contributing to the sustainability and effectiveness of organic waste management practices.

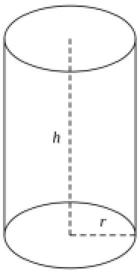


Fig 2. Chopper Tube

In order to plan and determine the calculations regarding the volume of the mixing tube, in particular the volume of the fume hood tube, the following formula is used:

$$V = \pi . r^2 . t$$

Design of hooded vessel cones, when designing the cone of a hooded vessel, calculations should be made as follows: The cone is a special type of circular base pyramid with 2 sides and 1 rib.

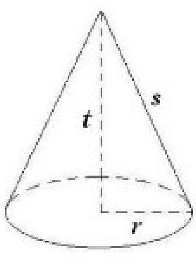


Fig 3. Cone

When planning the cone on the hood container, especially the volume of the cone, the formula used is:

$$V = \frac{1}{3} . \pi . r^2 . t$$

Planning the calculation of the crusher axis, in planning the organic waste crusher, the calculation to be planned is as follows:

1. Force acting on the shaft

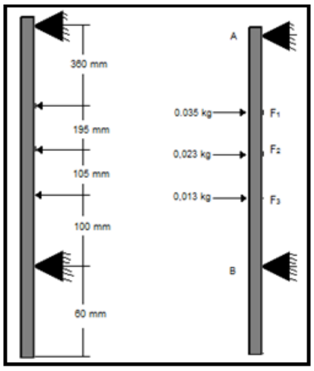


Fig 4. Forces on shaft

A = horizontal force on upper bearing

F1 = horizontal force on first blade

F2 = horizontal force on second blade

F3 = horizontal force on third

B = horizontal force on the lower landing

2. Shaft power

$$P_d = fc.P$$

P_d = rated power (kW)

fc = correction factor

P = rated output power of drive motor (kW)

3. Torque

$$T = 9{,}74.10^5 \frac{Pd}{n_1}$$

T = Torque (N.mm)

n_1 = Drive motor speed (rpm)

4. Shear stress

$$\tau_a = \sigma_B (Sf_1 + Sf2)$$

5. Shaft diameter

Determined for torsion and bending loads are:

$$d_s \geq \left\{ \frac{5{,}1}{\tau a} \sqrt{(k_m.M)^2 + (Kt.T)^2} \right\}^{1/3}$$

d_s = shaft diameter (mm)

τa = shear stress (kg/mm)

k_m = correlation coefficient

k_t = correction coefficient

and à à to determine the maximum shear stress as follows:

$$\tau_{\max} = (5{,}1 / d_s^3) \sqrt{(k_m.M) + (K_t.T)}^2$$

6. Shaft check

$$ds \geq 4{,}1.\sqrt[4]{T}$$

D. Knife Chopper

Knife chopper has 12 different sized blades provided in each knife. In the shaft there are 3 machete holders with 4 blades in each holder. The function of the grinder is to smooth or chop the organic waste, soften it and speed up the closed fermentation process of the fermenter. A machete has a blade that acts as a garbage disposal. This scimitar is designed to be resharpened when it begins to dull.

The blade can be easily removed from the disc holder and sharpened with a grinder or hand sharpening stone. Find the mass (Wp) of the helicopter as follows:

1. Dimensions of chopper (V_0)

$$V_0 = \{(p.l.t) - (\pi(7.5^2) - 2\{(\frac{1}{2}.\alpha.t).\frac{1}{2}.l\}$$

2. Chopper weight (Wp)

$$w_p = (\rho.V_0)$$

3. Split area

$$L_a = (L_{luar} - L_{dalam})$$

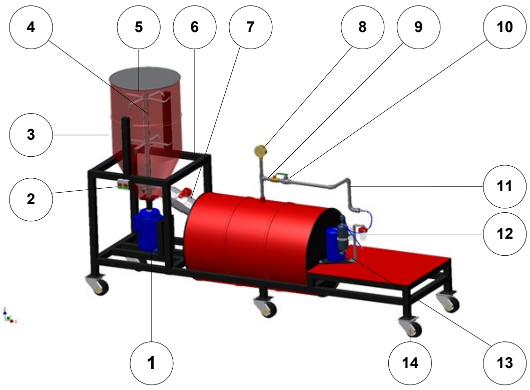
4. Chopper speed (V).

$$V = \frac{\pi.d.n}{60.100}$$

III. METHODOLOGY

Design Drawing Plan

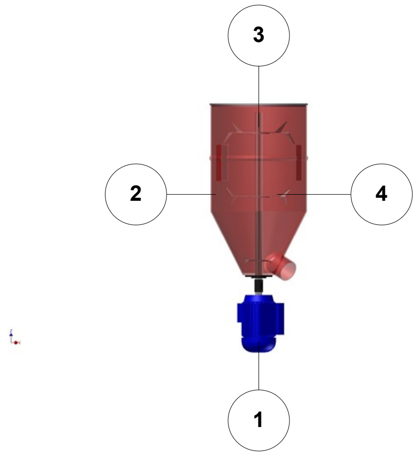
The design drawing plan for the organic waste disposer is completed after the design drawing plan planning stage is completed. Here is the design drawing of a 200 liter biogas generator for organic waste.



1. Motor	8. Manometer bourdon
2. *Power push button*	9. ½ inci ball valve
3. Chopper Tube	10. *Check valve*
4. Shaft	11. Gaspipe
5. Knife Chopper	12. Gas filter
6. Frame	13. Compressor
7. 3 inci valve	14. Wheel

Fig 5. Biogas generator

The parts to be designed are:



1. Motor	3. Shaft
2. Cover tube	4. Cover clip

Fig 6. Design of Organic Waste Chopper Machine Parts

IV. Results and Discussion

A. Calculation of the capacity

Calculating the capacity of the grinding section, a machine capacity of 10 kg was determined for each mill. The capacity of the mixer tube itself is as follows:

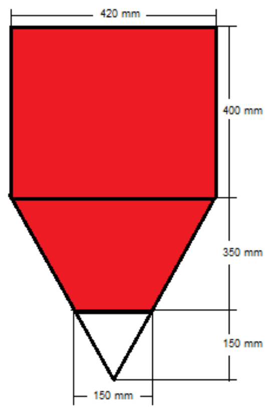


Fig 7. Mixer Tube

The calculation of the volume of the hood tube is :

V = volume of the tube + volume of the cone

$$V = \pi.r_1^2.t + ((\frac{1}{3}.\pi.r_1^2.(t_1 - t_2)) - (\pi.r^2)$$

$$V = 3{,}14.210^2.t + (\frac{1}{3}.3{,}14.210^2(420))$$

$$-(\frac{1}{3}.3{,}14.75^2.150)$$

$$V = 55389600 + 19386360 - 883125$$

$$V = 55389600 + 18503235$$

$$V = 73892835 \text{ mm}^3$$

$$V = 73{,}892835 \text{ dm}^3$$

$$V = 74 \text{ Liter}$$

This equals 1.21 liters based on the measurement of 1 kg of mango skin. And the specified capacity is 10 kg per hood, 10 kg of hood equals 12.1 liters. Therefore, the chopper tube has a volume of 74 liters > 12.1 liters, so the tube can hold the capacity of the chopper.

B. Calculation of the chopper blade shaft

The chopper blade shaft is used to transmit the rotation of the engine to the helicopter, the force acting on the shaft is the horizontal force of the chopper blade and no vertical force because the shaft is in an upright or upright position. This is the force acting on the helicopter blade shaft (Kaur, and Singh., 2024).

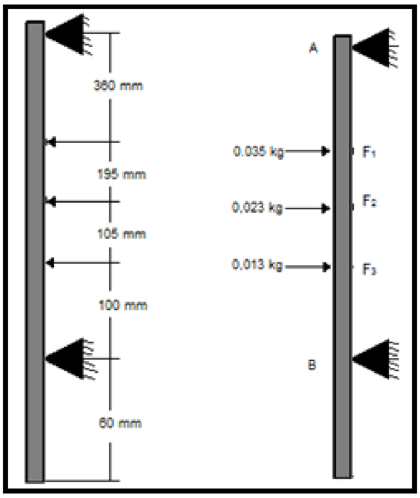


Fig 8. Forces on shaft

1. Forceacting on shaft

a. Horizontal reaction force

$$\sum_{MB} = F_1 + F_2 + F_3 - R_A$$

$$= (0.035 \,.\, 400) + (0.023 \,.\, 205) + (0.013 \,.\, 100)$$
$$- (R_A \,.\, 760)$$
$$= 14 + 4{,}715 + 1{,}3 - 0{,}760.R_A = 0$$
$$= 20{,}01 - 760\, R_A = 0$$

$$R_A = \frac{20{,}01}{760} = 0{,}0263\text{Kg}$$

$$\sum_{MA} = F_1 + F_2 + F_3 - R_B$$

$$= (0.035 \,.\, 360) + (0.023 \,.\, 555) + (0.013 \,.\, 660)$$
$$- (R_B \,.\, 760)$$
$$= 12{,}6 + 12{,}765 + 8{,}58 - 760\, R_B = 0$$
$$= 33{,}945 - 760\, R_B = 0$$

$$R_B = \frac{33{,}945}{760} = 0{,}0446\text{Kg}$$

b. Shaft check

$$M_A + M_B = F_1 + F_2 + F_3$$

$$0{,}0263 + 0{,}0446 = 0{,}035 + 0{,}023 + 0{,}013$$
$$0{,}071 = 0{,}071$$
$$0 = 0$$

c. The bending moment

$$M_{RA} = F_1 + F_2 + F_3 - R_B$$

$$= (0.035 \,.\, 360) + (0.023 \,.\, 555)$$
$$+ (0.013 \,.\, 660) - (0{,}0446 \,.\, 760)$$
$$= 12{,}6 + 12{,}765 + 8{,}58 - 33{,}896$$
$$= 0{,}04 \text{ Kg}$$

$$M_{F1} = F_2 + F_3 - R_B$$

$$= (0{,}035 \,.\, 195) + (0{,}023 \,.\, 300)$$
$$- (0{,}0446 \,.\, 400)$$
$$= 6{,}82 + 6{,}9 - 17{,}84$$
$$= -4{,}12 \text{ Kg}$$

$$M_{F2} = F_3 - R_B$$

$$= (0{,}023 \,.\, 105) - (0{,}0446 \,.\, 205)$$
$$= 2{,}41 - 9{,}14$$
$$= -6{,}73 \text{ Kg}$$

$$= (0{,}0446 \,.\, 100)$$
$$= 4{,}46 \text{ Kg}$$

$$M_{RB} = 0$$

d. Combined bending moment

$$M_{RA} = \sqrt{(M_{RA}V)^2 + (M_{RA}H)^2}$$

$$= \sqrt{(0)^2 + (0{,}04)^2}$$
$$= \sqrt{0 + 0{,}0016} = 0{,}04 \text{ Kg.mm}$$

$$M_{RA} = \sqrt{(M_{RB}V)^2 + (M_{RB}H)^2}$$

$$= \sqrt{(0)^2 + (0)^2}$$
$$= \sqrt{0} = 0$$

After knowing the force generated on the shaft, the next step is to determine the diameter of the chopper shaft, i.e. by calculating the correction factor.

This correction factor is necessary to take into account the possibility of occurrences of loads that have not been precalculated. The correction factor for normal drift is 1.0 to 1.5, then use the following formula to determine the shaft diameter:

e. Shaft diameter

P = 0.5 HP = 0,373 kw = 373 w,

n1 = 2800 rpm

fc = 1.0

$$P_d = f_c \text{ x } P = 1.0 \text{ x } 0.373 \text{ kW} = 0.373 \text{ kW}$$

$$T = 9{,}74 \text{ x } 10^5 . \frac{P_d}{n^2}$$

$$T = 9{,}74 \times 10^5 . \frac{0{,}373}{2800}$$

$$T = 1297 \text{ kg.mm}$$

$$\text{S30C}, \sigma_B = 48 \text{ (kg.mm2)},\ sf_1 = 6{,}0,\ sf_2 = 2{,}0$$

$$\tau_a = 48 / (6{,}0 \times 2{,}0) = 4 \text{ (kg.mm2)}$$

$$C_b = 2{,}0, K_t = 2{,}0$$

$$ds \geq \left[\frac{5{,}1}{4} . \sqrt{(C_b.M_{RA})^2 + (K_t.T)^2} \right]^{1/3}$$

$$ds \geq \left[\frac{5{,}1}{4} . \sqrt{(2{,}0.0{,}04)^2 + (2{,}0.1297)^2} \right]^{1/3}$$

$$ds \geq \left[1{,}275 . \sqrt{(0.0064) + (6728836)} \right]^{1/3}$$

$$ds \geq \left[1{,}275.2594 \right]^{1/3}$$

$$ds \geq 14.8 \text{ mm}$$

And the diameter of the chopping knife shaft used is 25.4mm to ensure the safety of the chopping knife shaft. Also, to know the shear stress that occurs, use the following calculation:

f. The shear stress (τ) that occurs is:

$$\tau = \frac{5{,}1}{d_s^{\,3}} . T$$

$$\tau = \frac{5{,}1}{25{,}4^3} . 1297 \text{ Kg.mm}^2 = 0{,}40 = 0{,}4 \text{ Kg.mm}^2$$

So get, such an axis is safe to use. After getting the shear stress, check the shaft with the following calculation.

g. Inspection of the axle

$$d_s \geq 4{,}1.\sqrt[4]{T}$$

$$25{,}4 \geq 24{,}60$$

From the inspection of the axle above, it appears that the axle used can safely transmit the rotation of the motor to the cutter.

C. Blade Computing

The blade is the main component of the system running on the design of the 200 liter organic waste disposer. Here are the calculations for machete supporters.

Table 1. Calculation Supporting Data

Supporting data	Description
Chopper blade material	S 30 C
The density of the chopper blade material	$7{,}2.10^{-6}$ Kg.mm^3
The volume of the chopper blade	48 cm^3
Length x Width x Height	256 x 20 x 1
The angle formed by the chopper blade	∝ 60°

To perform calculations in finding the dimensions of the chopper blades are as follows:

1. Chopper Blade Dimensions
   Dimensions of the first chopper blade (V_1)

$$V_1 = (\text{p.l.t}) - (\pi (7{,}5^2) - 2\{(\frac{1}{2}.\alpha.t).\frac{1}{2}.l\}$$

$$V_1 = (256.20.1) - (3{,}14 (7{,}5^2)$$

$$- 2\{(\frac{1}{2}.1{,}15.1).\frac{1}{2}.20\}$$

$$V_1 = (5120) - (176{,}63) - 5{,}75$$

$$V_1 = 4937{,}62 \text{ mm}^3$$

   Dimensions of the second chopper blade (V_2)

$$V_1 = (\text{p.l.t}) - (\pi (7{,}5^2) - 2\{(\frac{1}{2}.\alpha.t).\frac{1}{2}.l\}$$

$$V_1 = (151.20.1) - (3{,}14 (7{,}5^2)$$

$$- 2\{(\frac{1}{2}.1{,}15.1).\frac{1}{2}.20\}$$

$$V_1 = (3020) - (176{,}63) - 5{,}75$$

$$V_1 = 2837{,}62 \text{ mm}^3$$

   Dimensions of the third chopper blade (V_3)

$$V_1 = (\text{p.l.t}) - (\pi (7{,}5^2) - 2\{(\frac{1}{2}.\alpha.t).\frac{1}{2}.l\}$$

$$V_1 = (101.20.1) - (3{,}14 (7{,}5^2)$$

$$- 2\{(\frac{1}{2}.1{,}15.1).\frac{1}{2}.20\}$$

$$V_1 = (2020) - (176{,}63) - 5{,}75$$

$$V_1 = 1837{,}62 \text{ mm}^3$$

2. Chopper Blade Weight
   First chopper blade weight (Wp)

$$W_p = (\rho.V_1)$$

$$W_p = 7{,}2.10^{-6}.4937{,}62$$

$$W_p = 0{,}035 \text{ Kg}$$

   Second chopper blade weight (Wp)

$$W_p = (\rho.V_2)$$

$$W_p = 7{,}2.10^{-6}.2837{,}62$$

$$W_p = 0{,}023 \text{ Kg}$$

   Third chopper blade weight (Wp)

$$W_p = (\rho.V_3)$$

$$W_p = 7{,}2.10^{-6}.1837{,}62$$

$$W_p = 0{,}013 \text{ Kg}$$

   The compressive strength of the mango peel is worth 322.88 grams. The shear stress of the mango peel is = *0,6xfc*
   So, $\sigma k\alpha = 0{,}6x0{,}32 = 0{,}18 \text{ Kg/mm}^2$

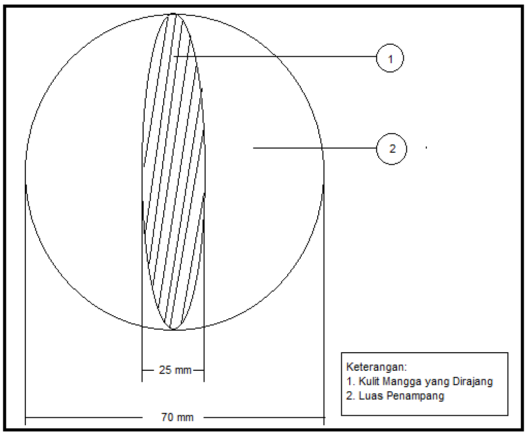


Fig 9. Mango Skin Shading Area

3. Exposed Skin Area

$$L_a = (L_{luar} - L_{dalam})$$
$$= 70 \text{ mm} - 25 \text{ mm}$$
$$= 45 \text{ mm} = 4.5 \text{ cm}$$

4. Chopper blade speed (V)

$$V = \frac{\pi.d.n}{60.100}$$
$$V = \frac{3{,}14.25{,}4.2800}{60.100}$$
$$V = 37{,}2 \text{ m/s}$$

D. Motor Calculations

Motor is the power source used to spin the blade. And to determine the power of the electric motor, it is first necessary to know the forces appearing on the shaft and the blades of the helicopter. (Harahap, and Sari., 2024). such as cutting force, moment of inertia of shaft and blade, moment of inertia of shaft and blade, force of inertia of shaft and blade and resultant force. The total power (Ptot) itself is the sum of the powers of the cutting power (PPOT), the shaft inertia (Ppo) and the blade inertia (Ppi). So the total horsepower is what the motor needs to power the chopper on the mixer tube.

1. Cutting Force (Fp)

$$F_P = A \,.\, fs$$
$$= 1{,}77 \text{ in} \,.\, 0{,}18 \,.\, 10 \text{ Kg} = 8{,}1 \text{Kg/cm}$$

2. Cutting Speed (Vp)

$$V_P = \frac{\pi.d.n}{60.100}$$
$$V_P = \frac{3{,}14.25{,}4.2800}{60.100} = 37{,}2 \text{ m/s}$$

3. Cutting Power (Ppot)

$$P_{Pot} = F_p.V_p$$
$$P_{Pot} = 8{,}1.37{,}2$$
$$P_{Pot} = 301 \text{ Watt} = 0{,}301 \text{ kW}$$

4. Moment of inertia of blade and shaft

First blade:

$$I_{pi} = \frac{1}{3}.m_{pi}.L_{pi}$$
$$= \frac{1}{3}.0{,}0035.0{,}256^2$$
$$= 0{,}11 \,.\, 0{,}065 = 0{,}007 \text{ Kg.m}^2$$

Second blade:

$$I_{pi} = \frac{1}{3}.m_{pi}.L_{pi}$$
$$= \frac{1}{3}.0{,}023.0{,}151^2$$
$$= 0{,}007 \,.\, 0{,}022 = 0{,}0001 \text{Kg.m}^2$$

Third blade:

$$I_{pi} = \frac{1}{3}.m_{pi}.L_{pi}$$
$$= \frac{1}{3}.0{,}013.0{,}101^2$$
$$= 0{,}004 \,.\, 0{,}010 = 0{,}00004 \text{ Kg.m}^2$$

So the total moment of inertia of the three knives is 0.00714 Kg.m^2. Next is to determine the moment of inertia of the shaft by using the following calculation:

5. Shaft Moment of Inertia

Shaft weight

$$W_P = \rho \,.\, V$$
$$V = \pi \,.\, r^2 \,.\, t$$
$$= 3{,}14 \,.\, 12{,}7^2 \,.\, 0{,}82$$
$$= 415{,}28$$
$$W_P = \rho \,.\, V$$
$$= 7{,}2 \,.\, 10^{-6} \,.\, 415{,}28$$
$$= 2990{,}016 \text{ gram} = 2.99 \text{ Kg}$$

Shaft moment of inertia

$$I_{po} = \frac{1}{3}.m_{po}.r_{po}$$
$$= \frac{1}{3}.2{,}9.12{,}7^2$$
$$= 1{,}49 \,.\, 1{,}61 = 2.40 \text{ Kg.mm}^2$$
$$= 0{,}002 \text{ Kg.m}$$

6. The angular velocity

$$\omega_2 = \frac{\pi.n^2}{30}$$
$$\omega_2 = \frac{3{,}14.2800}{30} = 293{,}06 \text{ rad/s}$$

7. Angular acceleration

$$\alpha = \frac{2.\pi}{\omega}$$

8.
$$\alpha = \frac{2.3{,}14}{293{,}06} = 0{,}02 \text{ s}$$
$$\omega_1 = \frac{2.\pi}{t}$$
$$\omega_1 = \frac{2.3{,}14}{0{,}02} = 3{,}14 \text{ rad/s}$$
$$\alpha = \frac{\omega_1 - \omega_2}{t}$$
$$\alpha = \frac{314 - 0}{0{,}02} = 15700 \text{ rad/s}$$

8. Torque of Inertia in Blades and Shafts

$$T_{pi} = \frac{I_{pi}.\alpha}{g}$$
$$T_{pi} = \frac{0{,}0071.15700}{9{,}8} = 11{,}37 \text{ Kgf.mm}$$
$$T_{po} = \frac{I_{po}.\alpha}{g}$$

$$T_{pi} = \frac{0,002.15700}{9,8} = 3,20 \text{ Kgf.mm}$$

9. Blade and shaft inertia

$$P_{pi} = \frac{T_{pi}.n^2}{9,74.10^5}$$

$$P_{pi} = \frac{11,37.2800}{9,74.10^5} = 3268.5 \text{ watt}$$

$$= 0.032 \text{ kW}$$

$$P_{po} = \frac{T_{po}.n^2}{9,74.10^5}$$

$$P_{po} = \frac{3,20.2800}{9,74.10^5} = 919,9 \text{ watt}$$

$$= 0.009 \text{ kW}$$

10. The total power required to perform the slicing is:

$$P_{tot} = P_{lpi} + P_{lpo} + P_{Pot}$$

$$P_{tot} = 0,032 + 0,009 + 0,301$$

$$P_{tot} = 0,342 \text{ kW}$$

So the required motor power is 0.342 kW, and is chosen according to what is on the market with a power of 0.373 kW or the equivalent of 0.5 HP. Furthermore, to determine the rpm rotation of the electric motor using the following calculations:

Determined in each chopper the machine is capable of chopping (m) 10 Kg (each chopping), and the number of blades in the shaft (z) 12 Blades, and (n2) Motor Rotation.

So:

$$Q = m.n^2.z$$

$$56 \text{ Kg/jam} = 10 \text{ Kg}.\, n^2 .\, 12$$

$$56 \text{ Kg x } 60 \text{ menit} = 10 \text{ Kg x } n^2 \text{ x } 12$$

$$3360 \text{ Kg/Menit} = 10 \text{ Kg x } n^2 \text{ x } 12$$

$$n^2 = \frac{3360.10}{12}$$

$$n^2 = 2800 \text{ rpm}$$

So the speed of the motor needed to chop waste with a capacity of 10 kg in each chopper is 2800 rpm, and in 1 hour this machine is capable of chopping mango skin as much as 56 kg/hour.

CONCLUSION

The design made by results in a biogas generator with a capacity of 200 liters, which has a shroud engine with a shroud tube size of 420 mm and an overall height of 750 mm, then the shaft in This design waste disposer uses a shaft with a diameter of 25mm and a shaft length of 810mm. Capable of shredding up to 56 kg/h of mango skin, the grinder requires a motor power of 0.5 HP (0.373 kW) and a speed of 2800 rpm. So, when assembling a helicopter, the first thing to do is to install the motor, then the chopper tube, then the shaft after the next chopper tube. There is a knife on the shaft, which is used for chopping.

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