

Sago Extraction Machine Design

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Abstract. The production of sago starch in Papua is around 200 thousand tons per year, even though the potential is 4.75 tons of dry starch per year. The large potential for sago starch production cannot be realized optimally due to the low production capacity. The production capacity is doubtful because the sago processing process is still carried out traditionally. The problems encountered can be solved by applying machining technology to the sago production process. The application of technology in the form of production machines will improve the quality of sago starch and production capacity. The production capacity of sago starch can be increased through the application of technology in the production process. Especially the sago pith grating machine technology and sago starch extraction machine technology, because these two processes consume the most time when using traditional methods. The working principle of the sago starch extraction machine that has been made is that the rotation generated by the driving motor is channeled through the pulley transmission and the V-belt drives the gearbox, the rotation of the gearbox output shaft through the pulley transmission and the V-belt drives the stirring shaft. The production capacity of the sago extraction machine is planned to be 80 kg/hour. The design of the sago extraction machine uses wheels to facilitate the mobilization of the machine to the sago plantation area.

Keywords. Extraction Machine, Merauke Society, Sago

1 Introduction

1.1 Sago and its Potential

The largest sago plantation in Indonesia is located in Papua, covering an area of 5 million hectares. Besides being the largest in Indonesia, sago plantations in Papua and West Papua are the largest in the world. The production of sago starch in Papua is around 200 thousand tons per year, even though the potential is 4.75 tons of dry starch per year. The large potential for sago starch production cannot be realized optimally due to the low production capacity. The production capacity is doubtful because the sago processing process is still carried out in the traditional way. Almost 100% of sago processing is done traditionally (manually).

Another factor that causes the low production of sago starch is the location of the sago plantation area which is located on the outskirts, quite far from settlements and poor road access conditions. The location of the sago gardens is mostly on the banks of rivers and forest edges. The problems encountered can be solved by applying machining technology to the sago production process. The application of technology in the form of production machines will improve the quality of sago starch and production capacity.

The steps that consume the most energy and time in the sago processing process are the crushing of the pith

and extraction. According to Haryanto and Pangloli (1992) [1], the average working capacity of 2 workers can only pierce 2.5 meters per day. Meanwhile, according to Sadikin (1980) [2], one stick of sago if done by 2 people for 8 hours per day will only be completed within 1 week. The research results of Darma et al. (2006) [3] showed that the average time required for grafting and extraction, respectively, was 53.22% and 38.92% of the total time required for processing. Thus, most of the time for processing (92.14%) is devoted to these two activities.

1.2 Traditional Sago Starch Production

People in Merauke generally produce sago starch in the traditional way, the process of producing sago starch is known as 'pangkur sago'. Sago pith is obtained through crushing using non-machine tools, in the form of tokok (adze). Tokok is shaped like a hammer made of wood and the end is given a piece of iron that serves to destroy the pith. The extraction process is carried out by kneading the tok and hitting the wood repeatedly. The traditional extraction process is shown in Figure 1, below.

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Fig 1. The traditional process of extracting sago by hitting with a stick and squeezing use hands [4], [5]

The production capacity of sago starch can be increased through the application of technology in the production process. Especially the sago pith grating machine technology and sago starch extraction machine technology, because these two processes consume the most time when using traditional methods. The application of technology will be more easily adapted if the technology is compatible with the geographical and cultural conditions of the residents in the production of sago flour.



Fig 2. Geographical conditions of sago plantation area [6], [7].

1.3 Solar Panel

The sago plantation area, mostly far from settlements, is located far in the forest and on the edge of a river, so it does not have good road access. In addition, the sago garden is not a large expanse, but grows in groups and is spread far apart. This condition is the main motive for the application of portable sago extraction machine technology, which aims to increase the production of sago starch flour. The sago starch extraction machine is equipped with an electric generator that can generate electrical energy to start the water pump machine. The

water pump machine supplies water continuously when the sago starch extraction process takes place.

1.4 Sago Extraction Machines

The technology of sago extraction machines has been widely researched, produced and applied, some of which are the following machines [8].

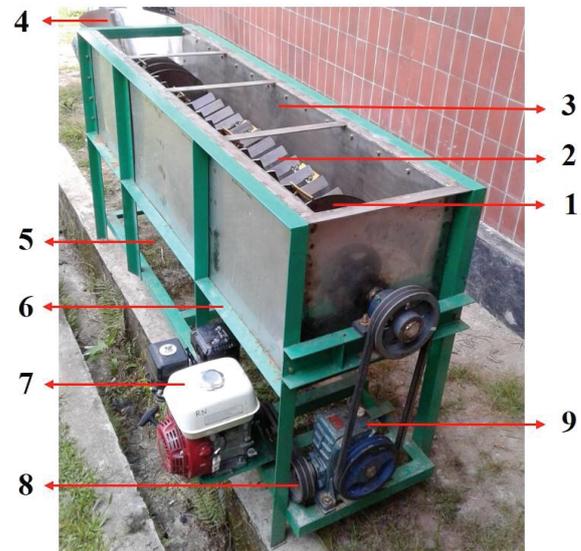


Fig 3. Threaded mixer type Sago Starch Processing Machine

The working principle of the sago starch extraction machine that has been made is that the rotation that has been made is that the rotation generated by the driving motor is channeled through the pulley transmission and the V-belt drives the gearbox, the rotation of the gearbox output shaft through the pulley transmission and the V-belt drives the stirring shaft [9].



Fig 4. Sago Starch Processing Machine type stirrer rotary blades

The working principle of the sago extraction machine is to combine 3 processes, namely stirring, kneading and screening, where the starch extraction takes place in the extraction tube simultaneously.

2 Research Method

The design of the sago starch extraction machine was carried out using the Autodesk Inventor Professional 2020 software, with the product results in the form of 2D and 3D images.

2.1 Design Criteria

The design of the sago extraction machine is planned with a capacity of 80 kg/hour, the sago extraction machine produces sago starch through a combination of stirring, squeezing and filtering processes. The driving motor is planned to use a gasoline motor. To support the sago extraction process, a continuous supply of water is needed. So the design of the sago extraction machine is equipped with an electric generator, where the electricity generated is used as an energy source for the water pump. The design of the sago extraction machine has wheels whose function is to facilitate the mobilization process to the sago land.

2.2 Main Components

The design of the sago extraction machine uses the following main ingredients:

1. Gasoline motor, as a driving force.
2. Reduction gear box, serves to continue the engine exhaust to the stirrer and increase torque.
3. 1000 W electric generator, to produce electrical energy.
4. Engine/frame mount.
5. Transmission system type V-belt
6. Extraction tank and stirring blade

3 Results and Discussion

3.1 Design Drawing

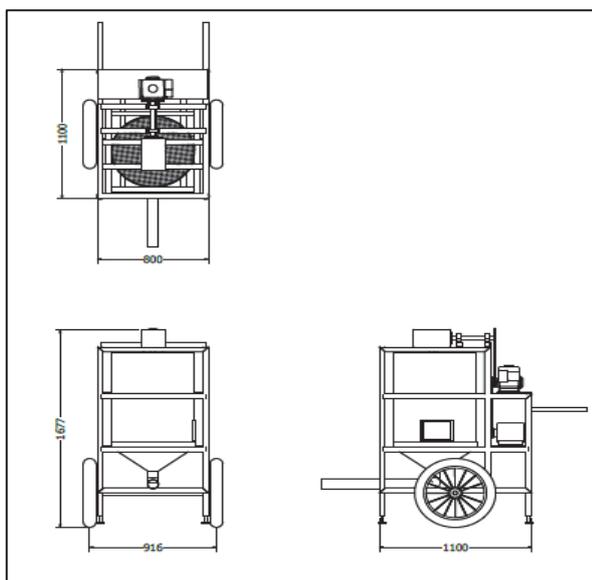


Fig 5. Portable sago extraction machine model

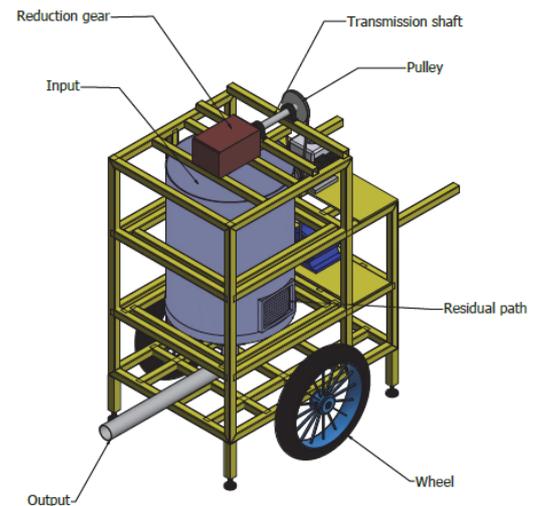


Fig 6. Portable sago extraction machine model

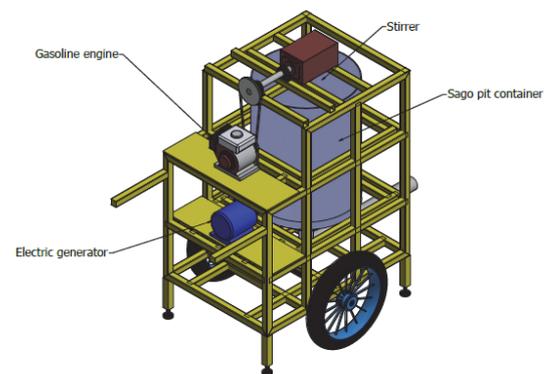


Fig 7. Description of sago extraction machine components

3.2 Procedure

The sago extraction machine is designed to use wheels to facilitate mobilization. The way it works starts from inserting the sago pith resulting from the chopping/grating process. The pith is added and water is added. Furthermore, the machine is operated using a gasoline motor, when it operates the stirrer will rotate stirring the pith mixed with water. The turbulence effect of the stirring process helps to separate the pith from the sago starch. The sago starch which is separated from the sago pith will flow through the outlet while the pith pulp is retained in the sieve in the sago extraction machine. The sago starch that comes out through the outlet is then deposited in a settling container, while the pith which is dissolved in water will be squeezed manually to maximize the yield of sago starch. The process is repeated until the raw materials run out. When operating the motor which is a gasoline motor, in addition to moving the sago extraction mixer, it also drives an AC generator, which produces 1000 W of electricity. The electricity from the generator is used to turn on the water pump, which supplies water to the sago extraction process.

3.3 Shaft Analysis

The analysis carried out on the shaft is about the size (diameter) of the shaft and the strength of the shaft in distributing power. The shaft receives torsional and bending loads, because this shaft can function to transmit power. For this analysis, calculations are carried out including the diameter of the shaft and the critical speed of the shaft.

Design power can be calculated using the following equation [10].

$$P_d = f_c \times P \quad (1)$$

Where:

P_d = Planned power (kW)

f_c = Power correction factor

P = nominal output power of the driving motor (kW)

Transmitted Power Correction Factors, f_c [10].

Power to be transmitted f_c

Average power required $f_c = 1.2 - 2.0$

Maximum power required $f_c = 0.8 - 1.2$

Normal power $f_c = 1.0 - 1.5$

The torsional moment (design moment) can be calculated using Equation 3 [10][11].

$$T = 9,74 \times 10^5 \frac{P_d}{n_1} \quad (2)$$

The deformation caused by the torsional moment on the shaft should be limited, for the shaft installed on the general machine under normal working conditions, the magnitude of the torsion deflection is limited to 0.25-0.3 degrees [5]. The amount of torsional deflection can be calculated using the following equation [10][11].

Where:

θ = Torsion deflection ($^\circ$)

d = Shaft diameter (mm)

l = Shaft length (mm)

T = Twisting Moment (kg.mm)

G = Shear modulus (8.3×10^3) (kg/mm²)

The shaft is one of the important components in transmitting power in the form of rotation, where the diameter of a shaft affects the amount of rotation. The size of the shaft diameter can be calculated by the following equation [10].

$$d_s^3 = \frac{16}{\pi \times S_s} \sqrt{(K_b \times M_b)^2 + (K_t \times M_t)^2} \quad (3)$$

Where:

d_s = Shaft diameter (mm)

K_b = Bending moment correction factor, K_b value is 1.5 for shafts with fixed bending moment; 1.5-2.0 for light bending loads, and 2.0-3.0 for heavy impact loads

M_b = Maximum bending moment (Nm)

K_t = Torsion moment correction factor, K_t value is 1.0 for finely applied loads, 1.0-1.5 if there is a slight deflection and impact, 1.5- 3.0 if there is a large shock or collision

M_t = Torque Moment (Nm)

S_s = Shear stress 40×10^6 MPa

The value of the working torque moment in the calculation of the shaft

diameter. It is calculated using the following equation [10], [11].

$$M_t = \frac{P}{\omega} \quad (4)$$

Where:

M_t = Torque moment (Nm)

P = Power of the Electric Motor (Watts)

ω = RPM of stripping roller (rad/s)

The critical rotation of the shaft is the highest rotation that the shaft can withstand. The critical rotation of the axis of a rotating object can be calculated using the following equations [10], [11].

$$\omega_c = \sqrt{g \cdot \frac{\sum \omega \delta}{\sum \omega \delta}} \quad (5)$$

Where:

c = Critical Rotation of Shaft

For the sake of safety, the maximum working rotation of the shaft should not exceed 80% of the critical rotation [10].

3.4 Bearing Analysis

Bearings are machine elements that can support a loaded shaft, so that rotation or back and forth movement can take place smoothly, safely, and with a long service time. Bearings must be sturdy enough to allow the shaft and other machine elements to work properly. If the bearing does not function properly, the performance of the entire system will decrease or cannot work properly [10], [11].

$$F_r = W_1 + W_2 + W_3 + W_4 \quad (6)$$

The load is a radial load which can be calculated using the following equation [10].

Where :

P_r = Radial load supported

F_w = Load factor, the value is 1.1-1.3 for ordinary work

F_r = Radial load carried by shaft

The velocity factor for ball bearings can be calculated using the following Equation [10].

$$f_n = \left(\frac{33,3}{n} \right)^{1/3} \quad (7)$$

Where :

f_n = speed factor

n = Shaft rotation

While the calculation of the age factor for bearings can be calculated by the following equation [10].

$$F_h = f_n \frac{c}{P_r} \quad (8)$$

Where :

f_h = Age factor

C = Specific dynamic nominal load (kg)

P_r = Dynamic equivalent load (kg)

The nominal life for the bearing can be calculated using the following Equation

$$L_h = 500 \times f_h^3 \quad (9)$$

4 Conclusion

The conclusions from the planning and calculations on the sago extraction machine are as follows: The design uses the following materials, the frame is made of square hollow iron with dimensions of thickness = 3 mm and a side width of 40 mm x 40 mm and equilateral angle iron with dimensions, thickness = 3mm, side width 40 mm x 40 mm. The overall dimensions of the frame are 1100 mm long, 916 mm wide and 1677 mm high, the extraction and mixing process container, the outlet and other parts that are in direct contact with the sago pith using food grade stainless steel material. The engine is driven by a 5.5 HP gasoline motor, the power generation unit uses a 2000 W AC generator. The wheelbarrow uses 17-inch wheels.

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