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Design of Sprocket and Chain Transmission System on Seaweed Dryer Machine

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ABSTRACT

Seaweed is an abundant aquatic product in Indonesia, where around 80% of its production is sold dry. The drying process of seaweed is done in 2 ways, namely direct sunlight or a drying machine method. Seaweed drying machines require a power transmission system to optimize the drying process. The aim of this study is to design a transmission system for a ratary dryer drying machine. The method used in this study is the design and selection of a sprocket and chain transmission system. The research result showed that the chain used was number 25, a single chain with 59 links and a ratio of 15 sprocket pins to 38. The axle distance is 100.4 mm using steel shaft material bearing with the symbol S30C with the drip lubrication method. The sprocket and chain that have been designed were capable of transmitting 14 watts of electric dynamo energy with a torque of around 4.75 Nm at 19.56 revolutions for a load of 1 kg of seaweed.

***Keywords**: chain, drying machine, seaweed, sprocket*

I. INTRODUCTION

Seaweed is an abundant aquatic product in Indonesia. Almost 80% of its production is sold dry, without further processing. In general, seaweed drying by seaweed traders is done in the usual way, using direct sunlight, which is highly dependent on weather conditions. Working manually or naturally, drying seaweed takes three to four days [1]. If the weather when drying seaweed is cloudy during the rainy season, it will cause losses to seaweed farmers. In addition, according to [2], conventional drying causes undesirable changes in the color, texture, flavour and nutritional quality of foodstuffs.

To accelerate the drying process, many drying methods and equipment have been developed, [3] made a dryer from a furnace, [4] made a prototype of a dryer, and even [5] made an IoT-based dryer. Most of which use conduction or convection heat transfer mechanisms. One of them is the rotary drying method, [6] on drying manihot esculenta chips in mocaf manufacturing, [7], [8] on seaweed drying. The working principle of the rotary drying method is to use heat that is transferred directly to the material to be dried through a rotating drum/ cylinder. The heat source used comes from a furnace or an electric heating element. A rotating system is used for uniform drying.

The engine development designed in this study uses a transmission system in the form of a combination of sprockets and chains. The reason we use a chain and sprocket drive system is because a chain drive system is cheaper than a gear drive system. Also, chain drive systems can transmit more power than belt and pulley drive systems. Chain transmission systems can also be used in systems that transmit power to low-speed motors. The previous research that supports this design research is the design of an electric gokar transmission system [9] and [10] on the design of a 50 kg capacity soybean washing machine with the French method. The design of the transmission in rotary drying machine is important because it is expected that the drum is able to work with the appropriate rotation and torque so that the seaweed can dry perfectly.

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II. RESEARCH METHODS

This research uses the experimental method This research uses the experimental method where researchers designed and tested the output of the rotary rotation attached to the seaweed drying machine. This research was conducted from March to October 2023 at the Laboratory of the Department of Mechanical Engineering, Faculty of Engineering, Borneo University of Tarakan. The research flowchart is shown in Figure 1.

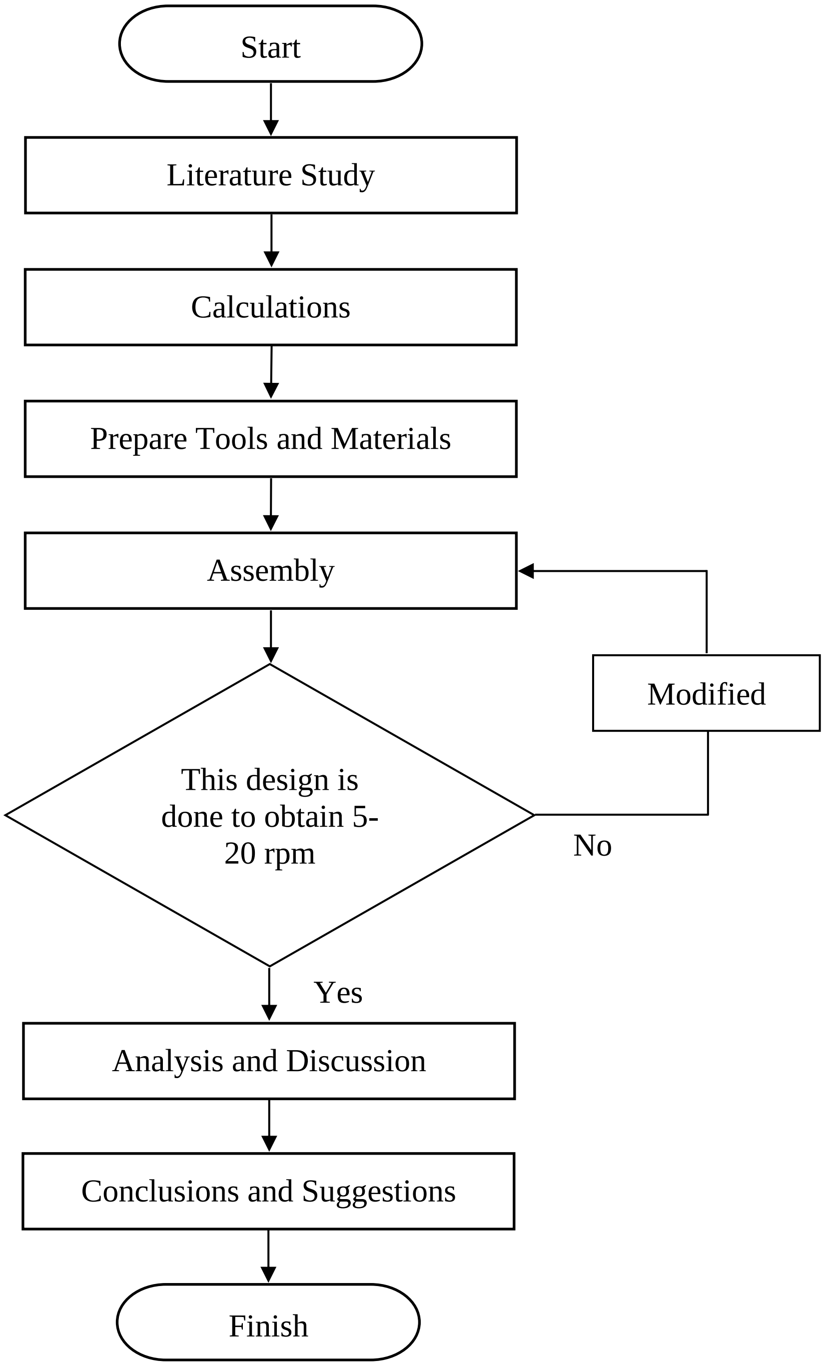
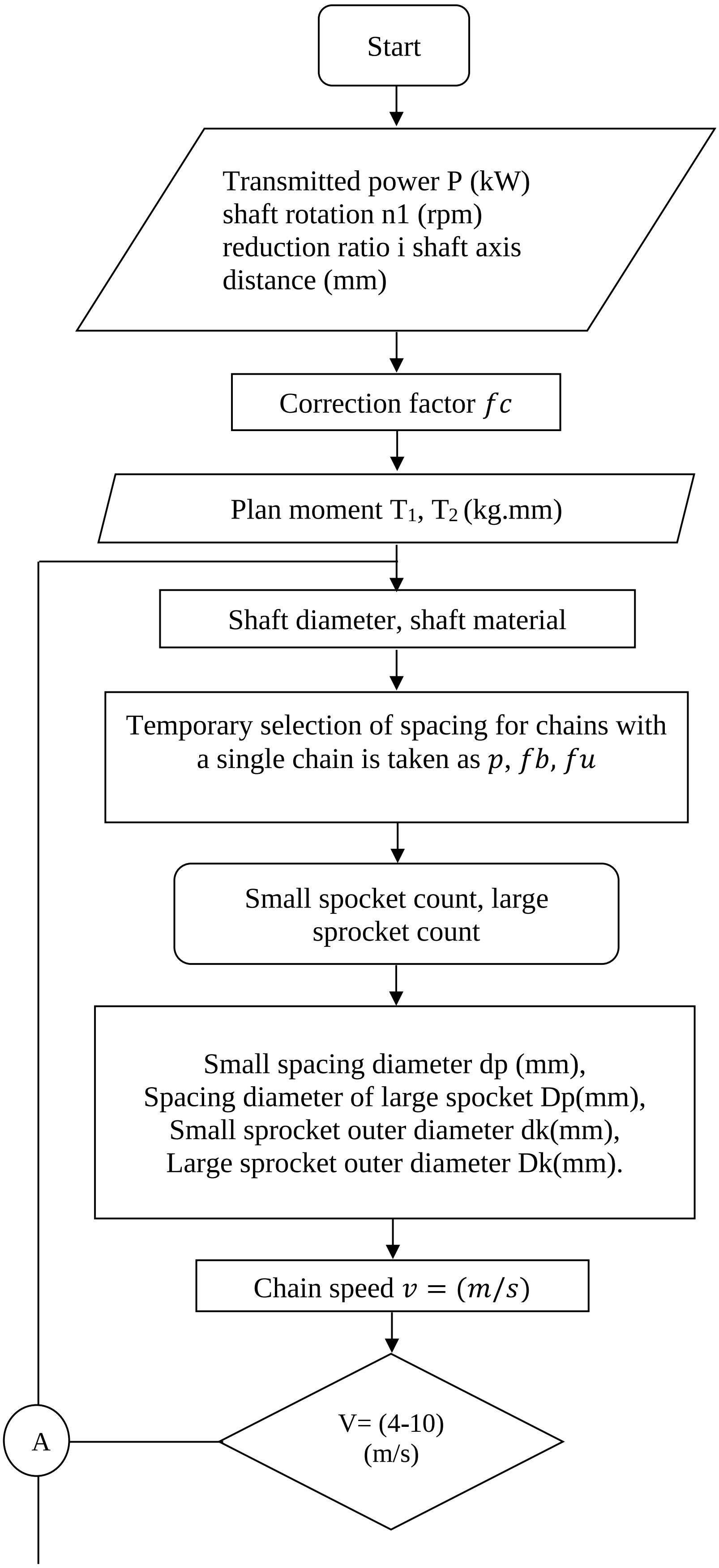


Figure 1. Flowchart of The Research Flow

To support the process of designing a sprocket and chain transmission system on a seaweed drying machine. Then you have to do the design procedure as shown in Figure 2 below.


Start
Transmitted power P (kW)
shaft rotation n1 (rpm)
reduction ratio i shaft axis
distance (mm)
Correction factor fc
Plan moment T_1, T_2 (kg.mm)
Shaft diameter, shaft material
Temporary selection of spacing for chains with a single chain is taken as p, fb, fu
Small spocket count, large sprocket count
Small spacing diameter dp (mm),
Spacing diameter of large spocket Dp(mm),
Small sprocket outer diameter dk(mm),
Large sprocket outer diameter Dk(mm).
Chain speed $v = (m/s)$
V= (4-10)
(m/s)
A

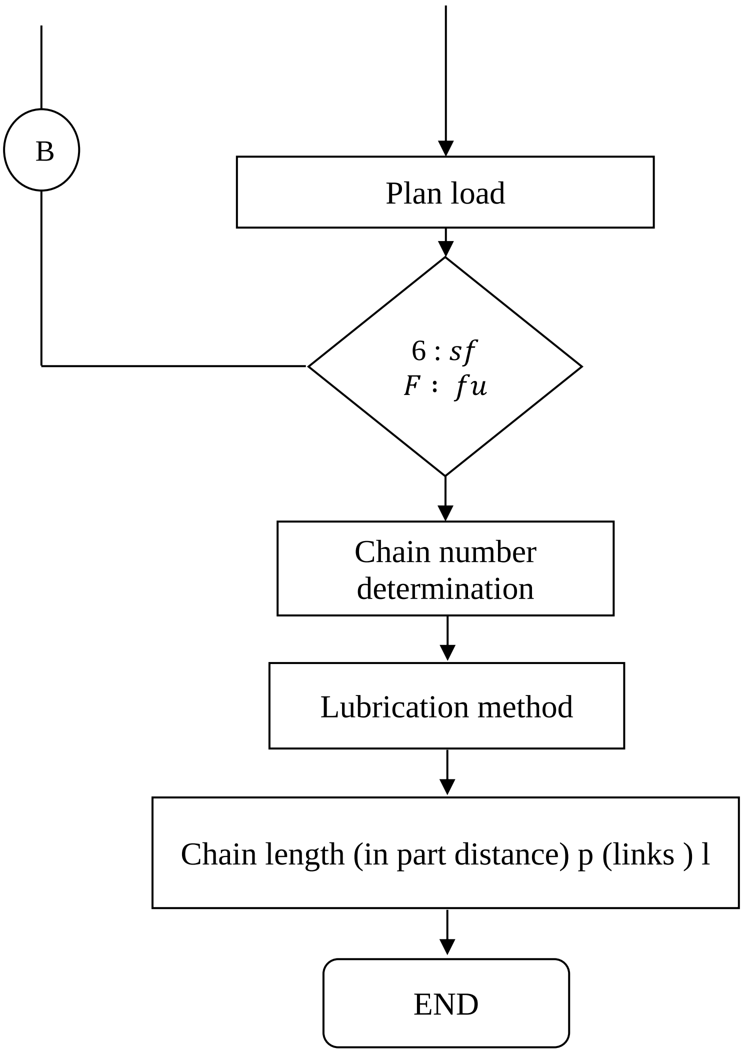


Figure 2. Flowchart of Chain Sprocket Transmission Design [11]

III. RESULT AND DISCUSSION

In planning the sprocket and chain transmission, the power to be transmitted is 14 Watt with a maximum rotation of 50 rpm. While the load to be moved is 4.6 kg, the load is the weight of 1 kg of seaweed and the weight of the rotary on the seaweed dryer is 3.6 kg. The desired rotation is 5-20 rpm, as this is designed for the transmission system of a seaweed dryer.

$$P_d = f_c \cdot P = 1.3 \times 0.014 \text{ kW} = 0.0182 \text{ kW} \approx 0.03 \text{ kW}$$

The result obtained is 0.0182 kW. According to chain selection diagram [11], the smallest value is 0.03 kW. Therefore, the results of the calibration are rounded to 0.03 kW and this value is used to determine the design moment value as follows.

$$T = 9.74 \times 10^5 \frac{P_d}{n_1}$$

$$T_1 = 9.74 \times 10^5 \left(\frac{0.03}{50}\right) = 759.72 \text{ kg} \cdot \text{mm}$$

$$T_2 = 9.74 \times 10^5 \left(\frac{0.03}{20}\right) = 1{,}899.3 \text{ kg} \cdot \text{mm}$$

The results obtained the value of the plan moment T_1 and T_2, the value is used to obtain the diameter size of the rotary drive shaft. The number of small sprocket gears that will be used in this electric dynamo is as follows $z_1 = 15$. The value is obtained from [11].

$$z_2 = \frac{z_1 \times n_1}{n_2} = \frac{15 \times 50}{20} = 37.5 \approx 38$$

So, the value of $z_1 = 15$ is then entered into the formula above, so that the value of $z_2 = 37.5$ is obtained and then rounded to 38 because the gear eye on the sprocket does not have the number of decimal places.

After obtaining the number of drive sprockets and the number of sprockets to be driven, then determine the diameter spacing for small sprockets d_p, diameter spacing for large sprockets D_p, small sprocket outer diameter d_k, and large sprocket outer diameter D_k with distance quotient $p = 6.35$ [11] as follows.

- Diameter spacing for small sprockets d_p

  $d_p = p/\sin(180°/z_1) = 6.35/\sin(180°/15) = 31.75 \text{ mm}$

- Diameter spacing for large sprockets D_p

  $D_p = p/\sin(180°/z_2) = 6.35/\sin(180°/38) = 79.37 \text{ mm}$

- Small sprocket outer diameter d_k

  $d_k = \{0.6 + \cot(180°/z_1)\} \times p = \{0.6 + \cot(180°/15)\} \times 6.35 = 33.65 \text{ mm}$

- Large sprocket outer diameter D_k

  $D_k = \{0.6 + \cot(180°/z_2)\} \times p = \{0.6 + \cot(180°/38)\} \times 6.35 = 3.87 \text{ mm}$

So, the results obtained from the above calculations are applied to the selection of sprocket diameters to be used in the seaweed dryer drive. The chain speed on the seaweed dryer is very low because this machine requires high torque at low speed to dry the seaweed evenly.

$$v = \frac{p \times z_1 \times n_1}{60 \times 1000} = \frac{6.35 \times 15 \times 50}{60 \times 1000} = 0.079 \text{ m/s}$$

The speed obtained is very low at $0{,}079 \text{ m/s}$ so that the rotary will rotate very slowly and the seaweed dries evenly. The plan load F (kg) on this electric dynamo does not exceed the maximum allowable limit on a single circuit no chain 25.

$$F = \frac{102 \times P}{v} = \frac{102 \times 0.03}{0.079} = 38.7 \text{ kg}$$

$$sf = 500 \text{ kg}/38.7 \text{ kg} = 19.3 \text{ kg} \quad (6 < 19.3 \text{ kg (good)})$$

The results obtained are good because they do not exceed the load that will be rotated by the drive on the machine when it is running. The selected chain number is 25, a single circuit to meet the transmission needs of the electric dynamo to be designed. To modulate the electric dynamo using a single chain circuit no. 25, drip lubrication was chosen for this sprocket transmission. The chain length of the seaweed dryer transmission is as follows:

$$L_p = \frac{z_1 + z_2}{2} + 2C_p + \frac{[(z_2 - z_1)/6.28]^2}{C_p}$$

$$L_p = \frac{15 + 38}{2} + 2\left(\frac{100}{6{,}35}\right) + \frac{[(38 - 15)/6.28]^2}{100/6.35} = 58.8 \approx 59$$

L = for Chain length = 59 link with No. 25.

From the calculation of the formula above, the result obtained is 58.8 and then rounded to 59 because the number of chains does not have the number of decimal places.

$$C_p = \frac{1}{4}\left\{\left(L - \frac{z_1 + z_2}{2}\right) + \sqrt{\left(L - \frac{z_1 + z_2}{2}\right)^2 - \frac{2}{9,86}(z_2 - z_1)^2}\right\}$$

$$= \frac{1}{4}\left\{\left(59 - \frac{15 + 38}{2}\right) + \sqrt{\left(59 - \frac{15 + 38}{2}\right)^2 - \frac{2}{9.86}(38 - 15)^2}\right\} = 15.825$$

$C \ = C_p \times p = 15.825 \ \times 6.35 \ = 100.4$ mm.

The results of this calculation are applied to determine the distance between the drive shaft and the driven shaft on the seaweed dryer.

Figure 3. Sprockets R25-38T and R25-15T

The size of the sprocket obtained from the previous calculation greatly affect the rotation output on the rotary seaweed drying machine which has been determined to be 5-20 rpm. So that the sprockets with sizes 38T and 15T are selected to get the desired rotary output of the seaweed rotary dryer, while the letter T on the sprocket means the number of teeth on the sprocket.

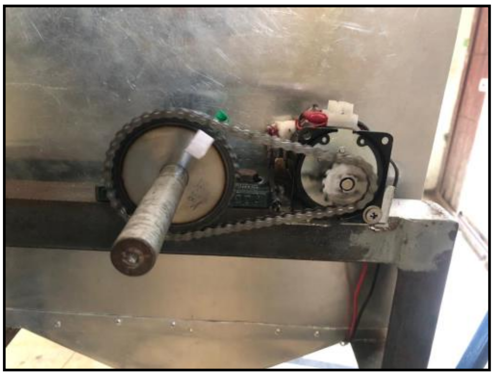


Figure 4. Transmission Position of Sprocket and Chain

The position of the sprocket and chain on the electric dynamo is horizontal and parallel to the frame of the seaweed drying machine so that the dynamo is stronger to withstand the load of the component to be rotated because the dynamo is bound to a strong iron frame. As in Figure 4, the transmission position of the sprockets and chains that have been installed in the seaweed drying machine.

From three repetitions can be averaged rpm generated is 19.56 rpm and the average power generated by 15.96 Watt. As shown in Table 1 test results using a tachometer with a load of 1 kg of seaweed, the results of this test are included in the desired criteria of 5-20 rpm.

Table 1. Test Results using a Load of 1 kg of Seaweed

Experiment	Rpm	Power (Watt)
1	19.6	15.9
2	19.6	16.0
3	19.5	16.0
Average	**19.56**	**15.96**

Table 2. Test Results without Load

Experiment	Rpm	Power (Watt)
1	19.9	16.1
2	19.8	16.1
3	19.9	16.1
Average	**19.86**	**16.1**

Table 2 shows the test results without load of seaweed. From the average value of rpm and power, the results of this test are in accordance with the desired criteria. From Tables 1 and 2, the torque of the seaweed dryer can be calculated as follows ($P = 0.018$ kW $= 0.02$ HP).

$$T = \frac{5252 \times P}{n}$$

Calculation of torque on the rotary using rpm test results using a load of 1 kg of seaweed is as follows.

$$T = \frac{5252 \times 0.02}{19.56} = 5.37 \text{ Nm}$$

Calculation of torque on the rotary using rpm test results without using a load of 1 kg of seaweed is as follows.

$$T = \frac{5252 \times 0.02}{19.86} = 5.29 \text{ Nm}$$

From the torque calculation above, the torque obtained does not exceed the torque on the electric dynamo used in the seaweed drying machine. So that the seaweed drying machine can work properly and can rotate the load of 1 kg of seaweed to dry evenly.

IV. CONCLUSION

1. From the design results, sprockets with sizes 38T and 15T were selected and the chain length used was 59 links.
2. From the results of the no-load trial, a rotation of 19.86 rpm and a torque of 5.29 Nm were obtained, while a trial with a load of 1 kg of seaweed obtained a rotation of 19.56 rpm and a torque of 5.37 Nm.

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