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Abstract. The need for oil palm seeds in Indonesia has increased lately. Palm seeds can be grown from the kernel. To get a uniform size kernel requires uniform size seeds. This study aims to design, make a separator of palm seeds so that the size of the uniform seeds. The design phase did using a CAD program to draw engineering drawings. Based on engineering drawings, we analyzed and made prototypes of palm seed sorting machines. The size of the prototype was 182 cm long, 50 cm wide and 94 cm high. This machine sorted seeds into large, medium and small dimensions The test results of 300 seeds consisting of 100 large size seeds, 100 medium size seeds and 100 small size seeds, produced 29.5% large size, 30.8% small size 28.2% small size. The capacity of the machine was 60,2 kg per hour. The palm oil seed sorting machine has an optimum percentage of 88.87%.

1. Introduction

Oil palm plantations (*Elaeisguineensis Jacq*) is currently one of the types of plantation crops that occupy an important position in the agricultural sector in Indonesia. Oil palm produces oil or fat and has the largest economic value per hectare compared to other plants, so that the development of oil palm plantations in Indonesia is sufficient high. The expansion of plantations and replanting of oil palm plants will lead to high production of palm kernel to be used as oil and the need for palm seed.

Tamrin, et al [1] reported that the germination of palm seeds can be done by germinating the kernel. The kernel is the core of the palm kernel which is coated with a shell. To get the kernel, the palm kernel shell must be removed or broken mechanically. Breaking the nut requires a shell breaker. The shell breaker developed was of two types, namely two cylindrical rotating and one rotating cylinder equipped with slippery curved plates.

Cracking the hard skin of palm seeds with a machine is a major problem that occurs when different types of kernel are mixed together for cracking, that is, when the bigger Dura nuts are mixed with smaller Tenera nuts [2]. Palm oil seed sorting machine can improve the efficiency of the performance of cracking the hard skin of palm oil seeds.

The cracker efficiency and kernel breakage factor affect the optimal performance of the cracker. It is a compromise between high cracking efficiency and low kernel breakage factor or ratio. The cracking efficiency of the cracker is greatly affected by the shaft speed, moisture content and feed rate. For the average feed rate of 714 kg/h the efficiency increased as the shaft speed increased. It was found to be 63.78, 74.83, 82.05, and 82.05% for the speeds of 1,650, 1,870, 2,125, and 2,230 rpm, respectively, at the same feed rate and moisture content of 10.94 % (d.b.). The best fit linear equations for all the moisture contents is given below for 10.94,11.74, 13.48, and 15.18 % d.b., respectively [3]. The oil palm fruit of length varies 20 mm and 50 mm and could be as large as in 25 mm in diameter in found in bunches [4]. Dimensions of palm seeds also vary. Ezeoha and Akubuo [3] report that the major diameter ranged between 15.68 ± 2.24 mm and 22.41 ± 2.19 mm with an average of 19.09 ± 2.01 mm. Range of

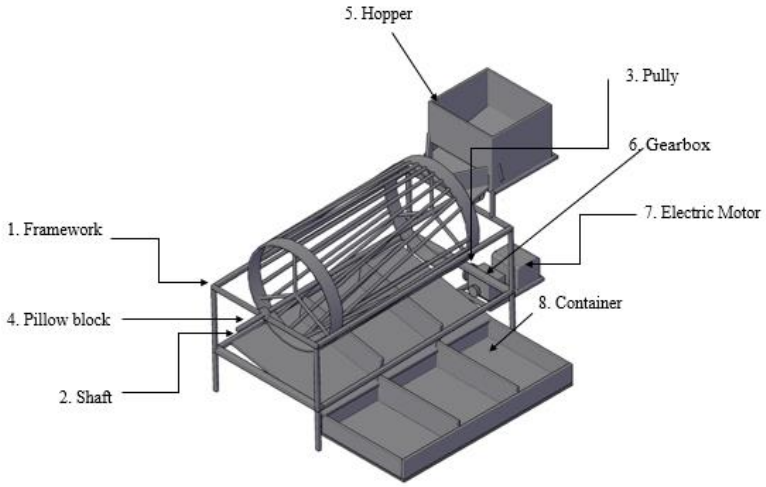

Figure 1. Parts of the palm oil seed sorter.

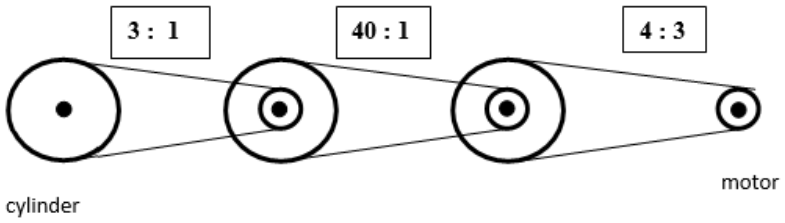

Figure 2. System reduction rpm from motor to cylinder

seeds diameter oil palm is large, it is difficult to obtain high palm kernel breaking efficiency. In order to separation efficiency high palm seeds, it is necessary to separate the palm seeds into three dimensions. This research aims to design and create a seed of palm oil separator machine in 3 range dimensions.

2. Materials and Methods

2.1. Materials and design of the palm oil seed sorter

The design of the palm oil seed sorting tool is expected to be able to sort palm seeds into 3 sizes, namely $1.0 \leq x \leq 1.5$ cm small size, $1.5 < x \leq 2.0$ cm medium size, and $2.0 < x \leq 2.5$ cm big size. After the seeds are separated, they can be cracked with a cracker to separate the kernel from the shell. This palm oil seed sorter section is generally divided into a framework, shaft, pillow block, pully, hopper, container, gearbox and electric motor. Each part of the sorting device is installed based on the design and functional theoretical calculations.

The supporting frame is made by joining 3 cm iron elbows with welding while the supporting frame is made with 8 mm steel bar. Hopper is made using an iron plate with a thickness of 1 mm and a reservoir is made using wood with a thickness of 1 cm. All of these components will form the sorter of palm seeds after each component has been arranged as shown in Figure 1.

2.2. Technical analysis

Palm oil kernels are separated by hollow cylindrical tools. The cylinder works with a slow rotation of 9 rpm. To get a 9 rpm cylinder rotation from the motor rotation at 1440 rpm using a reduction system. The reduction system used is presented in Figure 2.

The equation for reducing rotation from high rotation to low rotation is

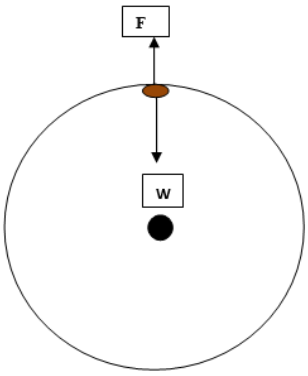

Figure 3. The force balance on the seeds when on the top of the cylinder.

$$\frac{N_S}{D_S} = \frac{N_O}{D_O}, \tag{1}$$

where Ns, Ds, No and Ds are rpm of electric motor, diameter of motor pulley, rpm of sorting machine, and diameter of sorting machine, respectively.

This machine is mounted seed pusher plate forward so that the seeds can move towards the end of the cylinder. The slope of the pusher plate is 36 and the length of the pusher plate is 10 cm. Based on the length and slope of the plate, it is reported that the movement of the seeds to the front as far as 10 cm Cos 36o or equal to 8 cm. Push plate mounted alternating hose or facing each other. Every one round, the seeds will move to front as far as 8 cm. The length of time the seeds in the separator can be estimated with the following equation:

$$t = \frac{1}{8\ cm}\ x \frac{L}{N}\ \ (minute), \tag{2}$$

where L and N are length of separating cylinder and cylinder rotation.

The working principle of this separator is that the seeds fall in the gap between two steel bars in the form of a line. This gap is getting to the front of the bigger, so that the small seeds fall first and are followed by the next larger seeds. This cylinder rotates so the seeds can move forward. If the cylinder speed becomes larger, the seeds will not move in the cylinder chamber.

Estimated rotation of the cylinder that seeds cannot fall down while spinning. If the force of the seeds to the cylinder wall is equal to the weight of the seeds, the seeds will not fall down. This condition will occur in a round cylinder with a diameter of 40 cm as follows:

$$F = W \tag{3}$$

$$m\ R\ \omega^2 = m\ g \tag{4}$$

then

$$\omega = \sqrt{\frac{9{,}8\ \frac{m}{s^2}}{0{,}2\ m}} = 7\ \frac{rad}{s} \tag{5}$$

$$rotation\ (N) = \ 7\ x\ \frac{60}{2\pi} = 66.87\ rpm. \tag{6}$$

Determination of V belt contact angle is

$$\mathrm{Sin}^{-1}\alpha = \frac{\mathrm{R-r}}{\mathrm{x}}, \tag{7}$$

Figure 4. Prototype of the palm seed sorting machine.

where R is radius of the large pulley, mm; r is radius of the smaller pulley, mm; θ is angle of wrap of drive and driven pulley, rad [5]. Determination of the belt tension is

$$2{,}3 \log \frac{T_1}{T_2} = \mu \, \theta \, \text{cosec} \, (\beta) \tag{8}$$

where T1 is tensions in the tight side of the belt, Nm; T2 tensions in the slack side of the belt, Nm ; μ is coefficient of friction; β is groove angle of V-belt, S is the maximum permissible belt stress, MN/m2; A is area of belt [5]. Determination of the torque and power transmitted for the shaft is

$$\text{Power (Tr)} = (T1 - T2)\, V = (T1 - T2)\, R\, N, \tag{9}$$

where Tr is resultant torque, Nm; T1 & T2 are tension in the belt, Nm; and R is radius of bigger pulley, mm.

3. Results and Discussions

3.1. Sorting Machine Prototype for the Palm Oil Seeds

After several stages of design and manufacture, a prototype sorting machine for palm oil is produced with dimensions of 182 cm length 94 cm height and 50 cm width and is equipped with components. This palm seed sorting machine (Figure 4) has a frame section where other main components are installed. The main components are hopper, pusher plate, drive motor (0.5 hp electric motor), gearbox, pully, v-belt, pillow block, shaft, small size output, medium size output and large size output. The supporting frame is made of 3 x 3 cm iron with a length of 130 x 50 x 50 cm, while the sorting frame is made of steel bar measuring 8 mm with a length of 120 cm and 40 cm in cylinder diameter. The shape of the hopper is square with a size of 28 x 28 cm and a height of 30 cm with a slope of 15^{o}.

In the process of sorting the required rotational speed is low, because if the rotation is too fast then the seeds will not be properly sorted. To drive this machine, the high rotating speed of the electric motor (1440 rpm) is reduced in three stages. In the first reduction using pulleys with a ratio of 3: 4, the second reduction using gearboxes with a ratio of 1: 40, in the third reduction using pulleys with a ratio of 1: 3, so it got the rotation of the cylinder sorting device is 9.87 rpm.

Separator container made from wood with a thickness of 1 cm with a length of 125 cm, width of 45 cm and height of 10 cm. In the reservoir container is divided into 3 parts, each part that is 41.6 cm long. This separator container is installed under the sorting machine. The measurement results of the smallest seed diameter of palm seeds are 1 cm while the largest diameter is 2.5 cm. This sorting principle is based on the smallest length of the dimensions of the palm oil which are $1.0 \leq x \leq 1.5$ cm small size, $1.5 < x \leq 2.0$ cm medium size, and $2.0 < x \leq 2.5$ cm large size.

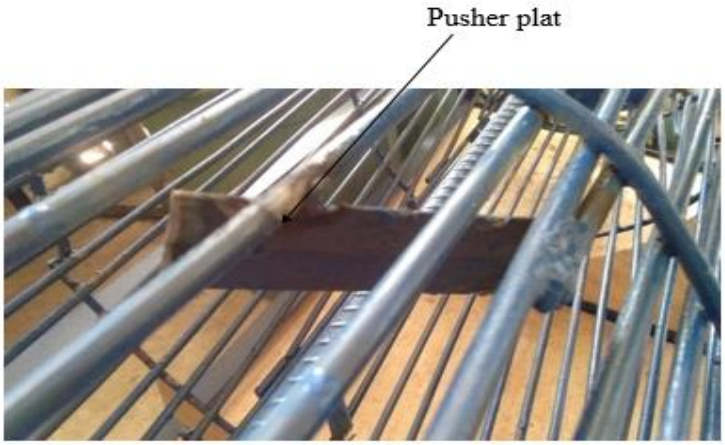

Figure 5. Pusher plat

The driving source of this sorting machine is the 0.5 hp electric motor, while the motor power is transmitted using a pulley and v-belt. Palm oil seeds are put into a square hopper, after which the seeds will fall into the sorting cylinder with a rotation speed of 9.0 rpm. This sorting machine has a seed pusher plate with a plate length of 10 cm, a distance of 8 cm with a slope of 36^{o}.

During sortating operations, the sortating cylinder rotates and the seeds always fall on the bottom. If the seeds which have the shortest diameter are smaller than 1.5 cm, the seeds will fall from the sortating cylinder to the container of small size palm seeds, the shortest diameter is 1.5-2.0 cm, then the seeds will fall on the medium size container. While the shortest diameter is greater than 2.0 cm, the seeds will fall in a large container.

3.2. Cylinder Rotating

Palm oil seed sortating machine has electric motor drive power with specifications: 0.5 hp power with 1440 rpm rotation. Based on direct measurements with the tachometer on the electric motor pulley, the electric motor rotation value is 1485 rpm. Measurement of electric motor rotation can be directly used as data to estimate the speed of the sortating cylindrical rotation. Rpm reduction system on the motor shaft to get the cylinder rotation is 160 times. The rotation speed of the motor axle is 1485 rpm, the rotation speed of the sortating cylinder where the seed sortation is 9.28 rpm.

3.3. Time of Palm Oil seed in Cylinder

Based on the time test, 300 palm oil seeds were in sortating cylinder only 0.8 minutes, while theoretically the result was 1.61 minutes. The difference that occurs between theory and direct test is that in theory palm oil will be driven by a forward plate with every one turn, then the seeds will shift with a distance of 8 cm. pusher plate with a length of 10 cm, the distance to the front is 8 cm and the slope is 36o, with 1 round of seeds only shifting 8 cm. While the test is directly one round, the seeds can pass 1 - 3 driving plate, because the seeds in this case get hit, so the seeds move faster towards the future. Figure pusher plate can be seen in Figure 5.

Based on technical analysis and performance test in sorting palm oil seeds, it has a cylinder rotation speed of 9.28 rpm, the length of the palm oil seeds is in the cylinder from the beginning to the end of 0.30 minutes and the machine capacity of 1.00 kg/minute.

3.4. Performance of Machine Test

Existing sorting machine have varying degrees of accuracy. The level of accuracy of sorting palm oil seeds was tested by sorting as many as 5 replications with 300 seeds divided into 3 sizes, namely 100 small palm seeds, 100 medium palm seeds and 100 large palm seeds, so each has a sample of 33.33%, a comparison between sizes small, medium and large are the same. The results of the sorting test for palm oil can be seen in Table 1.

Table 1. Performance of palm oil sorter machine (%)

Repetion	Small container			Medium container			Large container		
	Produce	Deviation		Produce	Deviation		Produce	Deviation	
		Large	Medium		Small	Large		Small	Medium
I	28,88	0,00	2,22	27,22	4,44	3,22	26,11	0,00	3,88
II	30,55	0,00	1,11	30,55	2,77	3,33	20,00	0,00	1,66
III	32,22	0,00	1,66	30,00	1,11	2,88	24,44	0,00	1,66
IV	29,44	0,00	1,11	28,33	2,77	2,11	27,22	0,00	3,88
V	33,33	0,00	1,11	31,66	0,00	1,44	23,88	0,00	0,55
Average	30,88	0,00	1,44	29,55	2,22	2,31	24,33	0,00	2,33

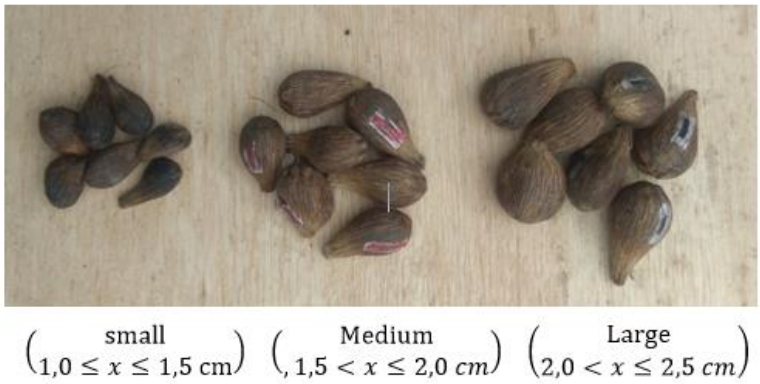

Figure 6. Palm seeds are sorted by small, medium and large sizes.

The results of sorting with five replications show non-uniform percent numbers on the number of samples sorted correctly between small, medium and large sizes. This is due to the mechanism of the seeds that come out of the hopper irregularly. When the seeds that come out together from the hopper are small, medium and large, then the small size seeds can go directly to the medium size space because they are pushed by medium size and large size and there are also small size seeds that are pushed to a large size space.

In Table 1 it can be seen that the most average deviation is at medium size. While the smallest average deviation is small size. This is due to the small size of seeds undergoing the first sorting process, so the possibility for deviations is very small. Whereas for medium size seeds with medium diameter, this sorting process is carried out after small seed sizes. The small seed size will be carried into the medium seed space, if the small seed size is in front of the medium seed size, and will also be brought in to the large seed size because the pusher plate can influence. There is also the medium size of the seeds being carried into large size seeds. When the medium seeds are in front of large seeds, so they will be carried to the size of large seeds. There are also large seed sizes that fall into medium size seeds, this is because large seeds are a little stuck at medium size and therefore large seeds will fall to medium size.

The uniformity of the results of the sorting of palm seeds varies greatly in size, in the size of small seeds with a sample of 33%, the results are perfectly sorted an average of 30.88%, and the seeds deviate in small sizes on average 0.00% - 1.44%. On medium seed size with 33% of the sizes, the average size is 29.55%, while the average size is 2.22% - 3,45%. On the size of large seeds, which are perfectly sorted, the average is 24.33%, while the average deviations are 2,6% and 8.6%. So the most deviant sorting results in a medium size container.

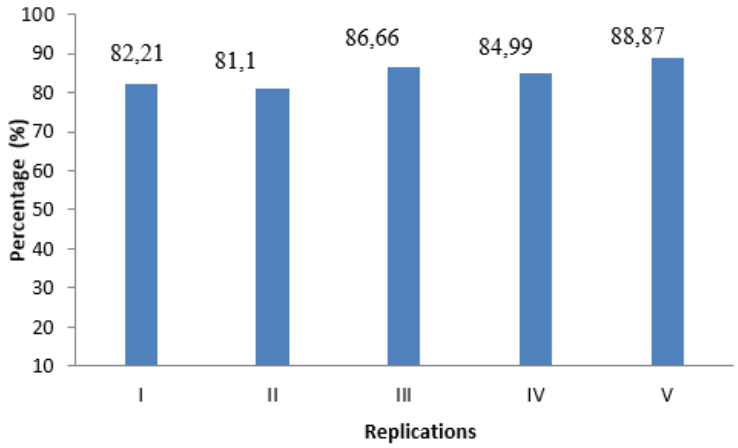

Figure 7. Performance machine

Table 2. The machine capacity

Replication	Weight (kg/menute)	Capacity (kg/h)
I	0,985	59,1
II	0,980	58,8
III	0,978	58,6
IV	1,048	62,8
V	1,033	61,9
Average	1,004	60,24

The performance of this machine for sorting palm seeds is the ability to separate the palm seeds based on a predetermined size. The results of testing the separation of palm oil seeds can be seen in Figure 7. Figure 7 shows that the palm oil seed sorting tool has an optimum percentage of 88.87% in the 5th sort. While the minimum sorting percentage is obtained in the 2nd sort that is 81.1%, so the average percentage of success is 84.77%. The machine can do the separation of palm oil seeds in three levels. The level of precision of the holes size must be a concern, because the size of the hole that changes can reduce the performance of this machine%.

3.5. The Capacity of Palm Oil Sorting

Capacity is the ability to do time work. The capacity of the palm seed sorter uses kg per hour. Tests carried out using a sample of 5 kg of palm seeds. The process of testing the work capacity of the results of this sorting is carried out in five repetitions, in each repetition the time is measured until all the palm seeds have come out of the cylinder chamber. The table of results of testing the working capacity of the machine can be seen in Table 2.

The results of capacity testing with 5 replications get the weight of the separated seeds 60.24 kg/h. The capacity test showed 1 kg/minute while theoretically the result was 1.18 kg / minute assuming 1 layers of palm oil. The difference that occurs is not too far, because in theoretical calculations that there are no cavity palm seeds, while in fact the pile of palm seeds there are many cavities. Another factor is that the feed rate is not continuous. If the feed is continuous, then the theoretical capacity is more than the facts.

4. Conclusions

This research has been able to produce a prototype separator tool for palm oil in three sizes, namely the size of small, medium and large seeds with a capacity of 60.24 kg / hour. Cylinder rotation rate 9.28 rpm. It is dimensions of 182 cm length 94 cm height and 50 cm width. Dimension of cylinder are a

length of 120 cm and 40 cm in cylinder diameter. The palm oil seed sorting machine has an optimum percentage of 88.87% .

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