Performance Test of Shallot Dehuller Machine (Type BEJE PB 01)

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Abstract. Shallot is widely used in daily life. Its demand tends to increase even though Indonesia is still facing global pandemic due to Covid-19 outbreak. Before processing, its outer layer should be removed. However, it is time and energy consuming. Therefore, a shallot dehuller machine with theoretical capacity of 20 kg/h was manufactured to increase peeling capacity. Various tests were conducted to examine the machine performance. The objectives of the research were to conduct performance test by identifying and evaluating mechanical aspects and providing recommendations after the tests concluded. An explanatory descriptive analysis had been chosen to observe, measure, and calculate the data. Results of performance test indicated that while the actual capacity was 14.52 kg/h, its efficiency was 71.44%. The shelling yield was around 36.29%. During the test, the noisiness also measured which was about 88.4 dB. Moreover, motor and engine vibration were also measured. The results were 6.48 and 6 Hz of motor and engine vibration (without load). Furthermore, motor and engine vibration with load were about 5.96 and 5.56 Hz, respectively. Machine performance was relatively moderate. On the contrary, due to low shelling yield, further modification is needed to achieve better results.

Keywords: Dehuller · Engine capacity · Noise · Vibration

1 Introduction

Shallot is widely known and cultivated vegetable in Indonesia. As a food item, shallots are usually served cooked. They are pungent when chopped and contain certain chemical substances which may irritate the eyes. They can be categorized as seasonal vegetable and contributes a lot in horticulture production along with garlic, big chili, cayenne pepper, potato, tomato, and carrot [1].

Shallot production in Indonesia shows increasing trend from year to year. It increases 14,88% from 2019 production and around 25% when compare to 2016 production [1]. Even though we are still facing global pandemic due to Covid-19, shallot remains important commodity. Most of its consumption (93,92%) comes from household sector [1]. However, shallot demand from small-to-medium enterprise is also increasing. Therefore, the demand of dehulled shallot tends to increase every year. The daily demand is

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high while the productivity of shallots is seasonal so its availability is fluctuating in the market which causes price fluctuations [2].

The purpose of dehulling is to remove uneaten or unwanted external parts, such as skin, stalks, and parts that are deformed or rotten [3]. This process starts with dehulling outer skin and cutting the roots off to remove contaminants [4]. Traditionally, the process is done using knife. However, it is time and energy consuming. Therefore, the shallot machine is designed and developed. It serves to assist faster and more efficient dehulling process especially in larger quantity. The common method used in dehulling machine is rotating shallots on top of perforated surface with certain angular velocity [5]. Machine in this study was labelled as BEJE PB 01. The objectives of the research were to conduct performance test by identifying and evaluating mechanical aspects and also providing recommendations after the tests concluded.

2 Methods

The research was conducted from May to July 2021 at Bogor Agricultural Development Polytechnic workshop and a factory producing agricultural machinery in Bogor namely PT Bahagia Jaya Sejahtera (PT BJS).

About 10 kg of shallots used in this experiment for testing the performance. Various workshop tools were used such as roll meter, digital scale, stopwatch, sound level meter, caliper, clamp meter, ruler, and beaker glass.

Descriptive explanatory method in this research was done through observing, calculating, and measuring the technical specification needed in developing the machine. Performance tests including actual dehulling capacity, machine efficiency, damage percentage, and dehulling yield. Ergonomic tests were also conducted to observe how well-fitted the machine for operators.

Data analysis including several testing parameters shown in Table 1.

Formulas:

- Theoretical Capacity
  Its theoretical capacity is 20 kg/h.
- Actual Capacity
  It is from the Eq. 1 below:

$$AC = \frac{W}{t} \quad (1)$$

Description:

AC actual capacity (kg/hour)
W total mass per operation (kg)
t total time (hour)

- Machine Efficiency

$$\varepsilon = \frac{AC}{TC} \times 100\% \quad (2)$$

Description:

Table 1. Testing parameters

Purpose	Parameter	Data Analysis
Identifying Components of Dehulling Machine	Anthropometry, Vibration, and Noise Test	Ergonomic Test
	Setup, Starting, Ease of Operation and Operator Safety	Service Test
Machine Performance Evaluation	Theoretical and Actual Capacity	Performance Test
	Efficiency	Comparing Theoretical and Actual Capacity
	Dehulling Yield	Comparing Dehulling Yield to Input
	Damage Percentage	Measuring the Rate of Damaged Shallots After the Process

ε efficiency (%)
AC actual capacity (kg/hour)
TC theoretical capacity (kg/hour)

- Dehulling Yield

$$Y = \frac{Output}{Input} \times 100\% \quad (3)$$

Description:

Y dehulling yield (%)

Ergonomic analysis was carried out to observe noise and vibration that might be generated from the machine. The parameters are listed below:

- Anthropometry
  The data needed in machine design were sitting elbow height, normal reach, forward reach, and grip breadth. According to Rahmatika et al. [6], these data are important to determine the machine design so that it will meet the users' characteristics.
- Vibration
  It was conducted to observe the magnitude of vibration emitted from the machine. It was regulated under [7].
- Noise
  Noise measurement was carried out to observe noise level of the machine. It was expected not to exceed permitted threshold. The duration of the test was

done according to Regulation of Minister of Manpower and Transmigration No PER.13/MEN/X/2011 [7].

3 Results and Discussion

Shallot dehuller machine (BEJE-PB 01) serves to peel the skin of the shallot. The machine generally consists of an intake or feed section, a peeler section, an outlet section, and a driving motor. The feeder section is in the form of an input funnel (hopper) which functions as a place to feed materials. The dehuller was equipped with peeler teeth made of rubber mounted on the disc and the wall of the dehuller chamber. The shallots enter the chamber and are then rotated by the disc. The shallot skin is rubbed against the peeler teeth and eventually detached and pulled out of the chamber. The illustration of machine design can be seen in Fig. 1.

The dispensing part was in the form of 2 funnels. The first funnel served as the outlet for the peeled shallots, the second funnel served as the outlet for the shallot skin. The propulsion motor served as a source of driving force to rotate the disc using 0.372 kW (0.5 HP) electric motor.

3.1 Ergonomic Test

Measurement of ergonomic parameters was conducted by measuring the dimensions of the machine and several components related to level noise and vibration in the machine. The machine is illustrated in Fig. 2.

The ergonomics analysis is as follows:

3.1.1 Anthropometry

Anthropometry is the adjustment of the design of the tool or design that will be produced according to the size of the human body which can determine the comfort in operating

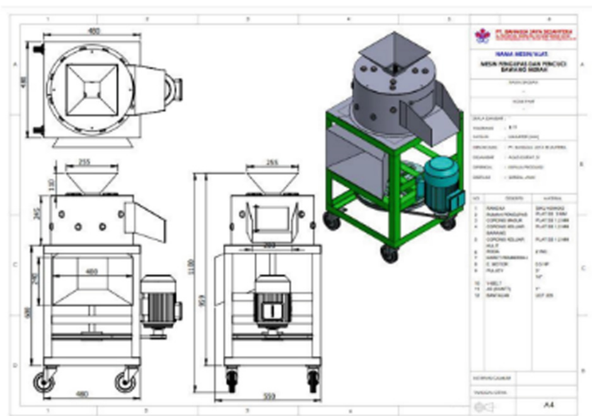

Fig. 1. Machine design (PT BJS archive).

Description:
1.Inlet lid
2.Dehulling Chamber
3.Residue Outlet
4.Motor

Fig. 2. Shallot dehuller machine (Courtesy: Personal documentation).

the tool or machine that has been made. The shallot dehuller machine was comfortable to use because its height was 110 cm (Fig. 2). Its height guarantees easy access for operators to put the materials into the feed funnel. For increasing ease of use and safety, machine frame was added as well as start button and warning labels. It was to prevent work-related accidents.

3.1.2 Noise Level

The measurement of noise level was done by measuring the noise level using sound level meter placed on the operator's ear during operation. The test results indicated the average noise was 93.9 dB (without load) and 88.44 dB (with load). The value of the noise level obtained was compared with the threshold value of the noise level with the exposure time per day. The noise threshold was the maximum time used to operate the machine per day. The average results of machine testing with load was 88.44 dB which indicated that the value of the noise level does not exceed the threshold determined according to Regulation of Minister of Manpower and Transmigration No PER.13/MEN/X/2011 [7]. It also indicated that the machine should be operated maximum 4 h per day in accordance with the recommended threshold. Noise measurement was carried out at the production site so that the sound was affected by other production activities. Measurements without load resulted higher results than those measured with load, because when the machine had materials inside, the load acted as buffer and minimize noise.

3.1.3 Vibration

Vibration measurements were carried out during operation. Vibration occurred during operation was caused by several components of the engine. Measurement of engine vibration was carried out by measuring engine and machine vibration with and without load. The results from vibration measurement on the machine and engine at no load were

Table 2. Service test

Parameter	Condition
Setting and Preparing	Easy
Starting the Machine	Easy
Ease of Operation	Yes
Operator Safety	Safe
Noise Level (dB)	88.4

6 and 6.48 Hz, respectively. When the dehulling chamber was loaded, the results were 5.56 and 5.96 Hz, respectively. It was expected the vibration on engine to be higher than machine because it acted as the driven motor. The recommended threshold for exposure per working day is 2 h and less than 4 h according to Regulation of Minister of Manpower and Transmigration No PER.13/MEN/X/2011 [7].

3.2 Service Test

To ensure the mass produce of the machine, service test should be conducted. This test was carried out by assessing the ease of operation when operator turning on, operating, and turning off the machine. Five respondents were chosen to operate the machine and the results are listed in Table 2.

3.3 Performance Test

3.3.1 Shallot Characteristics

The average diameter, length, and weight of tested shallot were 24.93 mm, 30 mm, and 8.18 g, respectively. The average diversity was of 82.13%. It had bulk density of 0.586 kg/cm^3.

3.3.2 Actual Capacity

Theoretical capacity of the machine was 20 kg/h. Average actual capacity from 5 replications measured by Eq. 1 was 14.52 kg/. It took around 3 min to finish each replication.

3.3.3 Performance Efficiency

It was carried out by dividing actual by theoretical capacity of machine using Eq. 2 and the result was 72%. A processing machine is efficient when this value around 85–90% [8]. Based on this result, further observation was done to determine the cause of this matter.

3.3.4 Dehulling Yield

There were 4 categories of post-processing: entirely peeled, partly peeled, unpeeled, and damaged. Research conducted by Setiawan [8] about dehulling soybean seed coat also resulting in similar categories. There are a few possibilities causing this to occur such as:

- Fresh shallots which size larger than the funnel would tend to be entirely peeled.
- High moisture level of shallot would increase the chance of getting damaged yield because they were easier to crush in this condition.
- Smaller size of shallots would likely unpeeled after the operation.

Dehulling yield was calculated by comparing the output mass with input using Eq. 3. The result was 36.29% after calculating the mass of unpeeled and damaged outputs. Figure 3 illustrates the damaged yield which was trapped under the disc.

3.3.5 Damage Percentage

This calculation was done by measuring a sample of 100 g of shallots (5 replications). The results are presented in Table 3.

Figure 4 displayed the example of damage results. This product should be processed immediately to prevent loss.

Fig. 3. Residues trapped under the disc.

Table 3. Results of testing parameters

Results	Sample	Whole	Partly Dehulled	Unhulled	Damaged
Total (g)	500	143	110	39	206
Average (g)	100	28.6	22	7.8	41.6
%	100	28.6	22	7.8	41.6

Fig. 4. Damage yield.

3.4 Recommendations

Based on the test results, the machine still need improvement. Therefore, there are several recommendations derived from the observations (Fig. 5). Several components should be added to increase its safety and quality. The recommendations are as follows:

3.4.1 The Inlet Lid

When the machine is working, the shallots might occasionally be thrown out of the hopper because the feeder is open. Therefore, a lid should be installed to prevent this from happening in future operation. Its function is to increase dehulling yield as the shallots will be kept inside the chamber during the operation.

3.4.2 The Outlet Strainer

After operation, shallots' residues were scattered on the floor. It made the cleaning more difficult. The addition of a strainer is recommended as it works to collect the residue from scattering around.

Damaged shallots might be a result from wide variation of shallots' size. In dehulling chamber, the shallots encounter one another and peeler teeth. Smaller shallots tend to crush during the operation and consequently will be the damaged results. Therefore, it is recommended that the size of shallots for dehulling process to be uniform. The size uniformity will produce stable machine operation and eventually will prevent high damage percentage.

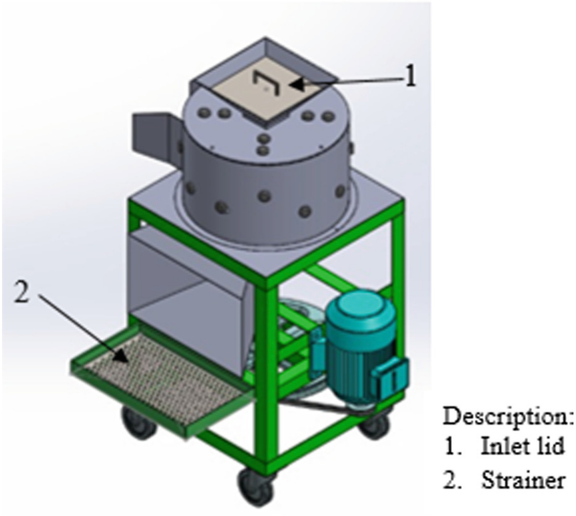

Fig. 5. Design recommendation (Courtesy: Personal documentation).

4 Conclusion

After completing the tests and observing several parameters, we can conclude that:

- Most of the testing parameters were already enough, suitable, and meet the standard;
- Machine efficiency was relatively low due to several shortcomings and constrains on the prototype;
- Several recommendations had been given to improve its performance.

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