A Design of A Cocoa Bean Sorting Machine

I Putu Gede Sopan Rahtika [a]
I Made Suarta [b]
I Komang Rusmariadi [c]
I Made Gede Ryan Prananta Hardianta [d]

Abstract

Cocoa plantations have employed thousands of farmer families throughout Indonesia, as well as have been the third largest export among the plantation sub-sector after rubber and oil palm. Therefore, the potential for the development of the cocoa industry as one of the drivers of growth and income distribution is very open. Cocoa bean production in Indonesia continues to increase, but the quality produced is still diverse such as less fermented, not dry enough, uniform bean size, high skin content, high acidity, and very diverse flavors. In this research, efforts to overcome these problems are accomplished by designing a cocoa bean sorting machine that can separate clean cocoa beans and root debris from cocoa beans so as it is expected to make it easier for cocoa farmers, workers, entrepreneurs and industries to more easily get a cocoa bean sorting machine so that the quality of cocoa beans improves and their selling price increases. Seeing these challenges, the authors took the initiative to create a new design a cocoa bean sorting machine with a simpler and more precise design.

Corresponding author:
I Putu Gede Sopan Rahtika,
Department of Mechanical Engineering, Bali State Polytechnic,
Badung, Bali, Indonesia.
Email address: sopan_rahtika@yahoo.com

[a] Department of Mechanical Engineering, Bali State Polytechnic, Badung, Bali, Indonesia
[b] Department of Mechanical Engineering, Bali State Polytechnic, Badung, Bali, Indonesia
[c] Department of Mechanical Engineering, Bali State Polytechnic, Badung, Bali, Indonesia
[d] Department of Mechanical Engineering, Bali State Polytechnic, Badung, Bali, Indonesia

1 Introduction

Indonesia is known as an agricultural country with most of the population working in agriculture. Indonesia is an agricultural country that has extensive agricultural land, and diverse and abundant natural resources. This is supported by the geographical location of Indonesia which is located on the equator. In general, agricultural commodities developed are annual crops and short-lived crops. Annual plants are plants that are generally more than one year old and harvested more than once such as rubber, coffee, coconut, cocoa, cloves, nutmeg and oil palm (Elna et al., 2012).

Cocoa plantations have employed about 900 thousand heads of farming families, mostly in eastern Indonesia, as well as providing the third largest foreign exchange contribution to the plantation sub-sector after rubber and oil palm (BPS, 2012). Goenadi et al. (2005), also mention that Indonesian cocoa has the advantage that it is not easy to melt so it is suitable when used for blending, so that in terms of quality, Indonesian cocoa is not inferior to world cocoa if it is fermented properly. Therefore, the potential for the development of the cocoa industry as one of the drivers of growth and income distribution is very open. Cocoa bean production in Indonesia continues to increase, but the quality produced is still varied such as less fermented, not dry enough, non-uniform bean size, high skin content, high acidity, and very diverse flavors (David et al., 2010).

Efforts to overcome this problem are by designing a cocoa bean sorting machine that can separate clean cocoa beans and root debris from cocoa beans to make it easier for cocoa farmers, workers, entrepreneurs and industry to get a cocoa bean sorting machine so that the quality of cocoa beans can improve and the selling price also increases (Saltini et al., 2013; Ardhana & Fleet, 2003; Jonfia-Essien et al., 2008).

Therefore, the author took the initiative to create a Cocoa Bean Sorting Machine Design with a simpler and more precise design, seeing the shortcomings that some of the observations above took. Based on the problems above, several problem formulations will be discussed in this study, as follows:

1. What is the design process for the cocoa bean sorting machine to be made?
2. Can the tool be made to speed up the sorting time of cocoa beans compared to the traditional method?

The results of this design are expected to make it easier for farmers and entrepreneurs in sorting these cocoa beans. The results of this design are expected to save time and energy in sorting cocoa beans.

2 Materials and Methods

In this paper, the author chooses the design of a cocoa bean sorting machine to improve the quality of cocoa beans. The author made the design of this cocoa bean sorting machine because the process of separating impurities and selecting cocoa beans was still done manually, so it took a very long time.

According to Ginting (2010), design is the planning and engineering calculation of materials and components, simulation tests, and capital creation of a tool. Planning is a creation to get a final result by taking a clear action or a creation of something that has a physical reality. Making a tool requires planning the components that will be used to meet the needs of the mechanism of the tool being made (Mott, 2004). Strength is an important consideration in the design, the design of construction must consider the following criteria: easy and simple; economical; aesthetics; and appropriate (Sonawan & Suratman, 2006). This can then increase the economic value as well. Technology is not only created but made precisely according to human needs (Sularso, 2002).

Based on the above problems, it is necessary to design a cocoa bean sorting machine with an electric motor drive, the working principle is to utilize the rotation of an electric motor which is channelled to the pulley and the flywheel shaft. At first from the rotation of the electric motor to the pulley and then connected to the V-belt to continue the rotation to the flywheel shaft, then from the rotation of the flywheel shaft, it becomes vibration to the sorting plate or perforated plate like a sifter and sieve separating the cocoa beans with cocoa bean waste. This machine concept is hoped that will make it easier for cocoa farmers and entrepreneurs in the process of sorting cocoa beans and improving the quality of cocoa beans before they are shipped (Oladapo et al., 2016; Sofu et al., 2016).
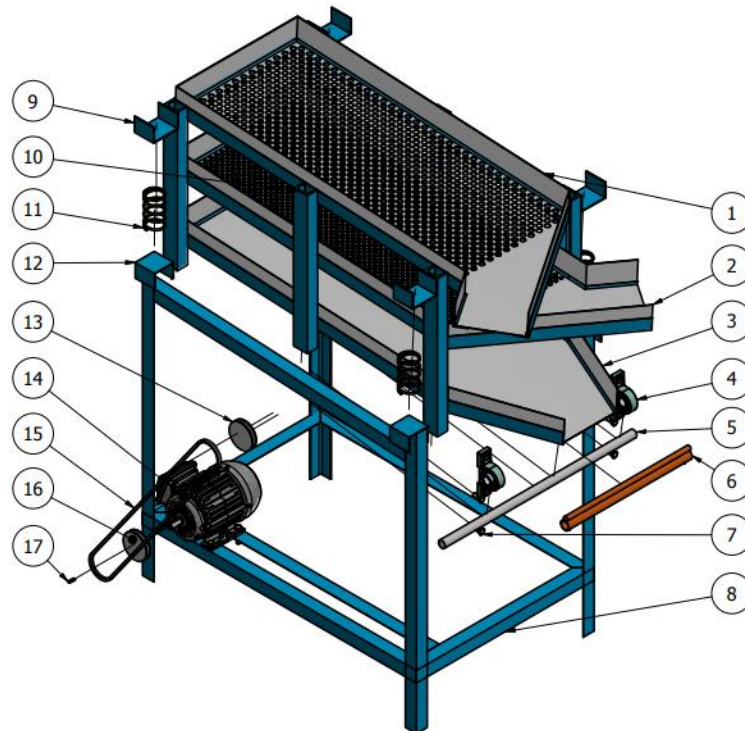
Machine components:

1.	Sieve 1	10.	Sieve holder
2.	Sieve 2	11.	Springs
3.	Sieve 3	12.	Spring stand plates
4.	Pillow Block	13.	Shaft pully
5.	Shaft	14.	Electric motor
6.	Imbalance Shaft	15.	V-Belt
7.	Screws	16.	Electric motor shaft
8.	Frame	17.	Stud
9.	Sieve stand		

Figure 1. The construction of the machine

Several materials were used as resources when making the Cocoa Bean Sorting Machine including some workshop equipment such as: welding machines, hand grinding machines, milling machines, lathes, compressors along with paint tools, sandpaper, ring locks, pliers, and others. The steps of the research procedure that were carried out by the author to get the results of the design were starting by conducting field surveys, such as in several agricultural industries in the Tabanan, Bali regions. Analysis of the data that had been obtained from the field survey was carried out to get the target type of machine needed to deal with the problem. After getting the type of machine needed, the authors made the design of the machine (Afriyie-Kraft et al., 2020). After the design of the machine was completed, calculations were carried out to get the appropriate calculation results desired by the designer. After getting the type of material and the volume of material needed, the author procures raw materials and then manufactures the components of the machine. After the design and construction of the cocoa bean sorting machine are completed, the next step is to test the cocoa bean sorter (Satriyo & Munawar, 2020; Hoffmann et al., 2020).

3 Results and Discussions

3.1 The design of the machine

This cocoa bean sorter is an easy and safe tool to use. The manufacture of a cocoa bean sorter aims to simplify the work process of businesses and industries in the cocoa bean sorting process so that later it can make businesses and industries easier and faster to sort dry cocoa beans and produce products in a fast time. The design model for this Cocoa Bean Sorting Machine can be seen in Figure 1.

The sorting process is achieved through three levels of the sieve. The top sieve selects the best quality cocoa beans, namely those that are relatively large. The sieve in the middle selects medium-quality cocoa beans, namely medium-sized ones. While the bottom one is not perforated for small-size cocoa mixed with dirt.

Sieving is achieved by using the rotating imbalance principle where the three-tiered sieve is connected to the machine frame by four springs. Under the sieve, a rotating imbalance is installed which will vibrate the sieve when rotated. Rotating imbalance is rotated by the electric motor through pulley and belt mechanisms. Based on the hole model on the surface, the sieve is divided into three types, namely: punched plate, wave wire, and grizzly. This design uses punched plate sieve.

Making holes on the sieve was done by using a hand drill with a 14 mm drill bit, measuring a 4cm edge line with a marker, then making a grid line with a size of 10x15mm and marking the holes to be drilled using a pin. When drilling, the plate was laid on wood and the drill bit was cleaned with a wire brush to keep it sharp. The process can be seen in Figure 2.
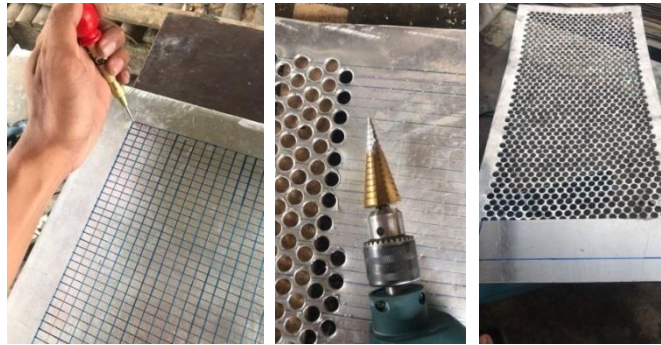

Figure 2. The process of making the sieves

Before cutting the iron, attention was paid to the working drawings so that there were no errors in the cutting. This iron cutting was done by using a hand-grinding iron cutting edge. At the plate-cutting step, hand grinding was used and started with measurements using tape, an angle ruler and a scraper. The welding of the iron was done using an electric welding machine with a 2mm welding electrode wire. The bolt holes were made using a 10mm drill bit hand drill (Brida et al., 2020; Viaene & Zilcha, 2002).

The next process is painting. Before painting, the tool was cleaned first using sandpaper so that it was free from rust. The painting process used a spray gun, and an air compressor with an epoxy base paint first, then continues with blue paint and clear gloss. The component assembly consisted of installing the pilo block to the sieve handle, installing the drive shaft, imbalance shaft, pulleys and all machine components (Suarbawa, 2022). The design results are the result of the work process from tool design, machine frame manufacture, sieve place, component assembly and finishing. The design results can be seen in Figure 3.

Figure 3. The photos of the machine

3.2 Testing

The last step in the design process is testing. Testing is an experiment on the design of the tool to ensure that the components of the cocoa bean size sorting machine function properly and can do the sorting. The stages of testing are as follows: preparing tools and materials, operating the equipment, weighing the materials, pouring the main ingredients, and recording the test results.

The tools used in testing were a scale and a stopwatch. While the main material used was cocoa beans that have been dried under the sun. The steps for operating the tool included: preparing 3 sack containers for the cocoa beans which would be sorted and placed at the end of the funnel sieve; connecting the plug to a 220-volt power source; and turning on the switch by pressing the on button.

After the machine has started, the dry cocoa beans were weighed using a scale according to the capacity of the sorting machine. The next step was to pour the dry cocoa beans onto a sieve according to the weight that has been weighed, then the beans would enter each of the prepared containers after being sorted. The time required for sorting was recorded for every test.

3.3 Test result and discussion

This section contains the results of testing the productivity design of the tool by manual sorting including a comparison of sorting times. The data obtained from testing the cocoa bean size sorting machine showed that the results of separating large and small cocoa beans can be separated perfectly. The average sorting process time was 1.74 minutes. Small dirt and contaminants could be separated from the cocoa beans.

Table 1
The test result of the manual sorting process

No	The amount of cocoa bean (kg)	Sorting time (minutes)	Bean Size (BS)			
			BS≥15mm	10mm ≤ BS < 15mm	BS <10mm	Total (kg)
1	5 kg	18,39	0,8 kg	3,8 kg	0,4 kg	5
2	5 kg	19,41	0.95 kg	3,87 kg	0,18 kg	5
3	5 kg	18,06	0.9 kg	3,75 kg	0,33 kg	4,98
Average		18,62	0,88 kg	3,80 kg	0,30 kg	4,99

The data was collected using the manual sorting method. The test was carried out by 2 people. In sorting 5 kg cocoa beans manually, the sorting times were 18.39, 19.41, and 18.06 minutes as shown in Table 1. Data collection was carried out using a cocoa bean sorter with an average time of 1.74 minutes, which means that the machine can be more effective in increasing the productivity of cocoa bean sorting. The detailed data are shown in Table 2.

The advantage of the cocoa bean sorting machine is that the cocoa bean size sorter can make the sorting process to be more efficient. This cocoa bean-size sorter has a capacity of 5 kg in one batch. This cocoa bean-size sorter can also separate dirt and other contaminants from the cocoa beans.

The designed machine has shown its ability to increase the efficiency of the sorting process, but in use, this machine requires some preventive maintenance such as checking the condition of the bearings and checking the condition of the belt. If the bearings are worn out and in operation they make noise, then they should be lubricated with grease. If the belt is loose, which can cause imperfect power transmission, then some adjustments should be done.

Table 2
Test result using sorting machine

No	The amount of cocoa bean (kg)	Sorting time (minutes)	Bean Size (BS)			
			BS≥15mm	10mm ≤ BS < 15mm	BS <10mm	Total (kg)
1	5 kg	2,19	0,9 kg	3,95 kg	0.14 kg	4,99
2	5 kg	1,56	0,5 kg	4,2 kg	0,27 kg	4,97
3	5 kg	1,48	0,6 kg	4,05 kg	0,33 kg	4,98
Average		1,74	0,66 kg	4,06 kg	0,24 kg	4,98

This machine also requires some corrective maintenance, such as replacing damaged bearings and replacing belts that cannot be adjusted due to excessive wear.

4 Conclusion

Based on the results of the Design of the Cocoa Bean Size Sorting Machine, the following conclusions can be drawn:
1) The Cocoa Bean Size Sorting Machine has dimensions of 1400 mm long x 750 mm wide x 1100 mm high using an electric motor drive with a power of HP and an electric motor rotation of 1400 rpm, the rotation of the electric motor is forwarded by a v-belt belt to the imbalance shaft that has been made on the main axis so that the rotation of the shaft on the sieve produces mechanical vibrations that can sort the size of the cocoa beans.
2) After applying appropriate technology, the work productivity of this cocoa bean size sorting machine results in a faster sorting time with an average time of 1.74 minutes in one sorting, so the results of sorting cocoa beans from this machine help ease the human effort to sort the cocoa beans.

Some suggestions that the author can convey regarding this cocoa bean-size sorting machine are as follows:
1) In carrying out the design of this cocoa bean-size sorting machine, there are still many shortcomings, therefore it is hoped that in the future this design can be analyzed and redesigned so that it can be developed further for more perfect results.
2) Before sorting the cocoa beans, it is expected to sort out large root waste so that the results of sorting cocoa beans are still maximized to extend the life of this cocoa bean size sorting machine, regular planned maintenance must be carried out and after using the bearings should always be cleaned and lubricated.

Rahtika, I. P. G. S., Suarta, I. M., Rusmariadi, I. K., & Hardianta, I. M. G. R. P. (2022). A design of a cocoa bean sorting machine. International Research Journal of Engineering, IT & Scientific Research, 9(1), 14–20. https://doi.org/10.21744/irjeis.v9n1.2254

References

Afriyie-Kraft, L., Zabel, A., & Damnyag, L. (2020). Adaptation strategies of Ghanaian cocoa farmers under a changing climate. *Forest Policy and Economics*, *113*, 102115. https://doi.org/10.1016/j.forpol.2020.102115

Ardhana, M. M., & Fleet, G. H. (2003). The microbial ecology of cocoa bean fermentations in Indonesia. *International journal of food microbiology*, *86*(1-2), 87-99. https://doi.org/10.1016/S0168-1605(03)00081-3

BPS, (2012). *Cocoa Production According to Regency/City in Bali Province*.

Brida, J. G., Carrera, E. J. S., & Segarra, V. (2020). Clustering and regime dynamics for economic growth and income inequality. *Structural Change and Economic Dynamics*, *52*, 99-108. https://doi.org/10.1016/j.strueco.2019.09.010

David, Jhon M., Ria Puspa Yusuf and Dewa Ayu Sri Yudari. (2013). The Effect of Fermented and Non-Fermented Cocoa Processing Methods on Product Quality and Product Selling Prices in Productive Business Units. *Journal of Department of Agrieculture Udayana University*, *7*(8), 1232-1237.

Elna, K., Mahmud, Z., Syakir, M., Munarso, J., & Ardhana, I. K. Rubiyo. 2010. *Budidaya dan Pasca Panen Kakao. Pusat Penelitian dan Pengembangan Perkebunan, Badan Penelitian dan Pengembangan, Kementan, Bogor*.

Ginting, R. (2010). Product Design. Jogyakarta: Graha Ilmu.

Goenadi, D. H., Dradjat, B., Erningpraja, L., & Hutabarat, B. (2005). Prospek dan arah pengembangan agribisnis kelapa sawit di Indonesia. *Badan Penelitian dan Pengembangan Pertanian, Departemen Pertanian Republik Indonesia*.

Hoffmann, M. P., Cock, J., Samson, M., Janetski, N., Janetski, K., Rötter, R. P., ... & Oberthür, T. (2020). Fertilizer management in smallholder cocoa farms of Indonesia under variable climate and market prices. *Agricultural Systems*, *178*, 102759. https://doi.org/10.1016/j.agsy.2019.102759

Jonfia-Essien, W. A., West, G., Alderson, P. G., & Tucker, G. (2008). Phenolic content and antioxidant capacity of hybrid variety cocoa beans. *Food chemistry*, *108*(3), 1155-1159. https://doi.org/10.1016/j.foodchem.2007.12.001

Mott, R. L. (2004). Machine Elements in Mechanical Design. Yogyakarta: ANDI.

Oladapo, B. I., Balogun, V. A., Adeoye, A. O. M., Ijagbemi, C. O., Oluwole, A. S., Daniyan, I. A., ... & Simeon, A. P. (2016). Model design and simulation of automatic sorting machine using proximity sensor. *Engineering science and technology, an international journal*, *19*(3), 1452-1456. https://doi.org/10.1016/j.jestch.2016.04.007

Saltini, R., Akkerman, R., & Frosch, S. (2013). Optimizing chocolate production through traceability: A review of the influence of farming practices on cocoa bean quality. *Food control*, *29*(1), 167-187. https://doi.org/10.1016/j.foodcont.2012.05.054

Satriyo, P., & Munawar, A. A. (2020). Data analysis on near infrared spectroscopy as a part of technology adoption for cocoa farmer in Aceh Province, Indonesia. *Data in brief*, *29*, 105251. https://doi.org/10.1016/j.dib.2020.105251

Sofu, M. M., Er, O., Kayacan, M. C., & Cetişli, B. (2016). Design of an automatic apple sorting system using machine vision. *Computers and Electronics in Agriculture*, *127*, 395-405. https://doi.org/10.1016/j.compag.2016.06.030

Sonawan, H., & Suratman, R. (2006). Pengantar Untuk Memahami Proses Pengelasan Logam. *Bandung: CV Alfabeta*.

Suarbawa, I. K. G. J. (2022). The rice sort machine design to improve rice granules quality. *International Research Journal of Engineering, IT & Scientific Research*, *8*(1), 17–26. https://doi.org/10.21744/irjeis.v8n1.2045

Sularso, K. S. (2002). Dasar Perencanaan dan Pemilihan Mesin, cetakan ke-10. *Jakarta: PT. Pradnya Paramita*.

Viaene, J. M., & Zilcha, I. (2002). Capital markets integration, growth and income distribution. *European Economic Review*, *46*(2), 301-327. https://doi.org/10.1016/S0014-2921(01)00097-6