Re-Design the Coffee Peeling Machine by Combining the Pulper and Huller Functions to Improve the Welfare of Coffee Farmers in Bondowoso Regency, Indonesia

Danang Yudistiro[1], Mahros Darsin[1,a)], Dwi Djumhariyanto[1], Robertoes Koekoeh Koentjoro Wibowo[1], Hari Arbiantara Basuki[1], Triana Lindriati[2], Mochamad Rifki Syahriza[1], Rachman Sugianto[1], Muhammad Ilham Al Ghiffari Syarif[1], and Ahmad Muhajir 'Azizi[1]

Author Affiliations
[1]*Mechanical Engineering Department, University of Jember*
[2]*Agricultural Technology Department, University of Jember*

Author Emails
[a)]*Corresponding author: mahros.teknik@unej.ac.id*

Abstract. Indonesia, renowned for its vast natural resources and strategic position in global trade, draws an influx of international traders. This dynamic cultural exchange has historically enriched Indonesia's heritage. Coffee, a cornerstone of Indonesia's export economy beyond oil and gas, possesses untapped domestic market potential. Panduman Village, nestled within Jelbuk District, Jember Regency, boasts a remarkable natural environment for coffee cultivation, featuring cool temperatures, fertile soil, and elevated terrain. Despite these favorable conditions, most of the village's population grapples with poverty. This study addresses the simultaneous pulping and hulling procedures to reduce production costs, aiming to improve performance and ultimately boost prosperity through innovative coffee peeling equipment. Farmers have flexibility in operating the machine, individually or in groups, thanks to its wheels, which enhance its movement. Structural calculations guarantee durability and effectiveness, and Autodesk Inventor software utilizes careful design. The resultant coffee peeling machine has a 320 kg/hour capacity and a gasoline motor with ten horsepower, among other fantastic performance parameters. This report provides a thorough analysis of the potential and difficulties within the setting of Panduman Village, highlighting the critical role that technological innovation has had in reviving Indonesia's rural economy and coffee industry.

KEYWORDS: COFFEE PEELING MACHINE, COFFEE FARMER, DESIGN MECHANICAL, ELECTRIC MOTOR.

INTRODUCTION

Indonesia is a resource-rich country with a crucial placement on the world trade map. All Indonesian advantages attract a large number of international traders to visit Indonesia. Following oil, coffee is a strategically important commodity with a massive global market [1]. The process of absorbing foreign culture and native culture went without incident. This practice first enhanced Indonesia's cultural assets, but as time passes, indigenous culture is gradually being replaced, as shown in Indonesian coffee culture [2].

Apart from oil and gas, the coffee plant is one of Indonesia's top export commodities, contributing to the country's foreign exchange. On the other side, while there is a lot of potential for coffee exports, there are also a lot of potential domestic coffee market prospects that can help coffee growers. Conditions and chances for Indonesian coffee growers to be innovative so that Indonesian coffee production grows and becomes more well-known. Efforts to enhance coffee output would benefit the welfare of coffee producers and the country [3]. Indonesia is the world's fourth biggest coffee producer [4]. Indonesia's potential as a coffee producer should be able to boost coffee producers' income.

Coffee cultivation in Indonesia began in 1699 during the Dutch East Indies Company (VOC) period. Robusta Coffee accounts for around one-third of all coffee farmed, with Arabica Coffee accounting for the balance [5]. The old Besuki residency (Situbondo, Bondowoso, Jember, and Banyuwangi) was the exclusive place for coffee production from 1883 to 1922, as ordered by the Belgian authorities [6]. These places, particularly the Jelbuk sub-district and Jember district, became hubs of local farmer's coffee production.

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Panduman Village is located in Jelbuk District, Jember Regency. The village has an area of 862,728 km2, a population of 6860 people, and a population density of 0.5 persons per km2. This settlement extends from the Jember Bondowoso highway to the Mount Argopuro region. Sumbercandik is one of Panduman Village's hamlets. This village's contours are ridges and mountains with elevations exceeding 1000 meters. Panduman Waterfall is located at the end of this village. This village is ideal for cultivating coffee because of its cool temps, fertile soil, and enough height.

The majority of the populace cultivates coffee. Green coffee and, to a lesser extent, bulk instant coffee are the main commodities traded between producing and consuming countries [7]. In addition to its property, it works with Perhutani to plant between government-owned plants. This village has a high diversity of bryophytes [8]. With this kind of potential, Sumbercandik's population should be wealthy, but the fact is that the vast majority of them are impoverished families.

Many inhabitants benefit from the district/central government's Self-Help Housing Stimulant Assistance (BSPS) program [9]. Another indicator of their poor economy is the high rate of stunting in Panduman village [10], which was 51.3% in 2018 [11]. If we examine the chain of poverty, we can see that it begins with farmers' vulnerability in post-harvest coffee (their staple commodity). Farmers often sell wet coffee for a low selling price of roughly $US 32 per quintal, which has not changed in two years. If the peel is dry, the price might triple. Even if there is, the price is relatively high, lowering their profit margin.

Coffee cherries are processed industrially to separate the coffee beans from the shell and mucilaginous material [12]. Coffee farmers use a coffee skin peeling machine in order to obtain green beans. Wet skin peeling machines, also known as pulper machines, are available in a variety of sizes, with modest capacities of 25 kg/hour [13], medium capacities of 120 kg/hour [14], and large capacities as utilized in industry. Indeed, machines like these have been found in old literature [15], and they continue to improve and are typically included in student theses [16-20]. In essence, devices like these have been demonstrated and may be utilized directly in community service programs without additional study. Farmers usually peel coffee beans using two different machines. Peeling using two other devices increases production costs. Therefore, researchers had the idea to design a machine with two functions. The first function is to peel the coffee beans' outer skin (wet skin). The following function is to peel the coffee bean husk.

RESEARCH METHODS

The research approaches employed in this study are literature study and experimental method. Using this approach may aid in verifying the design concept that has been established, as well as determining whether the initial ideas and designs perform as predicted. This study was carried out at the University of Jember's manufacturing laboratory. The research procedures begin with a literature review, followed by data collection collected through observation, design of the coffee peeling machine, manufacturing process, performance testing or application of the coffee peeling machine, and conclusion. Researchers are designing a coffee peeling machine with Autodesk Inventor software.

The initial step in constructing this pulper and huller machine is to comprehend the process of removing the skin from coffee beans to obtain green beans. Peeling the wet skin is the first step in peeling coffee beans. Wet skin peeling is also known as pulping. Following the removal of the moist skin, the coffee beans are sun-dried. The goal of this drying is to make it simpler to remove the epidermis of the coffee beans during the following procedure. Hulling is the next step after the coffee beans have been sun-dried. Coffee beans that have been peeled are called green beans. Figure 1 is a schematic of the coffee bean peeling process.

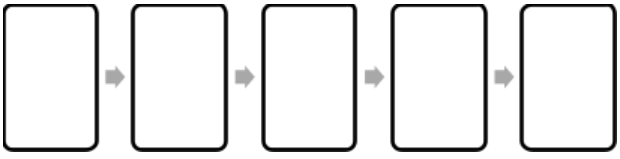

FIGURE 1. Schematic diagram of the coffee bean peeling process.

The design process is divided into three stages: idea design, embodiment design, and detailed design. Inspections are required at each stage to ensure that the process runs successfully. Work preparation is needed before the manufacturing process because steps must be completed to make it, such as occupational health and safety,

machining parameters, and welding parameters, which can be used as a direction in the manufacturing process to make it effective. Based on the data gathered and the extent to which the machine effectively performs its functions, performance tests are performed to determine whether the coffee peeling machine is operating.

Results and Discussion

Work preparation stages are used to construct this coffee peeling machine. The coffee peeling machine originally featured a ten-horsepower gasoline motor generator.

The benefit of this machine is that it can do two operations simultaneously. Investing in two devices with a single function (pulper alone or huller only) will cut production costs. Several potential process flows are simulated to create a machine that meets the farmers' demands. Developers don't make mechanical machines because several geographical advantages can be achieved. The position of Jelbuk village, which receives sunlight all year, is one of the geographical benefits. This benefit removes the need for drying devices in the process flow. Sunlight is still used in drying. As a result, the pulper and huller are combined into a single machine.

Another feature of this machine is its wheels, which aid in machine mobility. Farmers want machinery that can be relocated to various locations based on the coffee bean peeling, harvesting, and drying site. Farmers may move this equipment according to their demands thanks to the wheels on it. As they are group of famers, they may operate this coffee peeler in their own home or use it in turns. This pulper and huller machine is also built with frame structural calculations. The frame has a critical duty since it must bear both static loads, such as the weight of machine components, and dynamic stresses when the machine is in operation. The effect of static and dynamic loads on the frame is calculated using software.

This study resulted in a coffee peeling machine with dimensions of 1,300 mm length; 1,150 mm width; and 1,300 mm height. Design a coffee peeling machine with Autodesk Inventor software, as seen in the following Figure 2a. Work preparation (WP) stages are used to construct this coffee peeling machine. The coffee peeling machine features a 10-horsepower gasoline motor. The coffee peeling machine's performance test went smoothly. The coffee huller can hull 8 kg of 9 kg cherry coffee in 1.5 minutes or 320 Kg/hrs.

The results of the pulper and huller machine design can be seen in Figure 2a. Figure 2b depicts the exploded components therein and their functions.

Coffee producers must still complete the drying process before hulling the coffee beans. Figure 3 depicts the technique used by farmers on this equipment. The steps accommodate design consideration for steps in Figure 1. The soaking of coffee beans usually takes one night before it will be hulled the following day. The hulling process is to rend the coffee bean into two by crush them. The main purpose is to drain sap, not to peel off the outer skin. Then it was sun dried (step 4) for about three days, depending on the season and sun light intensity. It speed up the drying process to half in compare to drying of the full coffee (uncrussed coffee skin).

Observation of the peeling quality was carried out after husk hulling (step 6) by comparing the fully peeled-off coffee to the result of dried before hulling. It about 88% husk was removed by once hulling. The results can be improved by adjusting the gap between knife and the drum. Later, a 100% husk free can be achieved.

The yield or coffee extraction of the dual function coffee peeler calculated by comparing the 100% peeled coffee to that of wet one as received. The as received coffee was 69 kg and the clean-peeled coffee is 15 kg. Therefore, the yield is 22%. This still falls within the range of coffee yields in a number of global locations.

The real capacity of the machine was measured by weighting the clean-peeled off the coffee along the time required to process (exclude the drying process). It found that capacity of the machine is 320 kg/hour.

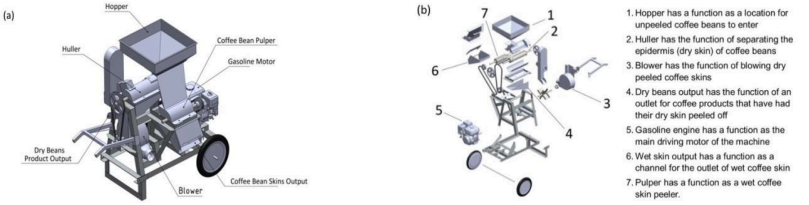

FIGURE 2. (a) Image of coffee pulper and huller after assembly, (b) Image of part locations for the coffee pulper and huller and their function.

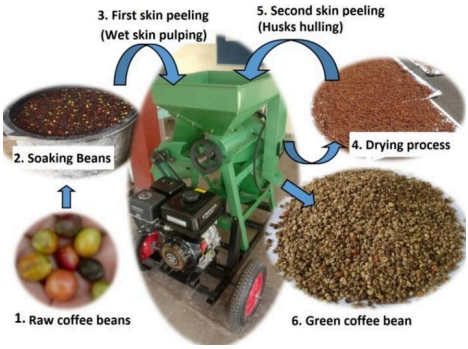

FIGURE 3. Coffee process flow used by farmers on the machine.

CONCLUSION

The coffee peeling machine was created with Autodesk Inventor software. According to the findings of the performance tests, the coffee peeling machine can function well with an efficiency of 100%, yield of 22%, and a capacity of 320 kg/hour. This coffee-peeling machine is 1,300 mm long, 1,150 mm wide, and 1,300 mm high.

REFERENCES

1. Gurram, R.N., Al-Shannag, M., Knapp, S., Das, T.K., Singsaas, E.L., & Alkasrawi, M. 2015 Technical possibilities of bioethanol production from coffee pulp: a renewable feedstock. Clean Technologies and Environmental Policy, 18, p.269-278.
2. Gumulya D., Helmi, and Ivana S. 2017 Kajian Budaya Minum Kopi Indonesia. Jurnal Dimensi Seni Rupa dan Desain Vol 13 Ed 2 (Universitas Trisakti)
3. Martauli D 2018 Analysis Of Coffee Production In Indonesia JASc (Journal of Agribusiness Sciences,Vol 1 Ed 2 (Fakultas Pertanian Universitas Muhammadiyah Sumatera Utara)
4. USDA 2023 Coffee: World Markets and Trade (United States Department of Agriculture Foreign Agricultural Service)
5. Wiedhayati D 2014 Indonesiaon Coffee (Directorate General For National Export Development. Ministry of Trade. Republic of Indonesia)
6. Chanakya, H., & Alwis, A.D. 2004. Environmental Issues and Management in Primary Coffee Processing. Process Safety and Environmental Protection, Vol 82 p.291
7. Izzah L. et al. 2023. Historical Review of Smallholder Coffee Farmers Population in Kayumas Village, Situbondo Regency Journal of Historical Studies. Master Program of History Vol 7 Ed 1 (Faculty of Humanities, Diponegoro University)
8. Purbasari Y A and Akhmadi A N 2019 Keanekaragaman Bryophyta Di Dusun Sumbercandik Kabupaten Jember Bioma: Jurnal Biologi dan Pembelajaran Biologi. Kabupaten Jember. BIOMA Vol 4 Ed 1 p.90
9. Mu'minin, Z. 2018 Efektivitas Pelaksanaan Program Bantuan Stimulan Perumahan Swadaya(BSPS) Di Desa Panduman Kecamatan Jelbuk Kabupaten Jember (Universitas Jember)
10. Ariati, L I P 2019 Faktor-Faktor Resiko Penyebab Terjadinya Stunting Pada Balita Usia 23-59 Bulan OKSITOSIN : Jurnal Ilmiah Kebidanan Vol 6 Ed 1 p. 28
11. Maulidah, W B, Rohmawati N, and Sulistiyani S. 2019 Faktor yang berhubungan dengan kejadian stunting pada balita di Desa Panduman Kecamatan Jelbuk Kabupaten Jember Ilmu Gizi Indonesia, Vol 2 p.89
12. Corro, G., Paniagua, L.L., Pal, U., Bañuelos, F., & Rosas, M.I. 2013 Generation of biogas from coffee-pulp and cow-dung co-digestion: Infrared studies of postcombustion emissions. Energy Conversion and Management, 74 p.471.
13. Ilmi, B. and Widiantoro H. 2021 Rancang Ulang Mesin Pengupas dan Pengering Biji Kopi Semi Otomatis Kapasitas 25 kg/jam Prosiding The 12th Industrial Research Workshop and National Seminar p.223

14. Nasution, A Y and Effendi R 2018 Perancangan Dan Pembuatan Alat Pengupas Kulit Kopi Basah Dengan Kapasitas 120 Kg/Jam Turbo : Jurnal Program Studi Teknik Mesin Vol 7 Ed 2 p. 140
15. Fukunaga E T 1957 A new mechanical coffee demucilaging machine Univ. of Hawaii, CTAHR, Hawaii Agricultural Experiment Station Bulletin p.115
16. Fikri A A, Arifin S, M. F. F. 2022 Perancangan Mesin Pengupas Kulit Kopi Basah Ensiklopedia Research and Community Service Review Vol 1Ed 2 p. 59
17. Fahmi, M., Amrila and Arief R. K. 2022 Analisis Kekuatan Rangka Mesin Pengupas Kulit Kopi Menggunakan Software Solidworks dengan Metode Elemen Hingga Ensiklopedia Research and Community Service Review Vol 1Ed 3 P.129
18. Hamni A., Harun, S., and Jaya, D. P. 2013 Rancang Bangun dan Unjuk Kerja Mesin Pengupas Kulit Biji Kopi Basah Sistem Rol Karet yang Produktif dan Ergonomik Journal Mechanical Vol 4 Ed 2 p.45
19. Kelik V., Hengky, H., and Kurniawan, D. 2016 Perancangan Mesin Pengupas Dan Pemisah Kulit Buah Kopi Kering Jurnal Teknik Mesin Vol 5 Ed 2 p.28
20. Primawati and Rahim B 2020 Meningkatkan Efisiensi Kinerja Petani Melalui Penerapan Teknologi Tepa Guna pada Alat Pengupas Kulit Kopi Vomek Vol 2 Ed 4 p.67.