The Design of Smart Coffee Drying Technology Innovation Based on Ultrasonic Chill to Achieve Inclusive and Sustainable Agro-Industry in the New Normal

Tiffany Ovilia Dwi Lestari [1*], Thabeb Tholib Baladraf [2], Lukman Ibnu Haqiqi [3]

[1]Department of Computer Science, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Semarang, Indonesia
[2]Department of Agricultural Industrial Technology, Faculty of Agricultural Technology, Universitas Negeri Jember, Jember, Indonesia
[3]Department of Pancasila and Civic Education, Faculty of Social Sciences, Universitas Negeri Semarang, Semarang, Indonesia
*Corresponding author: tiffanyovilia@students.unnes.ac.id

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ABSTRACT

Drying coffee beans manually using sunlight has disadvantages. When the weather suddenly changes, it will be difficult for coffee farmers to move coffee beans to a place that is protected from the rain. If allowed to rain, the slightly dry coffee beans will become wet and damp again. Humid conditions of coffee beans will reduce their quality. Coffee beans that return to wetness also cause longer drying time, disrupting the supply chain. This study aimed to determine the potential of COSMON as a smart drying technology based on ultrasonic chill. This research uses literature study, which is continued with tools, programs, mechanics; tools testing; and results analysis. This study results that the mass decrease is proportional to the rapid decline in air content. The fastest reduction rate was obtained from vacuum chill drying with the frequency of 45000 Hz because the higher the frequency value, the higher the ultrasonic frequency waves absorbed by the specimen. The more ultrasonic wave vibrations absorbed by the specimen, the faster the drying rate will occur. As a result, the coffee's average dry weight is 84% of its initial weight.

1 Introduction

The plantation is one of the sub-sectors experiencing the most consistent growth, both in area and production. The plantation provides a GDP of 4.98% to the economic structure (Badan Pusat Statistik, 2020). Coffee plays a role as a source of foreign exchange earnings, a provider of employment, and a source of income for coffee planters and other economic actors involved in cultivation, processing, and marketing (Widyotomo, 2013). Total coffee production in 2018 was 727.9 tons and only slightly increased to 729 tons in 2019 (Asosiasi Eksportir dan Industri Kopi Indonesia, 2020). This is because most processing processes in the coffee agro-industry are currently manual, one of which is the drying process. The manual drying process causes the productivity and quality of coffee to be not optimal. This is exacerbated by the new normal conditions that are being faced by Indonesia as a preventive effort to tackle the COVID-19 pandemic. This requires all activities to be completely limited so that it is necessary to use technology, one of which is in the agro-industry sector.

Drying coffee beans is usually done by drying in an open field (Soekarta & Irman, 2016). Manual drying using sunlight has disadvantages, including when the weather changes. For example, a sudden rain occurs, it will be difficult for coffee farmers to move coffee beans to a place that is protected from the rain. This is made worse if there is no one to guard it. As a result, the slightly dry coffee beans become wet again and damp. Moist coffee beans will reduce the coffee beans quality because they trigger the growth of other microorganisms that will interfere with the fermentation process. Coffee beans that return to wetness also cause longer drying times, disrupting the supply chain (Afriani, Suroso, & Irawan, 2019). This is interesting to find a solution by designing a Coffee Smart Dryer Machine Mobile Controller (COSMON). This tool is a smart coffee drying based on an ultrasonic chill that is integrated with a smartphone that can be an effective and efficient drying technology that is effective and efficient because it can increase productivity and maintain the coffee beans quality.

2 Methods

2.1 Problem Identification and Study Literature

I am finding and preparing various reference sources in journals, proceedings, scientific articles, and discussion in this final project. The discussion can include how the system works, tools and materials to be used, the analysis process, and conclusions.

2.2 Design Making

At this stage, the design was created as an initial description of the researcher regarding how the tool's form will be assembled in its actual form. The device used in this research was a laptop, while the material used in this research was Corel Draw X4.

2.3 Program Development

The programming stage is the initial stage for performing a specific function on a computer. A program usually has a particular form of execution model to be executed directly by the computer. The tools and materials used to manufacture this tool are a laptop, Arduino, and a USB cable. The material used in this research is Arduino sketch software.

2.4 Mechanical Tool Design

At the stage mechanical tool design of a coffee drying device based on an ultrasonic chill, researchers must understand the characteristics of the components used so that in this process, we can design a tool that suits what we want. The tools used for the manufacture of this tool are saws, grinders, drills, Arduino, laptops, plywood, angles, hollow irons, v-belts, and solders. The materials used in this tool's manufacture are ultrasonic sensors, temperature sensors, camera sensors, piezoelectric sensors, Wi-Fi sensors, and servo motors.

2.5 Tool Testing

In the testing tool, the tool begins with testing the electronic components to ensure that they function properly. Furthermore, testing the calibration in the program and ends with testing the whole tool.

2.6 Results Analysis & Reporting

After testing, the results of the analysis can be obtained from the tool, and then the results of the testing and analysis can be written in the form of a report. The analysis carried out in this research is the analysis of mass and moisture content.

3 Results and Discussion

3.1 System Overview Results

The design of an ultrasonic chill based coffee drying device is used for drying coffee at low temperatures. In this tool, there are several components, namely the ultrasonic sensor. The ultrasonic sensor works based on the principle of sound wave reflection and is used to detect a particular object in front of it—a Servo motor, which is used as a driving force. This tool's first process is that coffee is put into the conveyor through the entrance and towards the melt ultrasonic chill location. When arriving at the melt ultrasonic chill location, the ultrasonic chill sensor will emit ultrasonically and detect coffee passing through the melt ultrasonic chill location. The flowchart of how the tool works is presented in Figure 1.

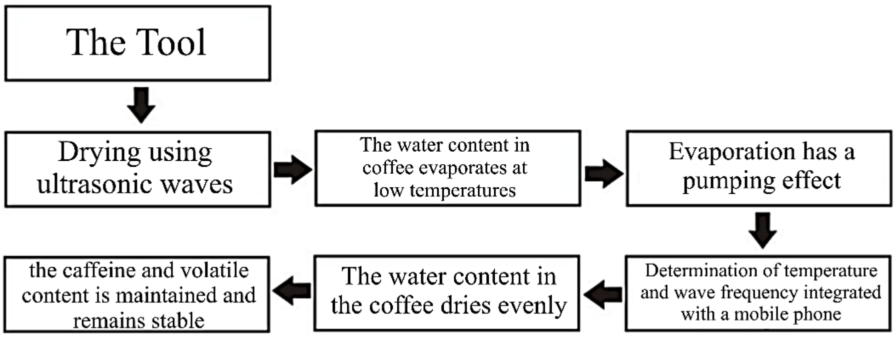


Figure 1. The tool works flowchart

3.2 Block Diagram of the System

The block diagram illustrates the system's overall flow in the design of an ultrasonic chill-based coffee drying device. The tool uses ultrasonic sensors, temperature sensors, camera sensors, piezoelectric sensors, Wi-Fi sensors, and servo motors. The block diagram is presented in Figure 2.

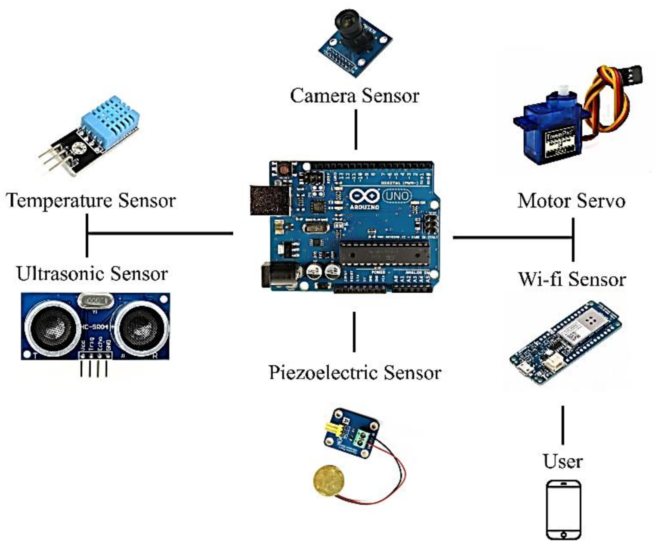
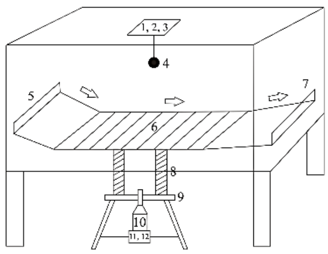


Figure 2. Block diagram system

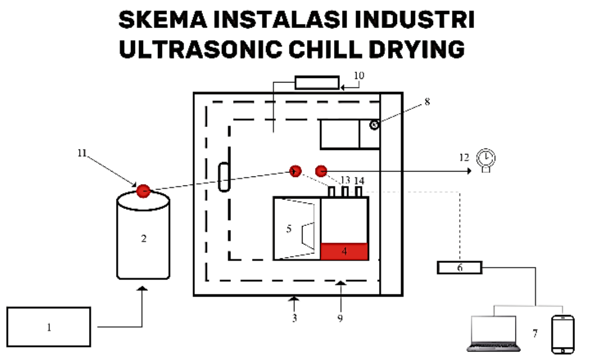
3.3 Mechanical Design

At this stage, the researchers designed the ultrasonic chill-based coffee drying system. The first created framework is designed in the Corel Draw X4 program. Positioning the framework components must be appropriate and precise. The researchers prepare two designs, namely laboratory scale, and industrial scale. The mechanical design of the ultrasonic chill-based coffee drying system is presented in Figure 3 and Figure 4.



1. Arduino Uno	7. Pintu Keluar Kopi
2. Sensor Suhu	8. Ingot Mold
3. Sensor Wi-fi	9. Copper Plate
4. Sensor Camera	10. Titanium Sonotrode
5. Pintu Masuk Kopi	11. Sensor Piezoelectric
6. Lokasi *Melt Ultrasonic Chill*	12. Sensor Ultrasonic

Figure 3. Mechanical design laboratory scale



1. Vacuum Pump	7. Komputer dan Smart Phone	13. Sensor Suhu, Camera dan Wi-Fi
2. Vacuum Tank	8. Thermostat	14. Arduino Uno
3. Chiller	9. Vacuum Chamber	
4. Spesimen	10. Thermokopel	
5. Ultrasonic	11. Katup	
6. Data Logger	12. Pressure Gauge	

Figure 4. Mechanical design industry scale

Ultrasonic chill-based coffee drying tool integrated with a smartphone as a coffee dryer officer can control and control temperature, frequency, and conditions during the drying process via a mobile phone. The application display is depicted in Figure 5.

Figure 5. Application display

3.4 Research Results

3.4.1 Tools Testing

The current study aims to design a coffee drying system based on ultrasonic chill using an ultrasonic sensor, a piezoelectric sensor, a temperature sensor, an Arduino, a motor driver, and others integrated into a smartphone. This system will make it easier for humans to dry coffee beans. In this system, the coffee beans will be dried using low temperatures and in a vacuum place quickly.

3.4.2 Mass and Moisture Analysis

Mass analysis was performed to determine the mass lost due to the drying process. During the drying process, the decrease in mass indicates the loss of water mass in the test specimen, in this case, coffee. The higher the frequency value, the more waves are absorbed (Kevin, 1983). The reduced mass in the specimen is directly proportional to the specimen's water content. The specimen's reduced mass indicates the loss of water content in the specimen so that the weight of the specimen is reduced. With the average dry weight of the coffee obtained is 84%, then the water content in the specimen contains every hour by reducing the mass of the specimen immediately after drying with the dry weight of the specimen. They then divided the current specimen weight. The mass reduction graph is presented in Figure 6.

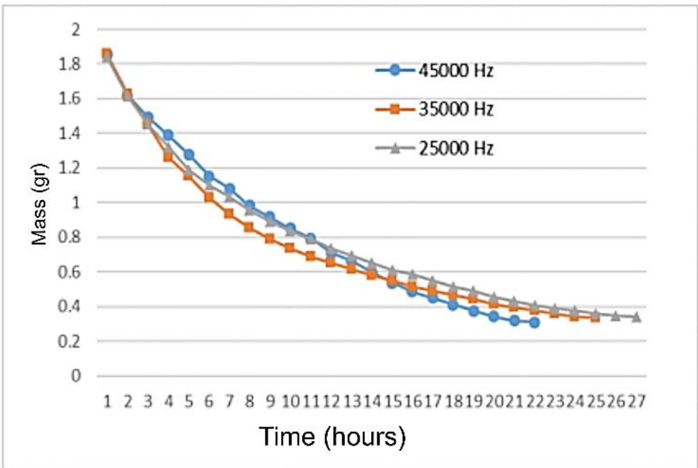


Figure 6. Mass reduction graphic

From Figure 6, the largest decrease in mass occurs in specimens with an emission frequency of 45000 Hz. The smallest final mass is on drying with 45000 Hz, followed by 35000 Hz, then 25000 Hz. This is due to the higher the frequency value. The higher the vibration absorption, the more vibration energy is absorbed by the specimen, which causes adhesion bonds between water and coffee to weaken. This vibrational energy also weakens the cohesion bonds between water. The decrease in mass is proportional to the rate at which water content decreases. The fastest reduction rate is the reduction rate from vacuum chill drying with 45000 Hz, which is the fastest because the higher the frequency value, the higher the specimen's ultrasonic frequency waves. The more ultrasonic wave vibrations are absorbed by the specimen, the quicker the drying rate that happened. It can be understood that the higher the ultrasonic emission frequency, the more the coffee drying rate will be. The drying rate graph is presented in Figure 7.

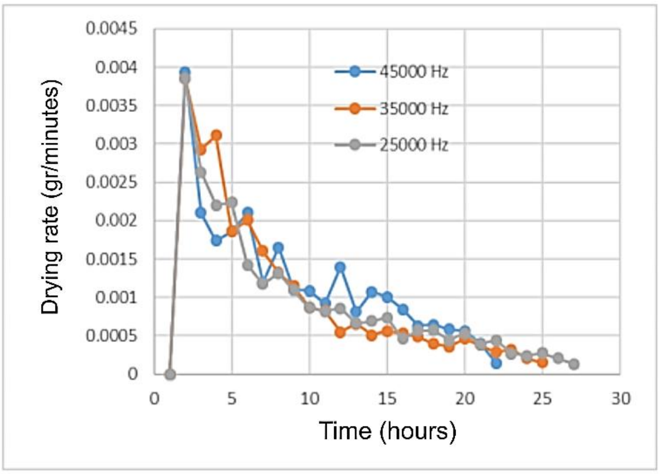


Figure 7. Drying rate

4 Conclusion

Based on research, it was found that COSMON with a beam frequency of 45000 Hz can help coffee farmers to optimize the amount of production and quality of dry coffee beans. The loss of mass in the specimen is directly proportional to the specimen's moisture content because the specimen's reduced mass indicates a loss of water content in the specimen so that the weight of the specimen is reduced. As a result, the coffee's average dry weight is 84% of its initial weight.

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