Automatic shoe drying oven integrated with Raspberry Pi Cloud system for advanced footwear industry

Yunus[1*], *Ade Priyo* Widhikdho[2], *Ali Hasbi* Ramadhani[1], and *Bima* Anshari[1]

[1]Departement Mechanical Engineering, State University of Surabaya, Surabaya, Indonesia
[2]School of Mechanical and Manufacturing Engineering, The University of New South Wales, Sydney NSW, Australia

Abstract. The drying oven functions to reduce the moisture content of raw materials until it reaches a certain moisture content to slow the rate of product damage due to biological and chemical activity. This research aims to design an automatic shoe-drying oven equipped with an LCD screen, exhaust fan, 8-level shelf, and electric heating temperature controller to provide maximum and even heating of leather shoes when gluing and drying leather shoes. Raspberry PI aims to combine and collect production process data in cloud storage in the form of a database, which will then be sent and displayed directly to the operator. The research methodology includes design, manufacturing, assembly, operational testing, performance testing, and evaluation stages. It can be concluded that the research results and progress reports include: (1) The design of the work system and mechanical system for the shoe drying oven can work well. (2) The Raspberry PI Cloud system can collect and display actual drying time data, (3) glue drying temperature of 60°C with a drying time of ±5 minutes, (4) skin heating temperature (texture creation) of 50°C-55°C requires warm-up time ±40 minutes, (5) This machine requires 850 watts of power.

1 Introduction

Technological developments in the era of the revolution industrial 4.0 are now supporting competitive competition with the intervention of an intelligent and automated system in the industry [1]. The widespread movement of the fourth-generation industrial revolution in recent years has had an impact on changes in work patterns in various sectors, especially in the business sector. Micro, small, and medium enterprises (MSMEs) have an important role, this sector has excellent potential in supporting the country's economy [2]. It is a reality for medium-sized business owners to meet market demand and economic needs.

UD. Candi Emas Jaya is one of the MSMEs in Sidoarjo which is engaged in shoe craftsmen. UD Candi Emas Jaya already has many customers. Every day UD. Candi Emas

* Corresponding author: yunus@unesa.ac.id

Jaya is able to produce 150 pairs of shoes. However, the shoes made by UD. Candi Emas Jaya has a quality and quantity that can be said to be lacking. Based on direct observations and interviews with the owner, the factors that affect the low quality and quantity, namely still using traditional tools, especially in the shoe drying process so that the process of heating and drying shoe glue becomes very long.

Drying is a method that can extend the shelf life of a wide variety of shoe materials [3]. UD. Candi Emas Jaya in the drying process using sunlight and stoves liquefied petroleum gas (LPG). Drying using manual tools usually takes a long time because the drying process using direct sunlight takes one or two days. [4]. Sunlight can also damage the material, fade the color, and loosen the adhesive on the sole [5]. The drying process using an LPG stove can also make the drying process uneven with a capacity of one pair of shoes per process [6]. The results of drying with LPG stoves have uneven drying quality, and the adhesion strength of the sole and upper is less strong. The drying process can be seen in Figure 1.

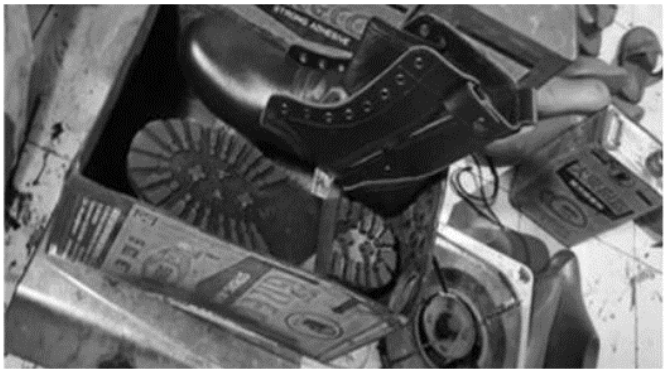

Fig. 1. Glue drying process with LPG burner

The slow production process makes UD. Candi Emas Jaya cannot fulfill the demand and the low quality of shoe drying makes it unable to penetrate the export market [7]. Support is needed to develop UD. Candi Emas Jaya because it has the potential to absorb a lot of labor and improve quality so that it has competitiveness in the export market. One of the supports that can be provided is the application of appropriate technology [8]. Appropriate technology such as high-capacity production machinery is urgently needed to improve competitiveness and efficiency, resulting in sustainable economic growth for business owners [9].

The appropriate technology that will be implemented is a shoe-drying machine. Compared to conventional drying and drying using an automatic shoe drying oven integrated with a Raspberry Pi cloud drying system. it has advantages in extremely fast drying, high efficiency, low energy consumption, and easy control [10]. Shimazaki & Aisaka [11], studied the effect of shoe soles on the amount of heat generated inside the shoe and showed that the heat generated from compression and expansion of shoe soles has a significant impact on quality.

Designing an automatic shoe drying oven equipped with a Raspberry PI with an LCD screen, fan, multilevel shelves, and electric heater temperature control to provide

maximum and even heating of leather shoes when gluing and drying leather shoes. Raspberry PI aims to combine and collect production process data in cloud storage in the form of a database, which will then be sent and displayed directly to the operator [12]. Copetti et al. [13] The two-dimensional model developed can encourage digitalization and make it easier for MSMEs to face the changes that occur, the government has increased the ease of access and transferred technology to MSME players so that they can survive in business competition. [14]. The need for the development of this machine is to assist MSMEs in improving the quality and quantity of their products, so that they can compete in the national market. In addition, this tool can provide a touch of technology to MSMEs.

2 Methods

This research activity is carried out through several stages, which include design, manufacturing, operational testing, performance testing, and evaluation.

2.1 Design

The design stage begins with the design of an automatic shoes-drying oven integrated with the Raspberry Pi cloud system using SolidWorks software. The design stages in this study consist of: 1) making a design starting from parts, components, and the main unit of the machine, 2) assembly of the design, by assembling all the designs of the parts that have been made, 3) the next step is to make a detailed framework as the basis for making the machine.

2.2 Manufacturing

Completed, then proceed to the manufacturing process stage of the automatic shoes drying oven integrated with Raspberry Pi cloud system based on the finished design, manufacturing starts with making the main components and supporting components. After the component is complete, the Raspberry Pi cloud system is installed.

2.3 Performance testing

After the engine is completed from the manufacturing stage, then proceed to the engine function test stage. In testing the work of the machine there are two types of machine tests, namely function tests without using loads and function tests using loads. The indicators used in testing the function of the tool are by conducting a function test on each component of the tool in the machine to determine the success of the function of the machine that has been made, then testing using a load with indicators of the quality of the drying results of the sole and upper glue, leather texture and production quantity.

2.4 Evaluation

Evaluate the activities during the start-to-finish stage by looking at what needs to be improved on future machines.

3 Result and discussion

This research was conducted for five months from May until September 2023 in collaboration with one of the shoe partners in Sidoarjo. Based on the observations found in the field delivered by UD. Candi Emas Jaya, the next step is to develop a tool to help overcome existing problems, namely by making an automatic shoe-drying oven integrated with the Raspberry Pi cloud system. Automatic shoe-drying oven integrated with the Raspberry Pi cloud system is a machine used for the process of drying shoes, drying glue, and forming profiles from shoe leather so as not to wrinkle. The design of the machine design uses 3D Modeling software and the results of the automatic shoes drying oven integrated with the Raspberry Pi cloud system can be seen in Figure 2.

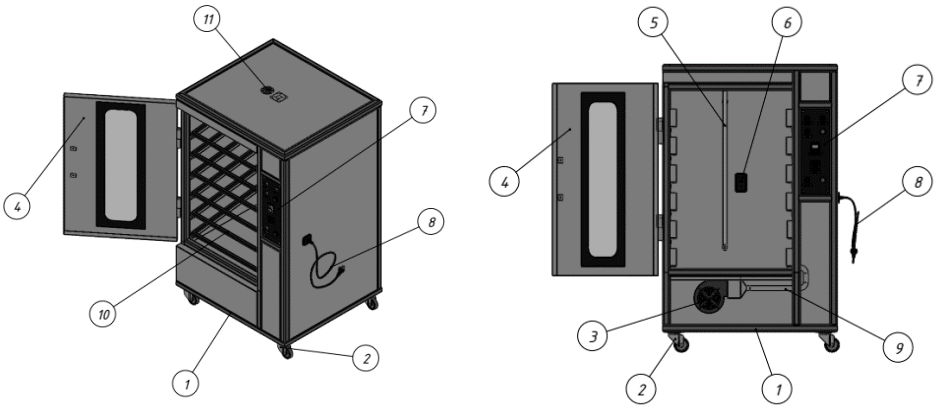

Fig. 2. Design of automatic shoe drying oven machine integrated with Raspberry Pi cloud system

Table 1. Machine description

No	Description	Specification
1	Frame unit	Stainless steel
2	Wheels	Plastic
3	Blower	90 Watt
4	Door unit	Stainless steel
5	Lights	10 Watt
6	Sensor (temperature)	0-150 ˚C
7	Control panel	1. Temperature control 2. Timer 3. Keypad 4. LCD 5. Bottom ON 6. Bottom OFF
8	Power cable	220 Volt

No	Description	Specification
9	Hot air duct	2”
10	Shoe rack	Stainless steel
11	Exhaust fan	15 Watt, 2500 rpm, 80.4 cmh

Based on Figure 2, it can be seen that the machine has six tiers in the oven designed to accommodate more shoes. Each shelf of the automatic shoe-drying oven integrated with the Raspberry Pi cloud system can be filled with six shoes. After the design is complete, then proceed to the manufacturing stage [15]. In the manufacturing process, the materials used use selected materials that are in accordance with the standards [16]. The material used in manufacturing is stainless 304. The results of the manufacturing stage can be seen in Figure 3.

Fig. 3. Results after manufacturing

The automatic shoe-drying oven integrated with the Raspberry Pi cloud system has been finished then to find out the performance of this automatic shoe-drying oven, a function test is carried out first. The machine performance test is carried out twice, namely the first with a function test by checking all engine components whether they are working properly or if there are still errors [17]. The process of testing the function of the automatic shoe-drying oven integrated with the Raspberry Pi cloud system is done by turning on the machine by pressing the ON button, leaving the machine on for ten minutes then checking the temperature in the oven machine room. The results of the function test obtained all engine components are in good working order and obtain a temperature of 50 ℃-110 ℃.

The load test is carried out to find out how effective the automatic shoe-drying oven integrated with the Raspberry Pi cloud system is when it is given a load of shoes. The load test process is carried out by turning on the oven by pressing the ON button, then the shoes are put into the machine and waited for three minutes. Based on the results of the load test, the temperature in the machine is around 60 ° C. The temperature inside the machine can also be controlled by automatic thermocontroll and timer. [18]. This is in accordance with the temperature required when heating the skin (texture formation) with a temperature of 50 ℃-55 ℃ [19]. How the machine works can be seen in Figure 4.

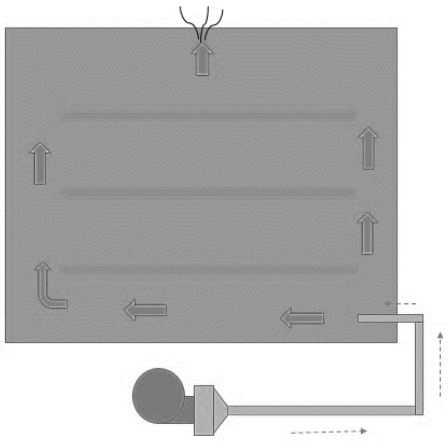

Fig. 4. Diagram of how the machine works

Based on Figure 3 the way the machine works starts from the heat source that comes from the heating element. The heating element temperature can be adjusted as needed with thermocontroll so that it is more evenly distributed [20]. The oven process can be set automatically with a timer so that it can produce good-quality shoes. The design of the working system and mechanical system of the shoe drying oven can work properly. The Raspberry PI Cloud system can collect and display actual drying time data [21]. Raspberry PI makes it easy for us to know how many shoes have dried evenly. In addition to Raspberry PI, the machine is also equipped with a thermocontrol and timer on the machine will make it easy for users to adjust the temperature and time of the oven according to the characteristics of drying shoes. The exhaust fan functions as an air circulation regulator in the oven so that the heat is evenly distributed and maintained constant throughout the oven space so that optimal shoe quality will be obtained, namely evenly dried glue [22]. The required glue drying temperature is 60°C with a drying time of five minutes. This machine requires 850 watts of electricity to operate [23]. The machine specifications can be seen in Table 2.

Table 2. Specifications of automatic shoe drying oven machine integrated with Raspberry Pi Cloud system

No	Description	Specification
1	Dimensions	p=94 cm; l=84 cm; t=1034 cm
2	Heating Element	Heater 1000 watt
3	Material	Stainless steel 304
4	Capacity	18 pairs
5	Power	850 watts

How to operate the automatic shoe-drying oven integrated with Raspberry Pi cloud system, as follows: 1) Plug the machine power cable into the power source, (2) Press Power On/Off, (3) Put the shoes into the rack and close the door, (3) Set the thermocontroller and timer for the shoe oven process, (4) Enter the nominal number of shoes processed in the system, (5) Press the start button to start the curing process, (6)

The machine work process will stop after the curing time has expired (when the time entered has expired, the system will send a signal to the server in the form of a notification that the curing process has been completed and (7) Exit the shoes when the alarm timer has sounded. The machine test results for three days can be seen in Figure 5.

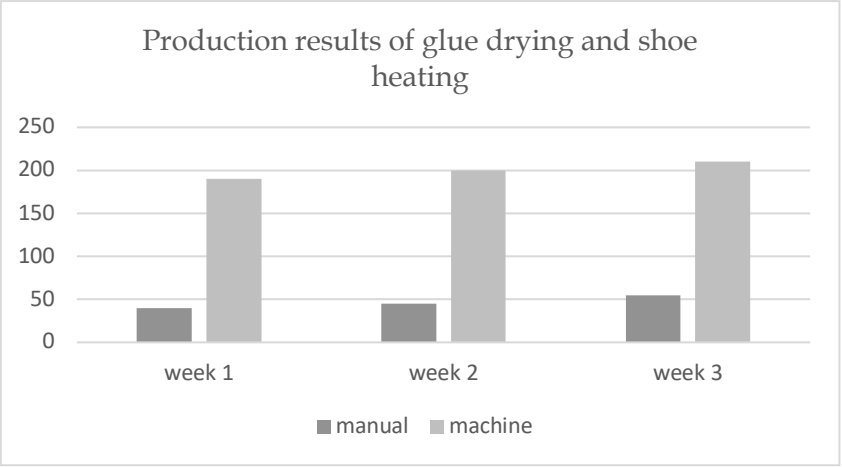

Fig. 5. Graph of shoe production comparison results

Based on Figure 5, it can be seen that the machine comparison test was carried out manually for three days. On the first day, the results obtained were 120 shoes manually while using the machine obtained a result of 450. On the second day, the results obtained were 145 using the manual tools owned while using the machine obtained a result of 420 shoes. The third day obtained a result of 150 using manual tools while using the machine obtained a result of 450 shoes. Based on these results, it can be seen that the use of manual drying equipment only obtained an average of 139 while the use of machines obtained quite stable results with an average of 440 shoes per day.

The oven machine can increase production significantly by almost three times compared to the manual process. The drying results using the tool can dry the glue evenly so that the bonding strength of the sole and upper is very strong. The automatic shoe dryer equipped with timer control and thermos control has a production capacity of 16 pairs of shoes per process. The time required for glue drying is three minutes while heating the leather takes 40 minutes. An automatic shoe-drying oven integrated with the Raspberry Pi cloud system is able to increase production capacity by five times compared to using the LPG gas stove heat dryer. The tool can increase production to meet demand from consumers who also do not forget the quality of the shoes [24]. Drying shoes using an automatic shoe-drying oven integrated with the Raspberry Pi cloud system shows that the drying results of sole and upper glue are very good and evenly distributed throughout the sole and upper parts. The results of drying shoes show that the drying shoe leather is not moist, tight, smooth, and shiny.

4 Conclusion

The design of the work system and mechanical system for the shoe-drying oven can work well. The Raspberry PI Cloud system can collect and display actual drying time data, glue drying temperature of 60°C with a drying time of five minutes, and skin heating temperature (texture creation) of 50°C-55°C requires a warm-up time of 40 minutes, This machine requires 850 watts of power. The automatic shoe-drying oven integrated with the Raspberry Pi cloud system can increase shoe production up to five times, especially in the drying process.

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