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Design of Temperature Monitoring Equipment for Furnaces Burning Charcoal Production

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ABSTRACT

The research aims to design a prototype temperature monitoring system for charcoal burning stoves based on the Arduino Uno microcontroller. This device helps operators monitor the combustion temperature and completion time of the combustion process, thereby increasing the efficiency of charcoal production. By using this tool, charcoal production time can be reduced by 1-2 days. This research involves using a type K thermocouple sensor to measure the internal temperature of the furnace, and the data is processed by Arduino Uno and displayed on an LCD screen. Research was conducted on charcoal company in Waringinkarya Village, Karawang Regency, using Research and Development (R&D) methodology and descriptive data analysis. The equipment used includes an infrared thermometer, Arduino Uno, type K thermocouple, 16x2 LCD module, 5V relay module, buzzer, lamp, PCB matrix, jumper cables and 250V socket. The production process lasted for 12 days, with temperature observations carried out using an Arduino Uno microcontroller. The design of the device includes hardware and software components, including thermocouple sensor stability testing, which provided positive results in monitoring charcoal combustion temperature. This article also discusses improving the visual efficiency of charcoal production time through graphs of temperature and production time, with tests carried out in periods 1, 2, and 3, showing the production process is faster than the operator's initial assumptions. Relevant references are listed in the article's bibliography..

Keywords: *Charcoal, Burning Furnace, Production Time, Efficiency*

Introduction

Energy is an entity that is eternal, meaning that it cannot be created or destroyed, but can change form. Therefore, energy plays a crucial role in ensuring the stability and security of a country. Energy scarcity is caused by increased use of non-renewable energy, which encourages the government to create policies to overcome this problem and ensure energy availability. The government has implemented strategic policies to overcome the energy crisis by substantially limiting petroleum exploration. Apart from that, the government is also actively encouraging the development and use of alternative energy sources as an effort to diversify energy and reduce dependence on petroleum[1]

Biomass is a renewable energy that needs to be developed optimally as a step to overcome the decreasing supply of fossil energy. Biomass consists of two groups, namely wood and non-wood. Charcoal can be used as an alternative fuel[2]

Charcoal is made from the imperfect burning process of wood, coconut shells, and other materials. Most people make charcoal for fuel needs, such as processing food ingredients into grilled or grilled meals[3]. In the modern era, charcoal has become an alternative energy source, especially in the form of high-density briquettes. The advantages of charcoal briquettes include their dryness, which ensures consistent calorific value. Their high density, which minimizes storage space requirements, and their ability to burn in systems designed for coal[4]. According to [5] The quality of charcoal can also be improved by carbonating and activating it to become activated charcoal.

Charcoal is generally a porous solid material made from carbon with a high degree of aromatization, the result of the thermal decomposition of plant waste biomass in conditions without oxygen or with limited oxygen[6]. The calorific value of charcoal ranges from 25 MJ/kg to 32 MJ/kg on a dry basis, this value is higher than the original biomass or liquid product, and burning charcoal is considered more environmentally friendly than coal[7].

According to[8]Activated charcoal is a porous solid containing 85-95% carbon from carbon materials heated at high temperatures. Organic materials such as coconut shells, palm kernel shells, wood

chips, animal bones, corn cobs, and rice husks produce activated charcoal[9]. Charcoal is generally a porous solid material made from carbon with a high degree of aromatization, resulting from the thermal decomposition of plant waste biomass in conditions without oxygen or with limited oxygen[6]. The calorific value of charcoal ranges from 25 MJ/kg to 32 MJ/kg on a dry basis, this value is higher than the original biomass or liquid product, and burning charcoal is considered more environmentally friendly than coal.[7]Activated charcoal, a porous solid material, is produced by burning carbonaceous materials through pyrolysis, namely thermal heating without oxygen. According to[10]charcoal is a black residue containing impure carbon, formed from removing water and volatile components from animals and plants. Heating wood, sugar, bones, and other objects usually obtain charcoal. This charcoal, which is black, light, crumbles easily, and resembles coal, is composed of 85% to 98% carbon, with the remainder being ash and other chemicals.

Charcoal, which comes from wood, has a high calorific value, making it useful for household purposes such as cooking or burning in the manufacture of clay materials such as pots, glassware and roof tiles. The availability of charcoal as an alternative energy raw material for households is very important, considering the high energy consumption in this sector[11].

The charcoal production process includes several things, namely drying raw materials. In this process, wood is first cleaned of contaminants such as insects, soil, and other dirt that stick to the wood. Next, the wood is cut into smaller sizes to make the composing process easier. The wood is then dried in the sun for two days to reduce its water content. Next, in the carbonization process, the dry wood is charcoaled or burned in a furnace until the wood becomes charcoal.

The composing process, according to[12]The raw wood material consists of all tree parts, stacked in an open area. The wooden branches are stored separately in special piles protected from rain to keep them dry. The covering of the woodpile above the kiln, which has no walls or doors, is carried out in two stages: initial covering with litter and final covering with soil, each approximately 15 cm thick. At the top, a gap of about 20 cm is left from the litter layer without soil for ventilation. Turning wood into charcoal begins with burning through an ignition hole at the front of the stove, using sawdust on top of banana stems and a little kerosene. All vents are closed during initial ignition except the ignition hole, which remains open until combustion becomes a continuous hot ember. Once the wood is burning and it will not go out, the ignition hole is closed, and the vents on the bottom side of the stove are reopened, including one vent hole under the demolition door. This step aims to dry the wood. Before demolition, water was sprayed over the pile to extinguish the burning charcoal. The litter and covering soil were removed, and then the demolition doors were opened gradually, accompanied by water spraying to prevent the fire from reigniting. Once complete, the charcoal is removed from the furnace using a spade and fork.

The traditional method of burning charcoal usually involves a pile of logs arranged in a circle. This pile is then covered with dry grass or moistened clay. To start a fire, a chimney or air hole is made at the bottom of the stack[11]. Furnaces come in various forms, including domes, boxes, iron drums, and earthworks. The charcoal produced from each type of stove also has unique characteristics[13].

According to [3]stated, "The most important stage Affecting the quality of charcoal is the combustion process and extinguishing the fire. The burning process is thorough and continues uncontrolled. As a result, a lot of wood has turned to ash, and others have not been burned, so the yield of charcoal from burning is low, namely 22.5%. The time required to make charcoal using an aran installation is shorter than burning it in the ground."

Previous research "Analysis of charcoal burning stoves to increase charcoal carbonization productivity", stated that Charcoal burning stoves are one of the important components in the charcoal-making process. This furnace is used to heat charcoal raw materials to a certain temperature so that the carbonization process occurs and produces good-quality charcoal. Optimal combustion can be achieved if several factors in the furnace operation are considered, including temperature, duration of burning or carbonization, reducing or closing the door, closing the chimney, and the top window. Charcoal-burning stoves can be made from various materials and designed in various styles, depending on the type of raw material and expected production capacity[14]

The stoves currently being developed and used by the community are still traditional and have several weaknesses. This traditional method of making charcoal produces quality that is not optimal and requires constant supervision during production. Traditional furnaces or kitchens use soil as an insulator to retain heat during carbonization and prevent air from entering the furnace. Charcoal produced using this method usually has a higher water content, higher volatile matter content, and lower bound carbon content. In previous research[12]

Based on previous research problems conducted by the analysis of charcoal-burning stoves, it can be concluded that traditional charcoal-burning stoves are used to heat charcoal raw materials, trigger the carbonization process, and produce good quality charcoal. Factors such as temperature, burning time, or

carbonization greatly influence the quality of the charcoal, and the process of closing the chimney and the top window influences the maximum combustion results. However, traditional stoves that are still widely used have weaknesses, including the low quality of charcoal and the need for continuous supervision in the production process, so the production process time is uncertain and results in unstable production quantities.

This research aims to design a prototype temperature monitoring system for charcoal-burning stoves based on the Arduino Uno microcontroller. According to[15], prototyping is a method in system development that uses an approach to create a program quickly and gradually so that users can immediately evaluate it. According to[16], Microcontrollers are one of the technological components that will play an important role in the era of Industrial Revolution 4.0 because a microcontroller system will serve every space and movement in the productivity of the industrial world. This system uses a type K thermocouple sensor to measure the temperature in the combustion furnace. The temperature data is then sent to the Arduino Uno to be processed and displayed on the LCD screen. This tool will help the operator to know the combustion temperature and completion time of the combustion process so that the charcoal-burning stove is more modern and efficient and can increase the productivity of charcoal making.

A thermocouple is a sensor that measures temperature and converts it into an electrical quantity via Max6675. Max6675 will receive a signal from the sensor in the form of an analog signal, then the analog signal is converted into a digital signal and transmitted to the Arduino microcontroller[17]. The working principle of a thermocouple is quite simple, consisting of two types of metal conductor wire connected at one end. One wire functions as a reference with a fixed temperature, while the other wire detects temperature changes[18]. According to[19]Thermocouples are the most commonly used sensors to measure temperature because they are relatively cheap but accurate and can operate at hot or cold temperatures. Some advantages of thermocouples that make them popular are their fast response to temperature changes and their operational temperature range, between -200°C and 2000°C.

The control device used in this research is an Arduino microcontroller, an electronic kit or circuit board with the main components of a microcontroller chip from the Atmel company, and open-source licensed programming software. Arduino has 14 input/output pins, of which 6 pins can be used as a PWM output, 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP head, and a reset button. Arduino supports microcontrollers and can be connected to a computer using a USB cable[20]. The programming language used in Arduino is not a complex assembler, but a simplified version of C with support from Arduino libraries. Apart from that, one of the tools for programming Arduino is the Arduino application version 1.6.10, specifically designed for creating programs for the Arduino Uno. A microcontroller is a chip that acts as an electronic circuit controller and usually has the ability to store programs in it[21].

LCD (Liquid Crystal Display) is a useful module for displaying data. This LCD is made from liquid crystal to display text or image data. The 16×2 LCD can be connected to any microcontroller according to needs. This system uses a 16x2 LCD with an I2C module to connect to the Arduino Uno microcontroller. In this system, the 16×2 LCD functions to display the results of temperature readings read by the thermocouple sensor which is processed by the Arduino microcontroller when the program is running[22].

A relay is a switch operated entirely electrically and is an Electromechanical component consisting of 2 parts: the Electromagnet (Coil) and the Mechanical (separate lift Contact/Switch Switch). The principle is that relays use electromagnetism to move the switch contacts so that a small electric current (low power) can deliver higher voltage electricity. For example, a relay that uses a 5V electromagnet can move an armature relay (which functions as a switch) to deliver 220V 2A electricity[23].

Although research on designing temperature monitoring devices for charcoal-burning stoves has shown various advances, there are still several gaps that need to be addressed to optimize the effectiveness and efficiency of this technology. These gaps include a lack of economic analysis and how the use of temperature monitoring devices affects the quality of the charcoal produced. In addition, the application of temperature monitoring devices is still limited. In-depth research must be conducted to evaluate the investment costs, long-term savings, and emissions and waste reductions necessary to understand the overall benefits of this technology in charcoal production. By overcoming these gaps, it is hoped that the charcoal production process can be more optimal in terms of quality, production efficiency, and environmental and economic impacts.

Research Methods

Framework of thinking

1. The main challenge in the charcoal industry is a lack of understanding about the temperature and duration of charcoal burning. This causes the combustion process to be inefficient and charcoal production results to be less than optimal.
2. An effective solution to overcome these challenges is to design a charcoal temperature monitoring device that can be installed in the kiln. This device allows the operator to combine temperature and process duration accurately.
3. This charcoal temperature monitoring device can be made using a type K thermocouple sensor and an Arduino Uno microcontroller, which is important in the era of Industrial Revolution 4.0.
4. The use of this charcoal temperature monitoring device is expected to increase the efficiency of the charcoal burning process and increase the productivity of charcoal making.

Based on the description above, the framework of thinking in this research on charcoal MSMEs can be described as follows:

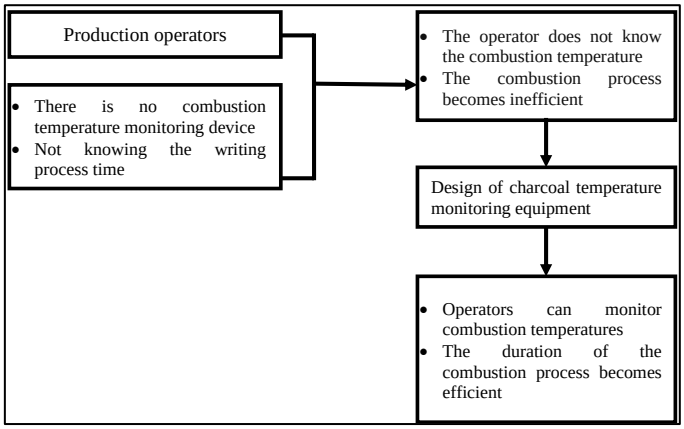

Figure 1. Framework for thinking

Object of research

This research involves making a prototype of a temperature monitoring device for a charcoal-burning stove. It is focused on hardware and software design and the effectiveness of using this supporting tool. The aim is to know the charcoal temperature in real-time, making it easier for operators to monitor it. charcoal and duration of authorship

Research procedure

The research implementation started from the observation and literature study stages. Observations were carried out 12 times over 12 days. **Table 1.** Then, prepare the tools and materials needed for designing the tool, make the tool and functional test the tool, analyze the data from the test results, and discuss and conclude. The following **Figure 2.** Below is a flowchart for this research:

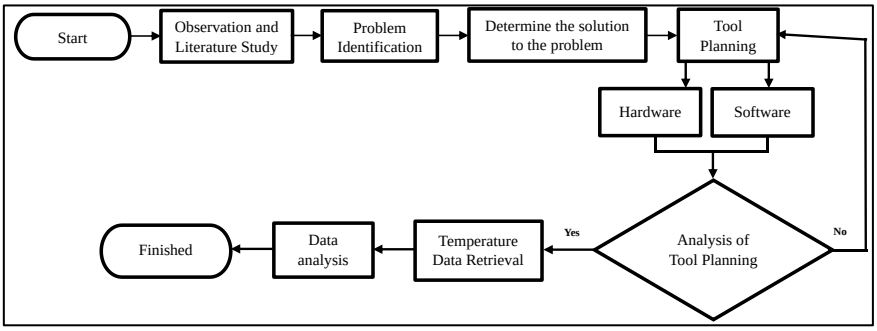

Figure 2. Research Flowchart

The research procedure has several stages. The first stage, namely observation and literature study, is a process of direct observation in the field to find out a problem at the charcoal company. Once the existing problems are known, the next stage is to determine the solution to the problem, so research is carried out with the title "Design of Temperature Monitoring Equipment for Charcoal Production

Burning Furnaces". Then, proceed with designing the tool, including designing hardware and software, and then making an analysis to find out if the tool is functioning well. After the analysis results show that the tool is functioning well, the next process is taking the data directly to the observation site with the aim of knowing the temperature data and charcoal production time; then, data analysis is carried out for results and discussion purposes.

Methods

Data analysis was carried out using a descriptive method by collecting existing data, which was then clarified, analyzed, and interpreted to provide solutions to problems. The research method used in this research is Research and Development (R&D), which is used to produce certain products and test their effectiveness. According to Nusa Putra, Research and Development (R&D) is a research method deliberately, systematically, to find, improve, develop, produce, or test the effectiveness of products, models, and methods/strategies/ways that are superior, new, effective, efficient, productive, and meaningful[24].

A good needs analysis is needed to achieve optimal results by considering the nature and characteristics of each component used so that damage can be avoided. The design stage includes several steps, namely designing the system block diagram, designing electronic devices, system Wiring Diagrams, programming the Arduino IDE Software, up to the design and function of the entire tool which produces a prototype of the charcoal temperature monitoring system,

Tools and materials

The research was conducted from October to December 2023 in Waringin Karya Village, Lemahabang District, Karawang Regency. The H. Maman charcoal company was observed in this research, namely the company that produces charcoal. The tools and materials in this research are as follows:

Tool

1. Infrared thermometer: used to determine the temperature of charcoal production before a prototype is made.
2. Arduino uno: becomes the control center for the device prototype.
3. Type K thermocouple and max6675 driver: These are used to measure temperature and convert it into electrical quantities via max6675.
4. 16x2 LCD module equipped with an i2c module: used to display temperature values visually.
5. Relay module 5v 1 channel: functions as a switch to conduct 220v electricity from the power supply to turn on the lights.
6. Buzzer: used as an audio temperature reminder.
7. Lights: used as a visual temperature reminder.
8. Pcb matrix 9x15: used as a basic basis for electronic design.
9. Jumper cables: used to connect electronic components.
10. 250v socket connects the power supply from the outside to the hardware.

Material

1. Traditional furnace: a place where charcoal is produced.
2. Wood Charcoal: main raw material.

Observation of Charcoal Temperature

From the results of interviews and initial observations, it is known that so far the charcoal production process only refers to an arbitrarily determined time, namely during the 12 day production process. Observations on the first day of the production process were carried out on Friday, December 15, 2023, to Tuesday, December 26, 2023, which means the production process ran for 12 days. The burning started on Friday morning, at 06.30 WIB. Temperature data Charcoal production obtained during the observation process can be seen in Table 1 below:

Table 1. Charcoal Combustion Temperature

Day	Time	Temperature °C
1	13:30	45
6	13:30	162
12	12:00	387

On the first day of observation, the temperature was 45°C. Then, after 6 days of the burning process, observations were repeated. It was found that the charcoal temperature reached 162°C. The final observation was carried out after the charcoal production process was declared complete by the production operator, namely within a period of 12 days, where the temperature increased quite significantly, reaching 387°C.

Tool Planning

In the initial stage of designing a tool, the first step is to develop a general system design. This involves detailed thinking and planning regarding the structure and function of the tool to be created. The system design process is then divided into two main aspects: hardware and software, each of which interacts and contributes to the tool's performance. Hardware includes all physical components such as electronic circuits, sensors, actuators, and other mechanical elements necessary to construct a device. Meanwhile, software consists of instructions and algorithms that regulate and manage tool operations, including developing computer programs, user interfaces, and data processing algorithms that enable tools to operate efficiently and effectively. By designing these two aspects in an integrated and harmonious manner, it is hoped that the tool created will operate optimally and achieve the targeted goals.

Electronic device design

This stage involves making a prototype electronic circuit for temperature monitoring using the Arduino Uno microcontroller, which acts as a controller and regulator of the electronic circuit work process[25]. Apart from Arduino, this device also utilizes other electronic components such as a thermocouple sensor and Max6675, which plays a role in detecting and measuring temperature[26], a 16x2 LCD which functions as an output display[27], then the next component is a buzzer which functions to change electrical vibrations. into sound vibrations[28], and the last component is a relay which functions as a switch and conductor of 250v electrical voltage[29].

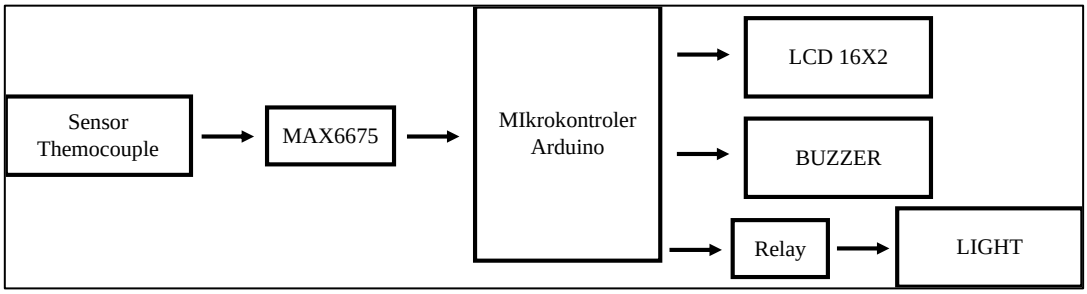

Figure 3. Block diagram of the system

Image Caption 3.

1. Thermocouple sensor and Max6675 driver function as input for the microcontroller to detect temperature.
2. The Arduino Uno microcontroller acts as the control center for the furnace control system, which receives signals from the Max6675 and processes the output to be displayed on the LCD screen.
3. The buzzer and relay will light up when they receive input from the microcontroller as a reminder combustion has reached greater than Set point.

***Wiring* Diagram**

A *wiring* diagram is a graphical representation of pin connections in detail to understand the relationships between the Arduino Microcontroller components in detail[30]. The following is an image of a hardware design wiring diagram:

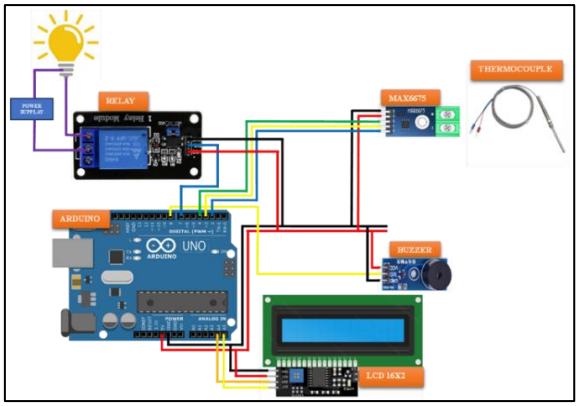

Figure 4. Wiring diagram

From Figure 4, information can be found to connect the PIN between Arduino Uno and several other electronic devices, to clarify the hardware assembly process, namely as follows:

Table 2. Hardware Pin Description

	Relay *Module 1 Chanel* (light)	
	Relay	Arduino Uno
1	Vcc	Vcc
	In1	Pin 7
	Gnd	Gnd
	Max6675 (themocouple)	
	Max6675	Arduino Uno
	Gnd	Gnd
2	Vcc	Vcc
	Sck	Pin 4
	Cs	Pin 3
	So	Pin 2
	Buzzer 5v	
	Buzzer	Arduino Uno
3	Gnd	Gnd
	I/O	Pin 8
	Vcc	Vcc
	LCD 16X2	
	Lcd	Arduino Uno
	Gnd	Gnd
4	Vcc	Vcc
	Sda	Pin A4
	Scl	Pin A5

Results and Discussion

Tool Working Principle

In **Figure 5.** it is explained that the Thermocouple Sensor detects the temperature of the charcoal stove, then the signal is conveyed by the Max6675 driver to the Arduino microcontroller and then processed and conveyed visually to the LCD, and if the combustion has reached greater than the set point, the Arduino microcontroller will analyze and conveys the output to the Relay and buzzer so that it is indicated that the charcoal burning has been completed.

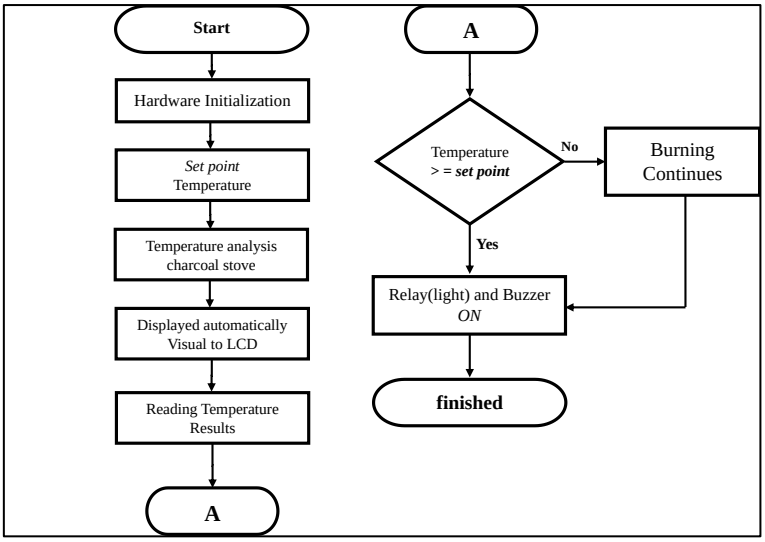

Figure 5. Temperature Control Flowchart

Hardware Box Design

Storage boxes are an important element in the product design process, especially for electronic devices. In designing the box design, you need the help of Autodesk Inventor software which can design three-dimensional images. In this case, the planned box will play a role in supporting the electrical components, so the design must consider the functionality aspect. Plastic is the main material in making the box.

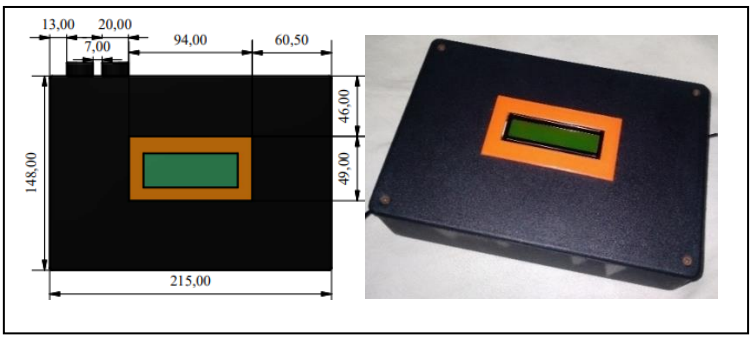

Figure 6. Hardware storage box

Frame design

The frame is a support tool and a place to attach electronic device storage boxes. It is made by considering several factors, one of which is safety, to avoid the heat of the charcoal burning process, which can damage electronic components.

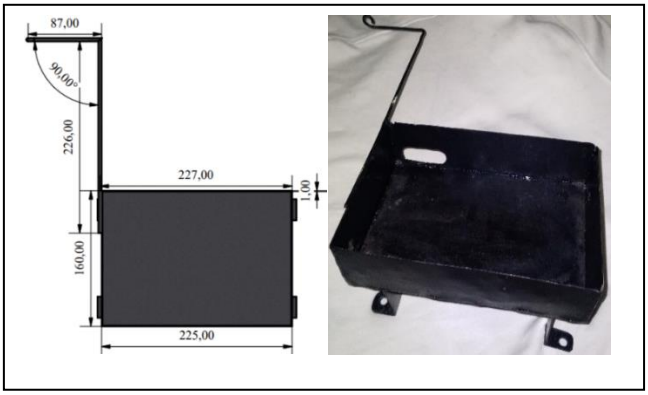

Figure 7. Box frame

Hardware

Hardware design in Figure 8. is a crucial element in making a tool or product. In it, planning is carried out involving mechanical and electrical aspects. Hardware design aims to avoid errors in making tools. To plan electrical components, you need the help of Microsoft Word software with the shapes feature to design the wiring diagram in **Figure 8.**

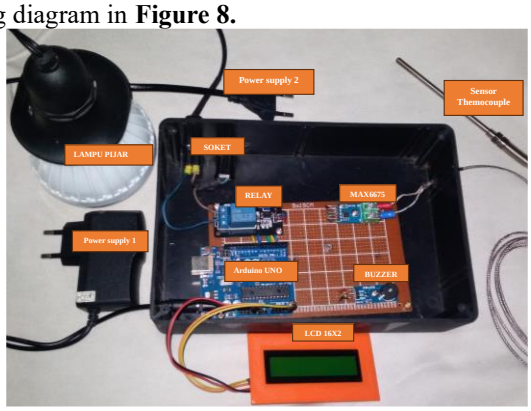

Figure 8. Physical shape of the tool

Use of Arduino IDE Software

Designing programs in Arduino software is very important because it involves creating and transferring programs to Arduino via Arduino IDE software. This aims to enter program code into Arduino. The following is the program code for designing a charcoal burning temperature monitoring tool using an Arduino Uno control center with a Set point value of 380°C as seen in **Figure 9.** below

CODINGAN_TUGAS_AKHIR_28.ino

```
#include<max6675.h>
#include<LiquidCrystal_I2C.h>

int sck = 4;
int cs = 3;
int so = 2;
int buzzer = 8;

MAX6675 suhu(sck,cs,so);
LiquidCrystal_I2C lcd(0x27, 16, 2);
const int relay = 7;

void setup() {
  lcd.init();
}
void loop() {
  lcd.backlight();
  lcd.setCursor(8,0);
  lcd.print(suhu.readCelsius());
  lcd.print((char)223);
  lcd.print("C");
  lcd.setCursor(0,0);
  lcd.print("SUHU :");
  pinMode(relay, OUTPUT);
  digitalWrite(relay, HIGH);

  if(suhu.readCelsius() >380){
    lcd.setCursor(0,1);
    lcd.print("PROSES SELESAI:)");
  }else{
    lcd.setCursor(0,1);
    lcd.print("PROSES BERLANJUT...");
  }
  delay(500);
  delay(500);
  if(suhu.readCelsius() >380){
    digitalWrite(relay, LOW);
  }else{
    digitalWrite(relay, HIGH);
  }

  if(suhu.readCelsius() >380){
    tone(buzzer, 2000);
    delay(3000);
    tone(buzzer, 3000);
    delay(3000);
}else{
    noTone(buzzer);
  }
}
```

Figure 9. Program code

Overall Tool Function Testing

The results obtained from the tests that have been carried out on the entire tool are as follows:

Table 3. Overall tool test results

Input Devices	Output Device	Succeed	
		Yes	No
Thermocouple Sensor	**Relay *Switch* (Light)**	√	
a. Given the treatment of normal conditions room temperature <35°C without any particular heat near the sensor. b. Given a temperature treatment of >380°C near a flame on the sensor.	a. The light doesn't turn on. b. The light is on continuously continuously.		
	Alarm buzzer	√	
	a. Doesn't sound b. Sound continuously		
	Lcd 16x2	√	
	a. Displays the statement "*proses berlanjut…*" b. Displays the statement "*proses selesai :)*"		

Stability Test of type K Thermocouple Sensor

The test is carried out directly on the charcoal production furnace. Figure 10. The prototype is placed at the back of the furnace or right near the air vent, then the tip of the thermocouple sensor is inserted into the vent, then the power supply component is connected to 250v electricity, then make sure the prototype is on and Vol. X, No. X, 2024 Industrial Engineering Journal: Journal of Research Results and Scientific Work in the Field of Industrial Engineering **Figure 10.** Application of the prototype in a charcoal production furnace observations are ready. Initial tests were carried out to measure temperature on the first day of charcoal burning with the aim of determining the stability of the type k thermocouple sensor.

Figure 10. Application of the prototype in a charcoal production furnace

After observing the stability test of the prototype device, it was found that the thermocouple sensor was declared stable because, during the temperature observation process, it did not experience significant temperature changes within 30 minutes after 10 observation trials, as seen in **Table 4.** As follows:

Table 4. Test results for the stability of the type k thermocouple sensor

No.	Time	Temperature °C
1	11:30	45,55
2	12:00	46,01
3	12:30	45,98
4	14:00	45,78
5	14:30	46,05
6	15:00	46,00
7	15:30	46,04
8	16:00	46,00
9	16:30	46,78
10	17:00	46.93
	Average	46.112

Equipment Test Results Data

Observation results from direct testing in the charcoal production furnace were carried out by daily observations every 12:00 for 3 periods of the charcoal production process. During the observation, the test equipment was observed for 30 minutes to determine temperature stability, then the results were recorded for further analysis. Before observations are made, set the temperature first, namely with the set point at 380°C. From this test, the following data results were obtained in **Table 5.** below.

Table 5. Temperature results data and charcoal production process time

Day	WEEK			Average °C
	V1	V2	V3	
	Temperature °C	Temperature °C	Temperature °C	
1	45	46	48	46.33
2	106	110	106	107.33

3	117	121	120	119.33
4	135	129	137	133.67
5	146	141	154	147.00
6	166	158	161	161.67
7	233	245	228	235.33
8	305	315	278	299.33
9	333	337	312	327.33
10	380	380	352	370.67
11	-	-	380	-
12	-	-	-	-

To find out changes in production time efficiency in visual detail and make it easier to analyze the temperature and production time, see Figure 10, namely with an explanation of the colored graphic lines orange means time and temperature before the temperature monitoring device prototype is used, then the gray line is the graph line for period 1 of the charcoal production process, next the yellow graph line is period 2 of the charcoal production process, and finally the blue graph line indicates the period 3 of the charcoal production process.

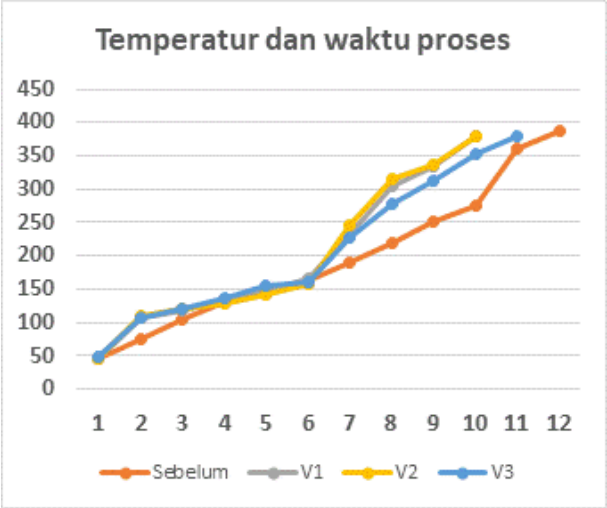

Figure 10. Graph of temperature and charcoal production time

Observations in period 1 were carried out on Thursday, April 4, 2024, with the lowest temperature of 45°C the first test found the highest temperature according to the set point of 380°C, namely on the 10th day of the production process. The second test was carried out on Monday, April 15, 2024, with an initial temperature of 46°C, the same as the first test. The second test's results showed that the charcoal-burning production process took only 10 working days. Then the final or third test was carried out on Sunday, April 28, 2024, with a temperature on the first day of 48°C, the highest temperature according to the set point of 380°C was achieved on the 11th day of the production process.

From the description above, it can be concluded that the production process is known to be faster than the operator's initial assumption.

Conclusion

Based on research background which illustrates that traditional stoves require continuous supervision in the production process, so that the production process time is uncertain and results in unstable production times. Then a research framework was created to design a prototype temperature monitoring tool for charcoal burning stoves, focusing on hardware and software design to make it easier for operators to combine charcoal temperatures in real-time and be able to find out the completion time for charcoal production. This prototype uses a type K thermocouple sensor to measure the temperature in the furnace and the temperature data is processed on the Arduino Uno so that it can be shown on the LCD screen. This research succeeded in designing a prototype of an effective and efficient charcoal temperature monitoring system. The test results show that this tool can shorten charcoal production time

by up to 1-2 days with increased efficiency. It can be concluded that this research has succeeded in achieving its objectives, the tool functions well in combining charcoal burning temperatures, and displays faster production time efficiency than assumed. initial operator. Thus, this research makes a positive contribution in increasing production efficiency through accurate and real-time temperature monitoring.

References

[1] C. Soolany and F. Fadly, "Rancang Bangun Dan Uji Kinerja Tungku Drum Kiln Pada Proses Produksi Arang Kulit Durian Sebagai Alternatif Bahan Bakar," *AME (Aplikasi Mek. dan Energi) J. Ilm. Tek. Mesin*, vol. 6, no. 2, p. 34, 2020, doi: 10.32832/ame.v6i2.3259.

[2] E. S. M. Willy Alexander,Dicky Seprianto, "Pengaruh Diameter Pipa Dan Lubang Bakar Pada Tungku," *Mach. J. Teknol. Terap.*, vol. 3, no. 2, pp. 55–61, 2022.

[3] Y. B. Yokasing, E. T. Kosat, A. Abdullah, and A. Pangalinan, "Rancang Bangun Teknologi Pembuatan Arang Tempurung Kelapa Cacahan," *J. Tek. Mesin*, vol. 3, no. 2, pp. 6–11, 2020.

[4] M. Jhonisius, "ANALISIS PERBAIKAN KECACATAN PRODUK BRIKET MENGGUNAKAN METODE TAGUCHI PADA UMKM RUMAH BRIKET," 2023.

[5] Z. Darajat, M. Septiani, and Fitria, "Pengaruh Waktu Aktivasi Terhadap Karakterisasi Arang Aktif Tongkol Jagung dengan Menggunakan Aktivator H2SO4," *J. Juara*, vol. 3, no. 1, pp. 8–15, 2023, [Online]. Available: https://www.sttibontang.ac.id/jurnal/index.php/jago

[6] M. R. C. A. G. Daful, "Biochar Production From Biomass Waste-Derived Material," *Elsevier Ltd*, 2020.

[7] Prabir Basu, *Biomass gasification, pyrolysis and torrefaction*. joe hayton, 2018. [Online]. Available: https://books.google.co.id/books?hl=id&lr=&id=BYM2DwAAQBAJ&oi=fnd&pg=PP1&dq=basu+Biomass+gasification,+pyrolysis+and+torrefaction:+Practical+design+and+theory.+Academic+press,+2.&ots=nJlz75nAtN&sig=W3OWDmWPBD_FAJF6sf2xwQpiirs&redir_esc=y#v=onepage&q=basu

[8] S. Teke, W. O. N. T. D. Dewi, W. Jali, and Y. Yumnawati, "Pembuatan dan Karakteristik Arang Aktif Ijuk Pohon Aren (Arenga pinnata) Sebagai Media Filtrasi Desalinasi Air Payau," *J. Berk. Fis.*, vol. 24, no. 1, pp. 10–21, 2021.

[9] S. Wardani and R. Mirdayanti, "Optimasi Suhu Aktivasi Proses Pembuatan Arang Aktif Limbah Tulang Kambing," *J. Serambi Eng.*, vol. 4, no. 2, pp. 498–505, 2019, doi: 10.32672/jse.v4i2.1327.

[10] B. W. Lope, A. T. Mandagi, and J. E. . Sumampouw, "Pengaruh penambahan serbuk arang kayu dan serat karung plastik terhadap nilai cbr laboratorium tanpa rendam," *J. Sipil Statik*, vol. 7, no. 11, pp. 1427–1434, 2019.

[11] J. Rochmadi, "Tungku Pembuat Arang Sebagai Media Pengganti Tanah Liat," *J. Politeknosain*, vol. 21, no. 1, pp. 18–21, 2022.

[12] J. Sulistyo, S. N. Marsoem, A. Kholik, and M. N. Wibowo, "Proses Pengarangan dari Tungku/Dapur Pengarang Konvensional dan Permanen di Wonosari, Gunungkidul.," *Semin. MAPEKI XX (Masyarakat Peneliti Kayu Indones. 2019*, no. 1, pp. 206–216, 2019.

[13] S. M. Ridjayanti, R. A. Bazenet, I. S. Banuwa, M. Riniarti, and W. Hidayat, "Karakteristik Arang Kayu Karet (Hevea Brasiliensis) Yang Diproduksi Menggunakan Dua Tipe Tungku Pirolisis," *J. Belantara*, vol. 6, no. 1, pp. 12–22, 2023, doi: 10.29303/jbl.v6i1.815.

[14] M. Z. Hidayatullah and Alfansuri, "ANALISA TUNGKU PEMBAKARAN ARANG UNTUK MENINGKATKAN PRODUKTIVITAS KARBONISASI ARANG," *J. Tek. Mesin*, vol. 6, no. 1, p. 2, 2020.

[15] Y. Darnita, A. Discrise, and R. Toyib, "Prototype Alat Pendeksi Kebakaran Menggunakan Arduino," *J. Inform. Upgris*, vol. 7, no. 1, pp. 3–7, 2021, doi: 10.26877/jiu.v7i1.7094.

[16] Fina Ayu Lestari and B. D. Cahyono, "Sistem Pengendali Mesin Solar Cells Automatic Tabber Stringer pada Penyolderan String di PT. Indonesia Solar Global," *INSOLOGI J. Sains dan Teknol.*, vol. 1, no. 5, pp. 543–552, 2022, doi: 10.55123/insologi.v1i5.856.

[17] A. Yudhanto, A. P. Sari, N. Rachman, and S. Subairi, "Implementasi Sensor Thermocouple Berbasis Telemetri Untuk Mengukur Thermal Pembakaran Propelan Roket," *JASIEK (Jurnal Apl. Sains, Informasi, Elektron. dan Komputer)*, vol. 2, no. 1, 2020, doi: 10.26905/jasiek.v2i1.4284.

[18] Barmawi, Azhar, and M. Kamal, "Rancang Bangun Penggunaan Sensor Thermocouple Pada Alat Penyangrai Biji Coklat Secara Otomatis Berbasis Arduino Uno," *J. Tektro*, vol. 7, no. 1, pp. 1–5, 2023.

[19] H. Yoal, W. Dirgantara, and S. Subairi, "Monitoring Suhu dan Kelembaban pada Penetas Telur Otomatis Menggunakan Metode Fuzzy Sugeno Berbasis IoT," *Blend Sains J. Tek.*, vol. 2, no. 2, pp. 176–183, 2023, doi: 10.56211/blendsains.v2i2.356.

[20] N. Alamsyah, H. F. Rahmani, and Yeni, "Lampu Otomatis Menggunakan Sensor Cahaya Berbasis Arduino Uno dengan Alat Sensor LDR," *Formosa J. Appl. Sci.*, vol. 1, no. 5, pp. 703–712, 2022, doi: 10.55927/fjas.v1i5.1444.

[21] D. Nusyirwan, M. Fahrudin, and P. P. Putra Perdana, "Perancangan Purwarupa Pengatur Suhu Otomatis pada Inkubator Penetasan Telur Ayam Menggunakan Arduino Uno dan Sensor Suhu IC LM 35," *JAST J. Apl. Sains dan Teknol.*, vol. 3, no. 1, p. 60, 2019, doi: 10.33366/jast.v3i1.1315.

[22] M. T. Firdausi and R. N. Rohmah, "Perancangan Sistem Otomatis Pengatur Suhu Dan Kelembaban Pada Kandang Jangkrik Di Daerah Masaran Sragen Berbasis Mikrokontroller Arduino," *J. Cahaya Mandalika*, vol. 3, no. 2, pp. 254–269, 2023.

[23] A. D. Kurniawan, "Design and Implementation of Home Security Using Telegram Botfather," *Fidel. J. Tek. Elektro*, vol. 2, no. 1, pp. 11–15, 2020, doi: 10.52005/fidelity.v2i1.105.

[24] A. A. Ridowi *et al.*, "PROTOTYPE KONTROL TEKANAN AIR MENGGUNAKAN SENSOR PRESSURE TRANSDUSER," vol. 05, no. 01, pp. 1–9, 2023.

[25] A. I. Yusuf and C. Bella, "Aplikasi Pengaman Pintu Otomatis Menggunakan Mikrokontroler Arduino Dan Module Rf Remote," *Portal Data*, vol. 1, no. 3, pp. 1–21, 2021, [Online]. Available: http://portaldata.org/index.php/portaldata/article/view/59/59

[26] R. Alfita *et al.*, "RANCANG BANGUN MESIN PRES KAOS MENGGUNAKAN MIKROKONTROLER BERBASIS ANDROID," *SinarFe 7-4*, vol. 4, no. 1, pp. 623–628, 2021.

[27] A. Apriantina, "Rancang Bangun Pemantauan Penggunaan Daya Listrik Berbasis Arduino Untuk Alat Elektronik," *Portaldata.org*, vol. 2, no. 3, pp. 2022–2023, 2022.

[28] N. Afianto and J. Jamaaluddin, "Rancang Bangun Alat Ukur Temperatur Bearing Pada Pompa Industri Berbasis Arduino UNO," *SinarFe7*, pp. 1–5, 2020, [Online]. Available: https://journal.fortei7.org/index.php/sinarFe7/article/view/246%0Ahttps://journal.fortei7.org/index.php/sinarFe7/article/download/246/205

[29] M. I. Hafidhin, A. Saputra, Y. Rahmanto, and S. Samsugi, "Alat Penjemuran Ikan Asin Berbasis Mikrokontroler Arduino UNO," *J. Tek. dan Sist. Komput.*, vol. 1, no. 2, pp. 59–66, 2020, doi: 10.33365/jtikom.v1i2.210.

[30] Maya Saralina and Bagus Dwi Cahyono, "Perancangan Panel Kapasitor Bank 1200Kvardi Pt. Tiga Kreasi Indonesia," *J. Ilm. Tek.*, vol. 1, no. 3, pp. 32–39, 2022, doi: 10.56127/juit.v1i3.373.