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Automation of Heat Treatment Chamber

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ABSTRACT:In this paper, we present the design and implementation of an automated heat treatment chamber using a Renesas microcontroller. The heat treatment process is commonly used to enhance the mechanical properties of metallic, chemical and wooden materials. However, manual operation of the heat treatment chamber is tedious and prone to human error. The proposed automation system provides a more efficient and accurate solution. The Renesas microcontroller is programmed to control the temperature, time, and atmosphere inside the chamber. The system includes a user interface that allows the operator to input the desired parameters for the heat treatment process. The microcontroller then communicates with the chamber's sensors and actuators to regulate the temperature and atmosphere accordingly. Experimental results demonstrate that the automated heat treatment chamber provides consistent and reliable performance compared to the manual process. The proposed system is suitable for industrial applications where precise and repeatable heat treatment is required. The proposed automation system provides an efficient and cost-effective solution for the heat treatment process.

KEYWORDS:Automation, Heat Treatment Chamber, Microcontroller

I. INTRODUCTION

Heat treatment is a crucial process in various industries, including mechanical and wooden manufacturing, to enhance the mechanical and physical properties of said materials. The traditional manual operation of the heat treatment chamber is prone to human error and results in inconsistent and non-repeatable output. To overcome these challenges, automation systems have been developed to control the heat treatment process. Wooden heat treatment is a critical process in the wood manufacturing industry to reduce the moisture content of wood and prevent decay, insect damage, and fungal growth. The traditional manual operation of wooden heat treatment chambers is a time-consuming process that involves maintaining the wood at a specific temperature for several hours. The current manual process leads to inconsistency and variability in the output, making it challenging to achieve the desired wood quality consistently. To overcome these challenges, automation systems have been developed to control the wooden heat treatment process. Automation offers several advantages over the manual process, including increased accuracy, repeatability, and efficiency. Automation also reduces the likelihood of human error, enhancing productivity and reducing production costs.

The motivation behind this study is to develop an automated wooden heat treatment chamber using a Renesas microcontroller to overcome the challenges of the manual process. The proposed system aims to provide a more efficient and accurate solution to the manual operation of the wooden heat treatment chamber, providing consistent and reliable performance. In this paper, we present an automated heat treatment chamber that is designed and implemented using a Renesas microcontroller. The proposed system provides a more efficient, accurate, and repeatable solution compared to the manual process. This paper aims to present the design and implementation of an automated wooden heat treatment chamber using a Renesas microcontroller. The proposed system offers a more efficient and accurate solution to the manual operation of the wooden heat treatment chamber, providing consistent and reliable performance. The objectives of this study are to develop a cost-effective solution that reduces the time and labour required for wooden heat treatment and enhances the quality and consistency of the output. The scope of this study includes the design and implementation of the automated wooden heat treatment chamber using a Renesas microcontroller, thermocouples, and a human-



machine interface (HMI). The system is designed to automate the heating, cooling, and humidity control of the wooden heat treatment chamber, providing accurate and consistent control of the process parameters.

The proposed system comprises a Renesas microcontroller, thermocouples, and an HMI. The microcontroller is programmed to control the heating, cooling, and humidity control of the wooden heat treatment chamber. The thermocouples are used to monitor the temperature of the chamber, and the HMI is used to display the process parameters and control the system. The system offers precise and repeatable control of the heat treatment process, reducing variability and inconsistency in the output. The proposed system provides a more efficient and accurate solution to the manual operation of the wooden heat treatment chamber, enhancing the quality and consistency of the output while reducing production costs.

II. RELATED WORK

The topic of automation of heat treatment chambers has gained significant attention in recent years due to the need for efficient and reliable heat treatment processes in various industries, including wood preservation, metal working, food processing, and more. In this literature survey, we will review the existing research and publications related to the automation of heat treatment chambers.

[1] provides comprehensive standards for wood preservation, including treatments and methods of analysis. It serves as a valuable reference for understanding the industry standards in the context of automation of heat treatment chambers. [2] presents an overview of wood preservation techniques, including heat treatment, and discusses the principles and practices involved. It provides insights into the challenges and opportunities for automation in heat treatment chambers. [3] discusses various aspects of wood protection, including preservation methods and environmental effects. It provides valuable information on the impact of automation in heat treatment chambers on wood protection practices. [4] evaluates the environmental effects of different wood preservatives used in heat treatment chambers. It provides insights into the environmental considerations associated with the automation of heat treatment chambers and the selection of appropriate wood preservatives. [5] presents a comparison of wood preservatives in stake tests, which are commonly used to evaluate the efficacy of wood preservation treatments. It discusses the potential of automation in heat treatment chambers to improve the performance of wood preservatives. [6] discusses the use of preservative-treated wood and alternative products in the Forest Service. It provides insights into the current practices and challenges associated with wood preservation in the context of automation in heat treatment chambers. [7] presents best management practices for the use of treated wood in aquatic environments. It discusses the potential of automation in heat treatment chambers to improve the compliance with best management practices and minimize the environmental impact of wood preservation processes.

Archer and Lebow [8] provide a comprehensive overview of wood preservation in their book "Wood Preservation," which covers primary wood processing principles and practices. Baechler and Roth [9] present a review of studies on the double-diffusion method of treating wood in the "Forest Products Journal." Barnes [10] edited a publication on "Wood Protection 2006" by the Forest Products Society, which provides insights into the latest advancements in wood preservation. Blew and Davidson [11] conducted a study on preservative retentions and penetration in the treatment of white fir, while Brooks [12] assessed the environmental effects associated with wooden bridges preserved with different chemicals. Cassens et al. [13] published a selection and use guide for preservative-treated wood, and Eaton and Hale [14] authored a book on wood decay, pests, and protection. Hunt and Garratt [15] presented the third edition of "Wood Preservation" in the American Forestry Series, which covers various aspects of wood preservation. ICC-ES [16] provides evaluation reports on wood treatment products and methods. Lebow [17] summarized the leaching of wood preservative components and their mobility in the environment in a General Technical Report. Gjovik and Davidson [18] published a research note on service records of treated and untreated wood posts, and Johnson and Gutzmer [19] compared different preservative treatments in marine exposure of wood panels. These papers collectively provide valuable insights into the field of wood preservation and the various methods, treatments, and effects associated with heat treatment chambers. The findings from these studies can be utilized to design and develop automation systems for heat treatment chambers to enhance the efficiency and effectiveness of the wood preservation process.



III. METHODOLOGY

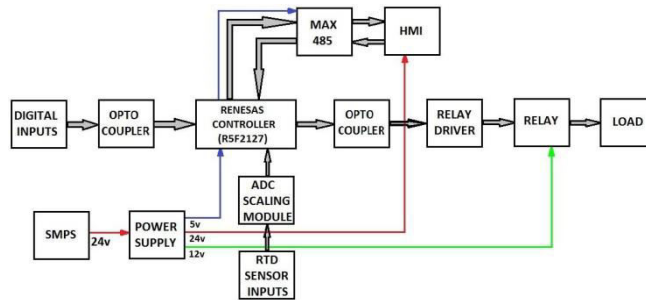
In existing system, maintaining accurate temperature is very tedious. This process is mainly depended on manual process. And also in manual process, wood is subjected to physical damage, the treatment of wood is possible for only certain types of wood. And maintaining ideal temperatures is difficult in manual process. Calibration of the sensors to obtain maximum accuracy is very difficult. There is no generation of graph for the process, and data of the process which cannot be stored. The inadequate process in maintaining ideal temperatures and further requirements are the major drawbacks found in existing system. The following methodology does not support for a long-term wood treatment process which are economically not feasible. These drawbacks are overcome by using advanced type of controller.

The proposed methodology of our project intends to eliminate the need for human operation by supplanting the supervisor with a microcontroller and multiple sensors. These sensors will assess the temperature of the chamber and material dynamically, relaying the readings to the microcontroller which will, in turn, regulate the burner of the heat treatment chamber according to present data points provided to it. These automated control panels are composed of computerized systems that leverage sensors and software to automate the regulation and surveillance of the heat treatment process. These systems feature a display screen which illustrates current temperatures, humidity levels, and other environmental conditions as well as any triggered alarms or warnings. Furthermore, the panels include controls which empower operators to establish desired temperatures, humidity, and other parameters; nevertheless, the heat treatment process is carried out automatically through pre-programmed algorithms and control logic.

The suggested methodology offers various benefits in comparison to traditional manual control methods. They can deliver more precise and consistent regulation of the heat treatment process, thereby yielding more uniform and predictable outcomes. Comparatively, they reduce operator workloads since the heat treatment process is executed autonomously without necessitating continual manual supervision. Furthermore, automated control panels can be configured to execute multiple successive heat treatment cycles, which can be advantageous for extensive heat treatment processes.

The automated control panel in a heat treatment chamber utilizes sophisticated sensing equipment and software to automatically manage and monitor the heat treatment process. The panel features a display screen that displays current temperature, humidity, and other environmental conditions, as well as any alarms or warnings generated by the system. This interface also provides control elements for the operator to adjust the desired temperature, humidity, and other parameters. The automated control panel executes algorithms and control logic that have been pre-programmed into the system in order to regulate the heat treatment process. Data from sensors measuring temperature, humidity, and other environmental conditions within the heat treatment chamber is compared with the operator-defined parameters, prompting commands sent to heating/cooling systems of the heat treatment chamber to modify temperature/humidity levels as necessary in order to maintain desired conditions.

The automated control panel of a heat treatment chamber facilitates the safe and accurate execution of the process, and enables the operator to attain the desired results. This is achieved by allowing the operator to input their preferred temperature, humidity, and other parameters, which are then regulated throughout the duration of heat treatment. Moreover, an integral component of the control panel involves monitoring for any alarms or warnings that may be triggered should these predetermined conditions be exceeded. Upon detection of such alarms or warnings, a message may be displayed on the screen and/or a notification could be sent to either the operator or a centralized control system. By leveraging this technology, it is possible to improve consistency and predictability within the heat treatment process while simultaneously reducing operators' workloads.



HARDWARE DESCRIPTIONS

This section provides a full explanation of the system's various hardware specifications. Additionally, comprehensive case studies are included for each piece of system hardware.

1. RENESAS MICROCONTROLLER

Renesas Hardware Company is a Japanese semiconductor. It has assembling, plan and deals activities in around 20 nations. It was the world's biggest auto semiconductor creator in 2014, and the world's biggest producer of microcontroller. It likewise makes contradicting message incorporated circuits and framework on a chip semiconductor. This type of microcontroller is only used for industrial automation process. It operates under 12 bits so it has a high processing speed with great accuracy. It receives digital temperature signal from the ADC scaling module and it can be store and shown in the human machine interface without any time deviation.

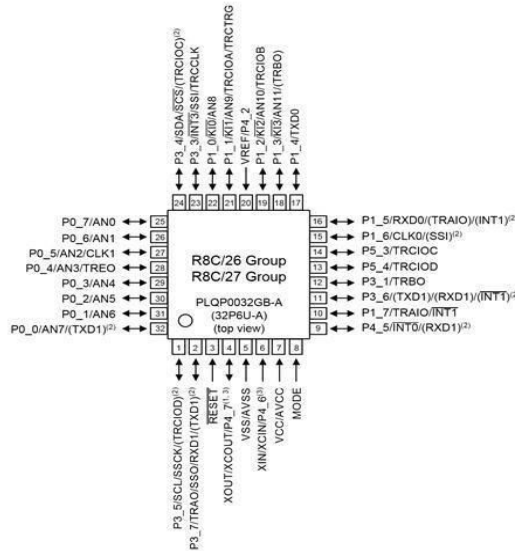
The controller which is operated under 5v dc supply. We must create a programmed for the microcontroller utilizing high performance embedded workshop depending on the criteria. It is a potent embedded application development environment geared toward Renesas micro-controllers. The most important thing is that it uses RS485 communication to communicate with the human machine interface. We must adjust the values for each step to meet our needs. This process can be divided into two main processes: manual and automated. We have the choice to handle each object separately in a manual process.



a) Fig Microcontroller R5F2127

The R8C are broadly useful gadgets with superior execution highlights and the best answer for the upcoming purchaser and industry applications. A ton of gadgets are likewise accessible with car determination and CAN interact. Consequently, acknowledging engine control applications is simple.

The inward 40MHz fast oscillator has a precision down to the absolute temperature range and can be aligned down to 1%. To make your framework more dependable, these gadgets incorporate different safeguard capabilities like clock-stop recognition, SFR assurance, information streak, guard dog time, and so forth.

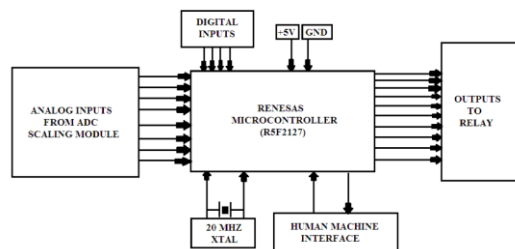


b) Fig Pin Diagram of R5F2127

This helps to reduce costs in the next generation of small application, white goods, industrial and security applications. Other applications include low power/battery applications and induction heating applications.

FEATURES OF RENESAS CONTROLLER

- Low pin - little memory - low cost.
- Fast opportunity to advertise.
- Streak just microcontroller.
- R8C computer processor execution - more execution on 8-digit application - 50ns (at for example 20MHz) for most brief guidance.
- Code thickness (produces 10 to half less code) - 2 x MCU register banks accessible (keep away from push and pop), fantastic code directions.
- Brilliant standing of Renesas Streak Innovation - strength and dependability - EMI, EMS countermeasures.
- Superior execution 0.2µm single-voltage streak.
- Information Glimmer to substitute outer EEPROM.
- Cost saving fringe incorporation - POR, LVD, WDT, Information streak, 2 x inside oscillators.
- Minimal expense advancement device chain - On-Chip Debugger by means of one wire - Streak interface through one wire.



c) Fig Proposed Setup



2. RESISTANCE TEMPERATURE DETECTOR

A Resistance Thermometer or Resistance Temperature Detector is a gadget which used to decide the temperature by estimating the obstruction of unadulterated electrical wire. This wire is alluded to as a temperature sensor. To gauge temperature with high precision, RTD is the only one arrangement in businesses. It has great direct qualities over an extensive variety of temperature. It is an electronic device that measures the resistance of an electrical wire to determine the temperature. The term "temperature sensor" refers to this wire. An RTD is the best option if we want to monitor temperature accurately because it has good linear properties over a large temperature range. Thermocouple and thermistor are two more typical electronic temperature measuring devices. This RTD is available on the market. However, we must be aware of the process for using it and for creating the signal conditioning circuitry. In order to reduce lead wire mistakes and other calibration issues. In this RTD, the temperature-related variation in resistance value is hardly noticeable.

As a result, a bridge circuit is used to measure the RTD value. The RTD resistance can be measured by applying a steady electric current to the bridge circuit and observing the voltage drop that occurs across the resistor. Thus, the temperature can also be established. By translating the RTD resistance value using a calibration expression, this temperature is ascertained.

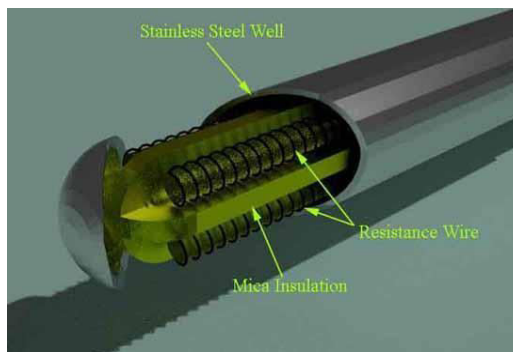
The variation of resistance of the metal with the variation of the temperature is given as,

$$R_t = R_0 [1 + \alpha (t - t_0) + \beta (t - t_0)^2 + \dots] \longrightarrow \text{Eqn 1}$$

Where, R_t and R_0 are the resistance values at $t^\circ\text{C}$ and $t_0^\circ\text{C}$ temperatures. α and β are the constants depends on the metals. This expression is for huge range of temperature.

For small range of temperature, the expression can be,

$$R_t = R_0 [1 + \alpha (t - t_0)] \longrightarrow \text{Eqn 2}$$

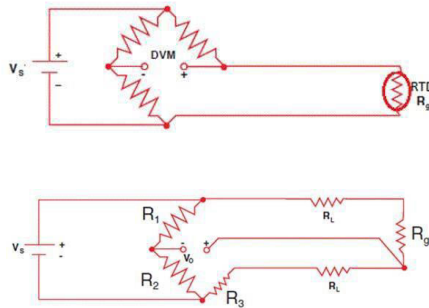


d) Resistance Temperature Detector

In RTD devices, Copper, Nickel and Platinum are generally utilized metals. These three metals are having different opposition varieties with particular to the temperature varieties. That is called opposition temperature qualities. Platinum has the temperature scope of 650°C , and afterward the Copper and Nickel have 120°C and 300°C individually. The figure-1 shows the obstruction temperature attributes bend of the three unique metals. For Platinum, its obstruction changes by roughly 0.4 ohms per degree Celsius of temperature. The virtue of the platinum is checked by estimating R_{100}/R_0 . Since, whatever the materials really, we are utilizing for making the RTD that ought to be unadulterated. On the off chance that it will not unadulterated, it will veer off from the regular opposition temperature diagram. In this way, α and β values will change contingent on the metals.

CONSTRUCTION OF RESISTANCE TEMPERATURE DETECTOR

The construction is typically such that the wire is wound on a form (in a coil) on notched mica cross frame to achieve small size, improving the thermal conductivity to decrease the response time and a high rate of heat transfer is obtained.



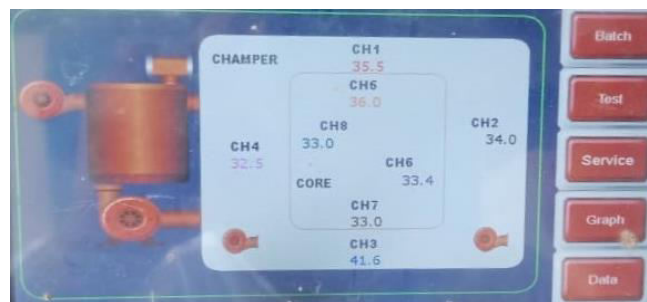
e) Circuit Diagram of Resistance Temperature Detector

3. ANALOG TO DIGITAL CONVERTER

The conversion system that makes up the ADC Scaling portion must examine an analogue signal in order to produce a digital signal that can be sent to a microcontroller. As a result, we must use the scaling method based on voltage to transform the analogue signal obtained from the resistance temperature detector sensor to a digital signal. Therefore, in order to scale between two separate ranges, we must establish similar values for the two ranges. Obtain the necessary values for various voltage levels using this type of scaling procedure. The main benefits of employing the scaling method are improved precision and fluctuation-free results. The sensor only provides four sets of analogue readings to a single ADC scaling module. We must therefore utilize two sets of scaling modules to scale eight sets of values in this operation. A single microcontroller receives both digital outputs from the scaling module for controller purposes. The essential step in this procedure is to transform analogue temperature signals into digital temperature values, which are then shown in the delta human-machine interface via RS485 communication. By utilizing this scaling module, the communication process's time variation can be avoided.

IV. EXPERIMENTAL RESULTS

The automation process using the afore mentioned hardware components has been built and successfully installed in a wooden manufacturing industry. The following sections will showcase the output of the product, while also discussing the advantages and future scope of this project as a product.

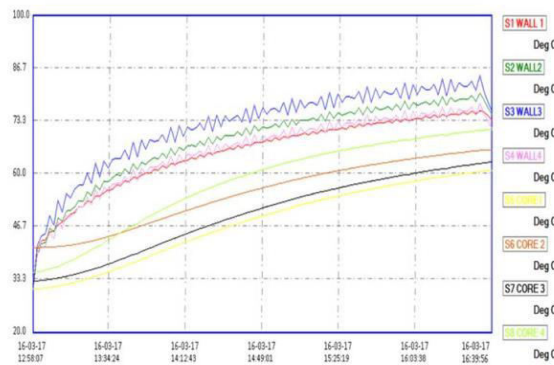


f)



Time	S1 WALL 1	S2 WALL 2	S3 WALL 3	S4 WALL 4	S5 CORE 1	S6 CORE 2	S7 CORE 3	S8 CORE 4	Remark
12:50:07	31.2	30.9	31.2	33.1	31.2	41.7	33.2	35.3	
13:00:08	41.1	39.7	42.0	39.7	31.2	41.8	33.3	35.3	
13:02:08	43.2	42.0	44.3	41.0	31.4	41.2	33.4	35.7	
13:04:08	43.6	42.0	45.1	42.0	31.6	41.2	33.5	35.6	
13:06:10	45.0	45.0	48.8	45.4	31.7	41.8	33.7	36.3	
13:08:12	45.4	45.0	47.3	43.9	31.8	41.8	33.6	36.9	
13:10:12	47.4	45.0	53.4	46.0	32.0	42.0	34.0	36.8	
13:12:12	48.0	48.0	50.0	46.0	32.0	42.0	34.0	37.4	
13:14:14	48.0	50.0	50.1	49.7	32.4	42.0	34.4	37.6	
13:16:16	50.0	51.0	54.1	49.2	32.7	42.2	34.7	38.3	
13:18:16	50.4	51.0	50.0	50.0	32.6	42.2	34.6	38.6	
13:20:17	51.8	53.4	57.3	51.8	33.0	42.0	35.0	39.4	
13:22:18	51.8	57.0	57.0	51.8	33.0	42.0	35.0	39.9	
13:24:18	53.2	55.0	60.3	54.3	33.8	43.0	35.8	40.5	
13:26:20	53.1	54.0	57.7	52.4	34.1	43.0	36.1	41.1	
13:28:21	54.8	57.0	59.0	56.2	34.4	43.0	36.4	41.7	
13:30:22	54.8	56.1	59.3	53.8	34.7	43.0	36.7	42.1	
13:32:23	56.4	58.0	63.4	56.8	35.1	43.1	37.1	42.8	
13:34:24	58.1	58.1	61.3	55.8	35.0	44.4	37.3	43.0	
13:36:25	56.2	56.1	63.7	57.0	35.8	44.2	37.8	44.1	
13:38:26	57.3	60.0	64.0	57.7	36.3	45.0	38.3	44.8	
13:40:27	57.2	59.6	64.0	57.7	36.7	45.0	38.7	45.4	
13:42:28	58.4	61.4	66.1	59.0	37.0	45.0	39.0	46.0	
13:44:29	58.1	60.2	63.8	57.8	37.6	46.0	39.3	46.8	
13:46:30	59.2	60.7	66.1	61.0	37.6	46.0	39.6	47.2	
13:48:31	59.1	61.1	64.3	60.5	38.1	46.2	40.1	47.6	
13:50:32	59.8	63.0	66.0	61.0	38.7	47.1	40.7	48.4	
13:52:33	60.3	62.0	66.3	60.1	39.1	47.0	41.1	49.0	
13:54:34	60.3	62.0	68.7	61.6	39.0	47.0	41.0	49.6	
13:56:35	61.2	64.1	68.0	61.7	39.0	48.0	41.0	50.1	
13:58:36	61.0	63.0	68.0	62.0	40.0	48.0	42.4	50.8	
14:00:37	62.0	65.0	70.0	63.0	40.0	48.0	42.4	51.2	
14:02:38	61.0	64.1	67.0	61.7	41.2	49.2	43.2	51.7	
14:04:39	62.0	66.0	71.0	64.0	41.0	48.0	43.0	52.0	
14:06:40	62.0	64.0	68.1	62.1	42.0	50.0	44.0	52.7	

g)



h)

Fig.Automation of Heat Treatment Chamber (f) HMI Output (g) Data Logging Output (h) Output Graph

V. CONCLUSION

The system's precision is improved by applying sophisticated regulated approaches. It eliminates every flaw in the manual procedure. It is possible to record data, and the datum may be valuable in the future. The automated system is also very user-friendly, and it is quite simple to communicate with it and other systems. The system's calibration feature is another crucial component that comes in handy during inspections. The heat-treated wood from the automated process is superior to the heat-treated wood from the manual process, due to factors like precision and accuracy, which results in the wood being more evenly heat treated, and better cured than the manual process. The automated heat treatment chamber has a variety of advantages over the manual process, which are cited in the upcoming sections.

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