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Furnace Control System Using the TCN4S Temperature Controller

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Abstract

In the academic world, especially in research activities at the University of Lampung, there are many things that the application of research requires an instrumentation system design to support these research activities. One example is used to melt metal or other materials. Therefore, this research aims to make a furnace using the Autonics TCN4S temperature controller. The basic configuration of a temperature regulation system consisting of temperature control is TCN4S, SSR (Solid State Relay), and Thermocouples. The results of this study indicate that the maximum temperature that can be achieved is 383°C within 710 seconds in an open space with an electric power of 1032.48 Watt and a strong current of 4.7 A so that the consumption of electricity consumption in the furnace is 0.2 KWh.

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Abstrak

Dalam dunia akademik khususnya dalam kegiatan penelitian yang ada di lingkungan Universitas Lampung banyak hal yang penerapan penelitiannya membutuhkan sebuah rancangan sistem instrumentasi untuk menunjang kegiatan penelitian tersebut. Salah satu contohnya digunakan untuk melelehkan logam atau bahan lainnya, oleh karena itu penelitian ini memiliki tujuan membuat alat furnace menggunakan temperatur controller Autonics TCN4S. Konfigurasi dasar sistem regulasi temperatur yang terdiri dari kontrol temperatur yaitu TCN4S, SSR (Solid State Relay), dan Termokopel. Hasil penelitian ini menunjukkan suhu maksimal yang dapat dicapai yaitu 383°C dalam kurun waktu 710 detik pada ruang terbuka dengan daya listrik sebesar 1032,48 Watt, kuat arus sebesar 4.7 A sehingga konsumsi pemakaian listrik pada alat furnace yaitu sebesar 0,2 KWh.

1. Introduction

A laboratory is used to do the measurement, observation, research, or research related to science with knowledge of science and others (Emda, 2017). Along with the development of knowledge and increasingly technology fast, demand development system reliable control. System reasonable control very required to increase efficiency in the research process. Equipment in the laboratory must be equipped with various supporting equipment for To do research science or other. One tool in the laboratory and often used for To do study is a furnace heating or in term scientific known with designation Furnaces. A furnace or heating furnace is the equipment used to melt metal or material and change its shape (e.g., rolling, forging) or properties (heat treatment). Based on the method producer hot, furnace by large classified Becomes two types: type burning (using ingredient burn) and type electricity. Furnace with type burning depends on the type of ingredient fuel used. Among them, Furnaces that use ingredients that burn oil, stone coal, or gas. Meanwhile, the type of electricity, of course, uses AC electric current according to the name of the type.

Settings temperature is wrong, one of the most crucial needs for world industry. Many production processes are carried out using temperature specific, so they are free from disturbance (Tadeus & Setiono, 2018). A furnace (Heater) emits hot or reaches more temperatures tall (Huda, 2011). a heating furnace consists of a heating chamber formed from several layers, including the inner layer covered by firebrick, the firebrick insulation layer, and the outer layer of metal (Arif & Kamaruzzaman, 2015).

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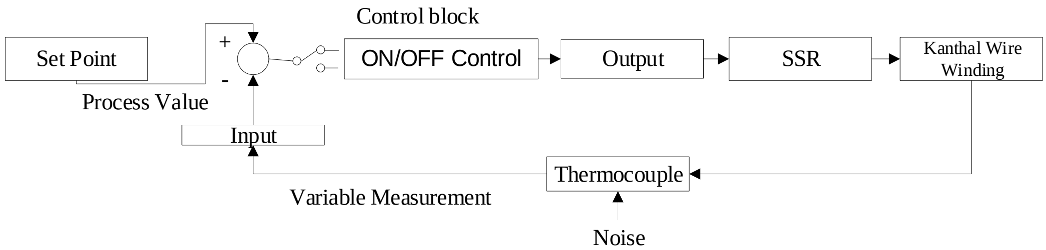
In world academics, specifically in activity research in the environment, University of Lampung a lot of applicability thing research need a design system instrumentation to support activity study. Major Physics University of Lampung is a wrong one example majors always consistent in activity study specifically in field science and technology. Because that significantly required a tool that can help activity study the however naturally Thing, they will swallow significantly cost expensive if at each study must buy tool new. Because of that, the impact could drop quality research due to expensive tools to support research. In the workshop room of the Basic Physics Laboratory building, there is an abandoned furnace that is no longer used because it cannot function properly but still has a good framework. There are other furnace tools, but the maximum temperature that can be reached is only up to a temperature of approximately 600°C.

One way to face the problem is to use device support to study artificial (work lecturer and student at University of Lampung). With effort, it is hoped the quality of study not decrease, and the price will be relatively lower with no quality different far with tools that have been so. On opportunity, this will research done for designing machine electric Furnace designed for making it easy for student or expert metal (metallurgist) do his research. The furnace is required in study to make it easy and optimize nature mechanical from metal. Study this also have the destination for make tool furnace heater (furnace) using temperature TCN4S controller to reach temperature 1000℃.

2. Method Study

The method used is planning beginning at a time making and testing for test performance Suite electricity and test speed achievement temperature. The tools and materials used in this research are the Autonics TCN4S series temperature *controller*, heating element, thermocouple temperature sensor, SSR (*Solid State Relay*), power cable, and plug.

Design device complex stages composing components electronics that become one unity in something system Suite so the tool can work well. The design device hard can be seen in **Picture 1.**



Picture 1. Basic configuration of temperature regulation system

Picture 1 is the configuration of the+ basis of a temperature regulation system consisting of temperature control, namely TCN4S, SSR, heating element, and thermocouple. The temperature control used is the temperature control from the Autonics TCN4S series, which has a temperature control function to convert the output from the temperature sensor into a process value and issue control output to the controller so that the process value will approach the set point value which will be directly displayed on the temperature controller display. SSR here working as controller a magnetic switch that changes the current to the heater ON and OFF, the thermocouple functions as a temperature sensor which measures the temperature contained in the heating element and will then be forwarded to the temperature control.

TCN4S Autonics Sensor Settings, the thermocouple sensor is connected to pins 10 and 11. A menu group will appear by pressing the mode button for 4 seconds PAr2 and be navigated using the direction buttons until a menu appears In-t. In this menu, we can select the default sensor type, namely KCA. The next step is to set the temperature reading correction factor by navigating to the menu In-b and entering the value corresponding to the calibration.

Autonics TCN4S actuator equipment settings and actuator equipment that can be used are relays and SSRs. The SSR input voltage terminal is connected to pins 1 and 2. The SSR is used by the Fotek brand 40DA series. They set settings by pressing the button mode for 4 seconds. A menu group will appear PAr2 and be navigated using the directional buttons until a menu appears oUt to determine the type of actuator, relay, or SSR equipment. When SSR is selected, the SSR output type can be selected through the menu SSrM options: Standard, Cycle, and Phase. After that, it is necessary to set the control cycle time by selecting the menu t by default for 20 seconds for relay actuators and 2 seconds for SSR. The Set Value (SV) setting or the Autonics TCN4S reference is set by pressing any key while the controller is running. SV can be changed to larger or smaller by pressing the directional buttons and setting it simply by pressing the mode button.

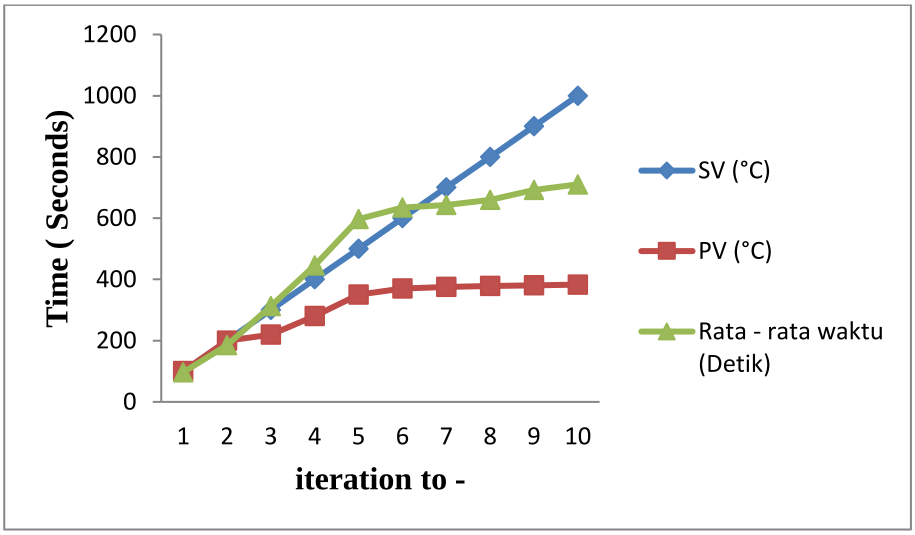
3. Results and Discussion

Tests are carried out to see whether the tool's temperature and time control system has been working correctly. The test starts by setting the input temperature Set Value (SV) and then pressing the mode button. The heater will be active until the input temperature is reached and the temperature is held according to the holding time. Then, the current flow to the heater will be cut off through the SSR module. Obtained data is shown in **Table 1**.

Table 1. PV Temperature Increase Data on Time

SV (°C)	PV (°C)	t1	t2	t3	t4	t5	Average Time (Seconds)	*Error* %
100	100	97	96	97	97	95	96.4	3.6
200	199.9	188	187	185	183	184	185.4	7.3
300	220	315	313	311	312	310	312.2	4.07
400	280	450	449	446	442	441	445.6	11.4
500	350	597	599	597	596	595	596.8	19.36
600	370	640	638	641	621	635	635	5.83
700	375	648	646	642	640	641	643.4	8.08
800	378	663	657	660	659	661	660	17.5
900	381	690	693	690	691	695	691.8	23.13
1000	383	715	713	710	709	705	710.4	28.96

Table 1 contains time repetition data measured using a stopwatch for five repetitions with a temperature range from 100° C to 1000° C. After obtaining the observation data, as shown in Table 1, it is then reflected in the form of a graph, as shown in **Figure 2**. However, as seen in the data above, the Process Value (PV) temperature did not reach the desired Set Value (SV) because the test was carried out in an open space. In the first and second data, the PV value is still close to SV, but in data three and so on, the PV value is very far from SV.



Picture 2. Graph of PV Temperature Increase with Time

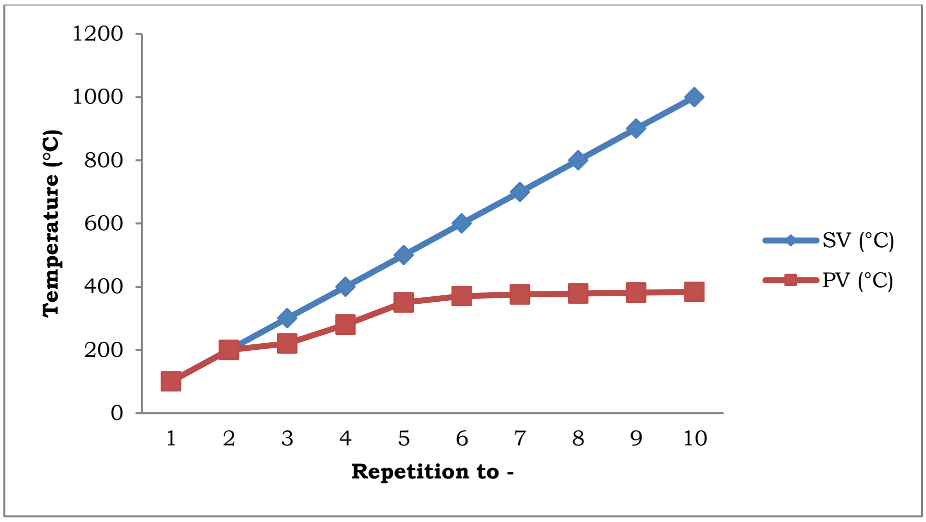
Based on **Table 1** and **Figure 2**, the first data with an SV of 100 °C obtained the exact PV value of 100 °C with an average period of 96.4 seconds, and the second data value of SV 200 °C obtained a PV value of 199.9 °C which is almost close to the SV value. With an average period of 185.4 seconds, the third data value of SV 300 °C obtained a PV value of 220 °C with an average period of 312.2 seconds. The fourth data value of SV 400 °C obtained a PV value of 280 °C with a period of an average of 445.6 seconds, the fifth data value of SV 500 °C obtained a PV value of 350 °C with an average period of 596.8 seconds, the sixth data value of SV 600 °C obtained a PV value of 370 °C with an average period. With an average of 635 seconds, the seventh data value of SV 700 °C obtained a PV value of 375°C with an average period of 643.4 seconds. The eighth data value of SV 800 °C obtained a PV value of 378 °C with an average period of 660 seconds, the ninth data value of SV 900 °C obtained a PV value of 381 °C with an average period of 691.8 seconds, the last data is the tenth value of SV 1000 °C did get a PV value of 383 °C with an average period of 710.4 seconds.

The second sensor test examines the temperature relationship between the Set Value (SV) and Process Value (PV).

Table 2. Input Temperature (SV) to Process Temperature (PV)

SV (°C)	PV (°C)	*Error* (%)
100	100	0
200	199.9	0.1
300	220	26.7
400	280	30
500	350	30
600	370	38.3
700	375	46.4
800	378	52.7
900	381	57.7
1000	383	61.7

After obtaining data such as **Table 2** above, temperature testing was carried out starting from 100 °C to 1000 °C. The relationship between the input temperature (SV) and the process temperature on the sensor can be seen in **Figure 3**.



Picture 3. Input Temperature (SV) to Process Temperature (PV)

The graph above shows the relationship between input and process temperature. It was found that the process temperature for the first and second tests, respectively, with temperatures of 100 and 200, obtained linearity to the input temperature. However, when the third to the final test, the results differed from the input temperature below the input temperature. This happens because the incoming current to coil wire khantal is too small, i.e., 1.05 mA. The cause is because coil wire length, measurement done in the room open not in the box furnace then the ambient temperature influential, density coil wire also influence measured temperature because the more meeting coil wire eats will the more tight coil wire the heat up.

The electrical power used in the furnace can be known after the length of the coil of wire is 1.89 m, and the resistance of the wire is 24.6 with an electric voltage of 220 V as follows:

R = Wire Length × Wire Type Resistance (Equation 1)
= 1.89 m × 24.6
= 46.49

$P = \frac{V^2}{R}$ (Equation 2)

$= \frac{220^2}{46,49}$

$= \frac{4800}{46,49}$

= 1032.48 *Watts*
= 1.03248 K *watts*

From equations 1 and 2 above, the electric power used by the furnace is 1032.48 *Watts*. Meanwhile, the current strength is obtained at 0.0047 A with the following calculations:

$I = \frac{P}{V}$ (Equation 3)

$= \frac{1{,}03248}{220}$

= 0.0047 A

Consumption of electricity consumption in the *furnace* is calculated from a temperature of 100 ° C to a temperature of 383 ° C with a time of 710 seconds or 11.8 minutes, as follows:

$KWh = \frac{P}{1000} \times \frac{t}{60}$ (Equation 4)

$= \frac{1032{,}48}{1000} \times \frac{11{,}8}{60}$

= 1.03248 *Watt* ×0.197 *Hour*

= 0.2 KWh

So, the consumption of electricity when the *furnace* is used is 0.2 KWh.

4. Conclusion

Based on the data analysis that has been carried out, it can be stated that the results of the research are not following the objectives because the maximum temperature that the furnace can achieve is 383 ° C in an open space with a period of 710 seconds, the heating element used is kanthal wire A1 with a coil length 189 cm long, and the resistance of the wire is 24.6. The electric power used in the furnace is 1032.48 *Watt,* and the current is 0.0047 A. So the electricity consumption in the furnace in 710 seconds is 0.2 KWh.

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