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Furnace Engine Modification to Lower Power

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Abstract. Furnace machine or heating furnace is a tool used for heat treatment processes or usually called heat treatment, furnace machines have several types from the beginning found furnace machines, namely induction furnaces/conventional furnaces and then transformed into electric furnaces, electric furnaces are more often used for processes heat treatment because it is cleaner compared to the convection furnace.The furnace machine requires 5000 watts of power, 13.1A. to reach the temperature of 8000 takes 7296 seconds. Furnace machine testing is by quenching using ST-42 steel which is held at 6000 and varying time, the first test material is not treated with heat traetment, for the second test material with a variation of 15 minutes, third 30, fourth 60, fifth 90, sixth 120 minute. the results of the quenching process were tested using the Brinell and Vickers hardness test methods.

Keywords: Electric Furnace, Electric Furnaces, Modified Furnaces

INTRODUCTION

Metallurgy is a field of materials science and engineering that studies the physical and chemical behavior of metal elements, metal intermediate compounds, and metal alloys called alloys or lacquers. Metallurgy is also a metal technology, that is, the application of science in metal production and engineering metal components for use in products intended for consumers and manufacturing industries. Metal production involves processing ores to extract their metal content and combining metals, sometimes with non-metallic elements, to produce alloys. Metallurgy differs from metal processing crafts, although technical progress in metal processing depends on the development of metallurgical science, as well as technical progress,

Engineering is a field of science that relies on the principles of physics, mathematics, chemistry, and engineering application processes handled by the engineering itself to explain in detail the events and analysis of mineral form processing units, metal extraction processes as well as mixtures of materials, analyzing relationships with the behavior of metal properties in their structure. During the process, the process of strengthening or

heating the metal occurs with the progress of failure degradation (decrease in resistance) in the metal. (wikipedia.org/metalurgi).

The heat treatment process is an activity to make more strength from the old material, namely the quench process. The primary purpose of the heat treatment process is to create a material whose surface is challenging but still ductile. Electric induction heaters follow the heating principle of alternating electricity (AC). The induction heater is then tested by heat treatment using an ST 37 steel specimen with water media cooling media; the variation of this test is the variable temperature. This induction heater has a temperature capacity of 1200 0C.

The use of metallurgy is quite broad; besides being studied in the field of science education, it is also used in education, engineering, etc. Such as technical practicum, engineering training, processing of excavated materials (such as coal, gold, metals, etc.), metal extraction processes, metal refining, metal heat at the stage of metal formation, and study of operating technology and its design based on metallurgical systems. Purification activities are generally supported by purification tools performed during the failure process, degradation conditions, decrease in material resistance, and changes in material structure. After that, the technical party can conduct an analysis and output from the analysis results based on existing activities (Rizal Agus, 2016).

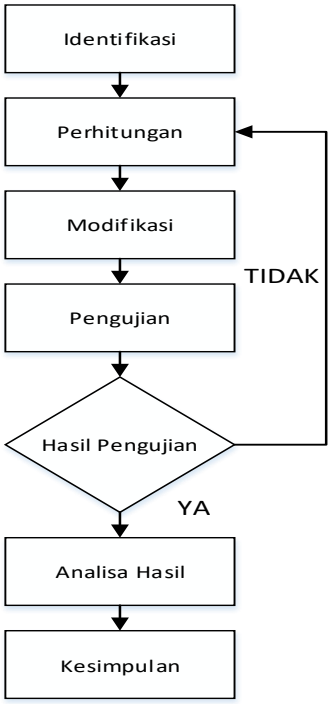
Furance, often also called a furnace, is a tool used for heating. Its name comes from the Latin Fornax, oven. Sometimes, people also call it a kiln. The furnace itself is often analogous to a furnace as an industrial use used for many things, such as making ceramics, extracting metals from ore (smelting), or in oil refineries and other chemical plants, for example, as a heat source for fractional distillation columns. The furnace is the kitchen as a heat receiver for combustion, which has a fire gate at the bottom as the base for fuel, and around it is a boiler water pipe attached to the wall of the combustion chamber wall that receives heat from the fuel by radiation, conduction, and convection (Kreith F, 1991).

A furnace is equipment used to melt metal for the manufacture of machine parts (casting) or to, heat a material and change its shape (e.g., rolling/rolling, forging) or change its properties (heat treatment). Since the exhaust gases from the fuel are in direct contact with the raw material, the type of fuel chosen is essential. For example, some materials will not melt sulfur in fuel. Solid fuel will produce particulate matter that will interfere with the raw material placed in the furnace. An *electric furnace* is a heating device that uses a heat source from electricity (wikipedia.org).

Today's conventional furnaces sometimes need more accuracy in process time and temperature. This research aims to make a microcontroller-based electric furnace machine with the primary function of the heating process more accurate to maintain time and temperature. It can be adjusted automatically and on the monitor via LCD. (Supriyanto H, 2015). However, the electric furnace machine has a weakness: the power consumption required is too large, so it requires circuit modification.

METHOD

An electric *furnace* is a heating equipment whose heat source is from electricity. The advantages of electric furnaces are more precise time accuracy, cleaner than conventional furnaces, and the operator can adjust the temperature for heating. (Suprayitno H, 2015) Every tool/machine always has advantages and disadvantages, as this electric *furnace* requires a large enough consumption of electrical power. So, a modification process is carried out to reduce the power consumption of the furnace's electric engine. The following is the methodology of the modification process:



Gambar 3.1 Flow Chary Identification

Preferably, when we make data unmodifying tools, we must require field observations to know what we need; the tools to be modified must be under how many in the field. From field observations of furnaced tools/machines, there is a drawback, namely, the power needed to operate the tool is too large, so it needs to be modified to be used in the field. After obtaining data from the field, the reference is books and journals; after obtaining literature, modifications to the tool are carried out, and experiments are carried out to solve a deficiency of the tool.

Modification Process

To achieve perfection, the furnace engine must be modified, and the modification process includes a series of heating wire elements, namely changing the series of heating wire elements from the star circuit to the delta circuit, with a note that the modification process must be the same as the working principle of the components, to make it easier to understand the circuit, a *wiring diagram is designed.* The following is the series before modification and after modification.

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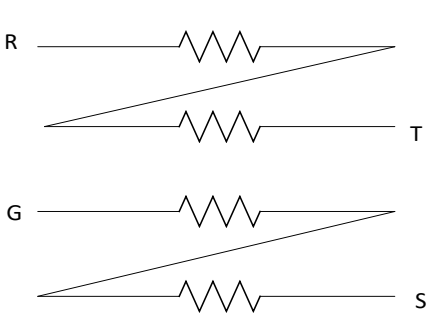

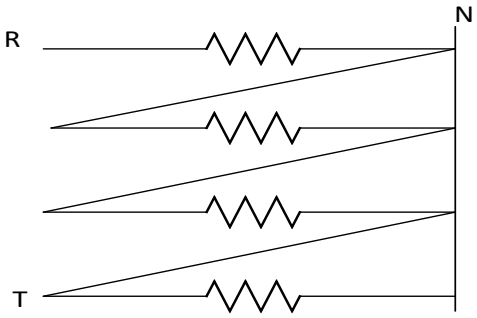

Figure 4.2 Elements Before Modification Figure 4.3 Elements After Modification

DISCUSSION

Comparison of power consumption before and after modification. After carrying out the modification process, it is required to calculate the difference in power difference, usually called making comparisons. From the comparison results, it can be known how much power difference is needed to operate the *Furnace* engine. *The furnace* engine uses 3-phase electricity, which is 380 V. Please note that every 1watt equals 0.00263 A. can be calculated by the formula: $I = \frac{1}{380} = 0{,}00263$. For more details see the table 4.1.

Table 4.1 Power Calculation

Engine power before modification	Engine power after modification
i = 0,00263 x 8200 watt = 21,5 A $P = \frac{V^2}{R}$ $= \frac{380^2}{17{,}5\Omega}$ = 8200watt $I = \frac{P}{V}$ $= \frac{8200}{380}$ = 21,5 A	i = 0,00263 x 5000 watt = 13,1 A $P = \frac{V^2}{R}$ $= \frac{380^2}{28{,}9\Omega}$ = 5000watt $I = \frac{P}{V}$ $= \frac{5000}{380}$

Constant Temperature Analysis

Cash temperature analysis is to find out the temperature in the furnace engine to withstand the desired temperature, on constant testing using a temperature of 600 0C. To make it easier to analyze graphs, the following is a constant temperature analysis on furnace machines, temperature drops ranging from 3 - 50 C during the test time of 120 minutes.

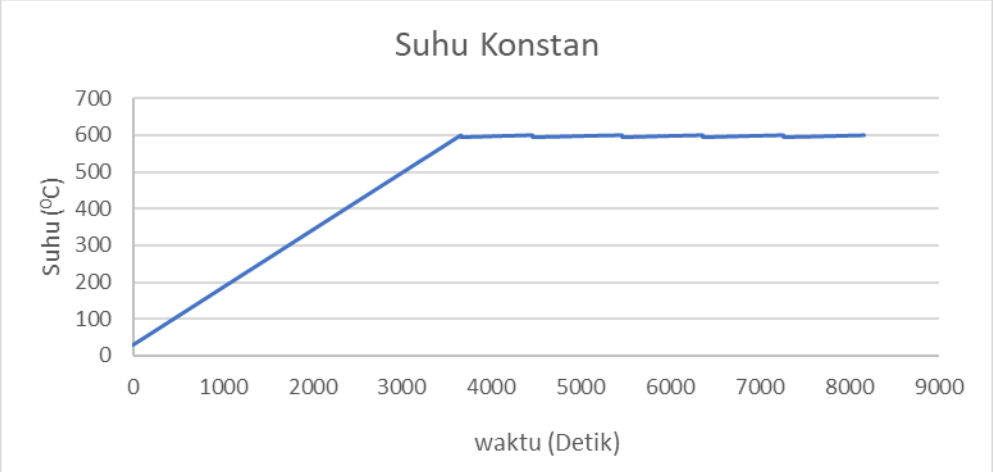

Figure 4.4 Constant temperature for 2 hours

Constant Temperature Test Analysis

This constant temperature testing is testing the temperature of the furnace engine to withstand the desired temperature. This test uses a temperature of 6000 and uses time variations, namely 15 minutes, 45 minutes, 90 minutes, 120 minutes, the material used is St 42 steel. And hardness tests were carried out with the Brinell and Vickers methods.

Table 4.2 Hardness Testing Data

No	Material Code	Temperature (^{0}C)	Time variation (Minutes)	Types of Testing	
				Brinell (N/m^2)	Vickers (N/m^2)
1	**A**	-	-	148	724
2	**B**	600	15	143	210
3	**C**	600	30	145	185
4	**D**	600	60	147	185
5	**E**	600	90	149	189
6	**F**	600	120	150	189

Description: material code = material code to distinguish materials/samples

Formula:

Brinell Testing

L = 615 x 0.002 x 4

=4.92 results see in hardness table

Information:

L = Diagonal length

N = result of using indicator numbers (beginning-end)

I = microscope magnification constant 2.5x= 0.004 and 5x=0.002

B = When 0 = 2.5 constant (4)

0 = 5 constants (2)

Vickers Testing

L = 535 x 0.002

=1,605 results see in hardness table

Information:

L = Diagonal length

N = indicator measurement result

I = microscope magnification constant 2.5x= 0.004 and 5x=0.002

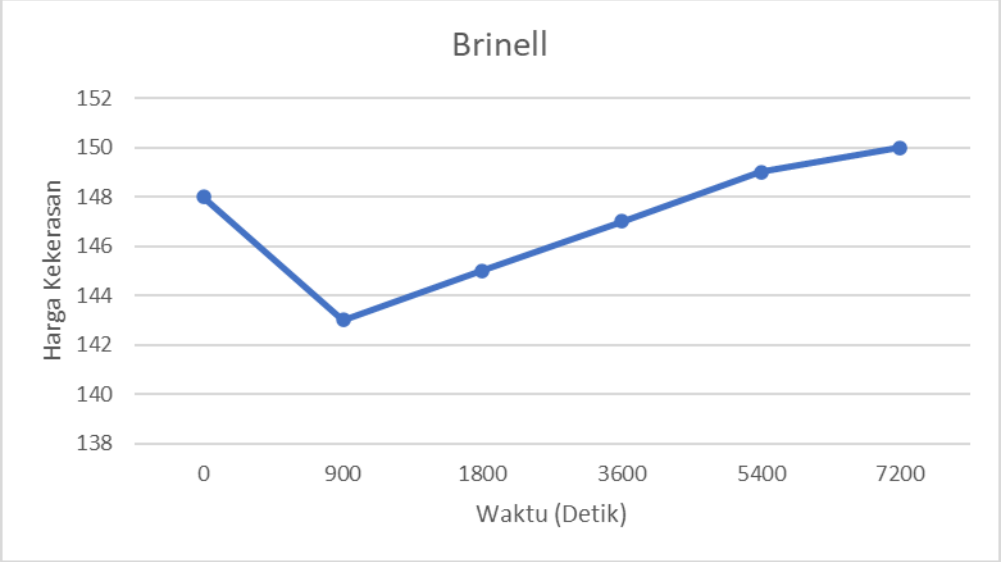

Figure 4.5 Vickers Hardness Test Graph

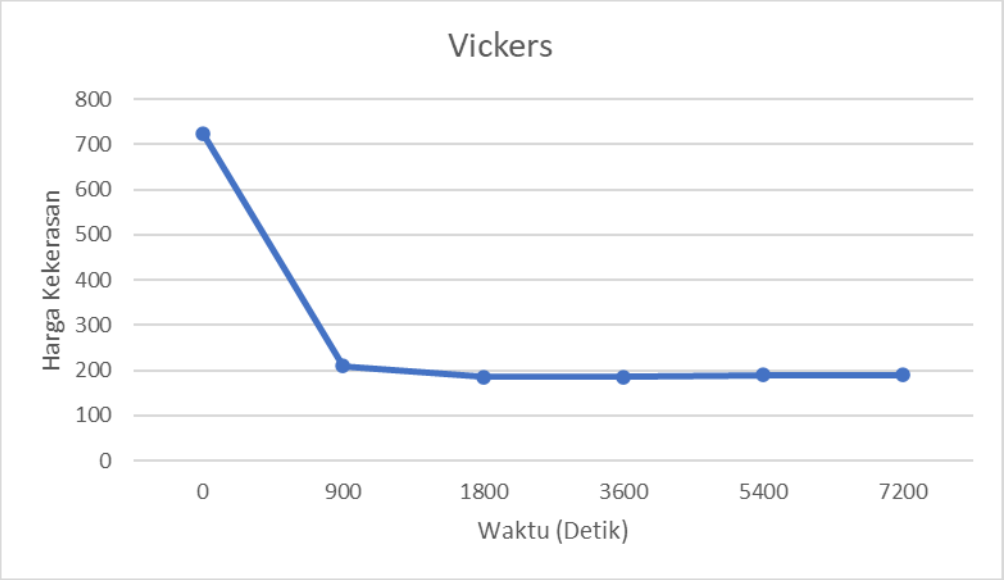

Figure 4.6 Brinell Hardness Test Graph

Temperature Achievement Analysis

Furnace machines are used for the heat treatment process/heat treatment to achieve perfection and appropriate data, and then engine testing is carried out. In this test using a stopwatch to determine the speed of temperature change of this *furnace* engine with units of 0C, the following is a comparison of temperature achievement before and after modification. To make it easier to understand, see the comparison in the table. 4.1 Temperature Achievement Before Modification and Table 4.4 Achievement After Modification.

Table 4.3 Temperature Achievement Before Modification

No	Initial temperature ^{0}C	Final temperature ^{0}C	Temperature achievement time (Second)	Real-time (Seconds)	Speed of heat transfer ($^{0C/sec}$)
1	30	50	36	36	0,5556
2	50	100	209	245	0.2392
3	100	150	385	630	0.1299
4	150	200	432	1062	0.1157
5	200	250	463	1525	0.1080
6	250	300	559	2084	0.0894
7	300	350	582	2666	0.0859
8	350	400	569	3235	0.0879
9	400	450	590	3825	0.0847
10	450	500	520	4345	0.0962
11	500	550	694	5039	0.0720
12	550	600	971	6010	0.0515
13	600	650	1136	7146	0.0440
14	650	700	1211	8357	0.0413
15	700	750	1198	9555	0.0417
16	750	800	1395	10950	0.0358
			average	(^{0}C/Second)	0,0827

Table 4.4 Achievements After Modification

No	Initial temperature ^{0}C	Final temperature ^{0}C	Temperature achievement time (Second)	Real-time (Seconds)	Speed of heat transfer (^{0}C/sec)
1	30	100	185	185	0.3783
2	100	150	130	215	0.5882
3	150	200	182	392	0.2380
4	200	250	264	656	0.1275
5	250	300	305	951	0.0773
6	300	350	322	1273	0.0525
7	350	400	363	1636	0.0392
8	400	450	366	2002	0.0305
9	450	500	447	2449	0.0249
10	500	550	486	2935	0.0204
11	550	600	723	3658	0.0170
12	600	650	807	4465	0.0136
13	650	700	725	5190	0.0111
14	700	750	988	6178	0.0096
15	750	800	1118	7296	0.0080
			Average	(^{0}C/Second)	0,1090

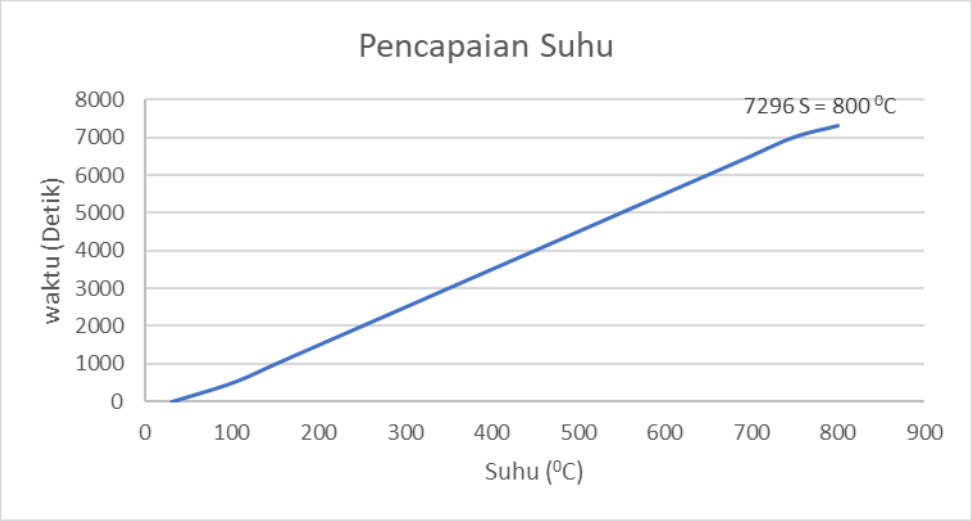

Figure 4.7 Temperature Achievement Speed Graph

From the data above, it can help us to read and understand how *a* microcontroler-based electric furnace engine works which takes 7296 seconds to reach a temperature of 8000C. After obtaining the data, the calculation of the time accuracy of the Furnace engine is carried out, the formula can be calculated:

Total Time = (Temperature Achievement + Heating Time)

Information:

Total Time = Total time is the total amount of time that occurs during the *Heat Treatment process* using the Furnace electric machine.

Temperature Achievement = Temperature achievement time is the time it takes for the furnace electric machine to reach the desired temperature at the time of testing.

Heating Time = Heating time is the time required by the material according to the material literature.

CONCLUSION

The results of engine testing can be analyzed from the electric *furnace* engine that has been modified, and a conclusion can be drawn:

1. This Furnace *machine* is handy for the *Heat Treatment process*.
2. From the modification process, the original 8200 watts of electrical power was reduced to 5000 watts so that *the Furnace* machine can be used in the upside machine laboratory.
3. The process of achieving temperature to reach a temperature of 800 is faster than before the *Furnace* engine was modified; the temperature achievement ratio was 7296 0C / s, while before the modification, it was 10950 0C / s.
4. The temperature limit *of Heat Treatment* in *Furnace* machines is 1200 0C because the temperature limit of nickel wire and thermocouple sensor is 1200 0C.

The limit of the capacity or dimensions of the material is a length of 28 cm, a width 30 cm, and a height 20 cm. If the material exceeds that size, it will result in complex retrieval.

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