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Design, Manufacturing, and Evaluation of Mini Scale Aluminum Melting Furnace Fueled by LPG Gas to Support Practicum Activities

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***Abstract* - The Manufacturing Engineering Laboratory is one of the laboratories in the Mechanical Engineering Department of the Bali State Polytechnic. This laboratory is a place for student practicum in manufacturing process courses. The Manufacturing Engineering Laboratory is still lacking in equipment, this can be constrained by the learning process or the implementation of research, especially regarding metal casting techniques. This study aims to design a metal smelting furnace that can support the smooth process of learning and research in the laboratory. Metal smelting furnaces are designed to smelt non-ferrous metals using gas as fuel. The combustion process is carried out by mixing LPG gas fuel and air from the blower. Furnace testing was carried out on locally sourced aluminum scrap material. The test results show that the ability of the furnace to melt 2 kg of aluminum scrap at a temperature of 703.1 ^{o}C for 15 minutes with 0.285 kg of LPG fuel.**

Keywords: manufacturing, process, casting, metal, smelting furnace.

I. INTRODUCTION

The Manufacturing Engineering Laboratory at the Department of Mechanical Engineering of the Bali State Polytechnic is a place for student practicum for the Manufacturing Process course. This laboratory is still lacking in equipment, this is an obstacle in the lecture or research process in the laboratory, especially regarding metal casting engineering material studied in the Manufacturing Process course. To overcome these problems, it is necessary to design a metal casting tool that can support the smooth process of lectures and research in the laboratory.

In the casting process, the metal must be heated until it melts, then it is poured into the mould. The process of heating and smelting metal is carried out in the furnace (furnace). There are various types of metal smelting furnaces, both the shape and the type of fuel used [1].

The crucible furnace is the oldest used furnace. This furnace has the simplest construction and uses a fixed position where the liquid metal is taken using a ladle or dipper. This furnace is very flexible and versatile for small and medium-scale foundries. This furnace fuel is gas or fuel oil, because it is easy to monitor its operations [2].

Several metal smelting furnaces have been developed by previous researchers.

Shaleh [3], examined the process of making a crucible furnace with LPG gas fuel for the use of recycling aluminum waste as a raw material. Tests were carried out with three variable crucibles with diameters of 138 mm, 112 mm and 88 mm for 30 minutes. The most efficient test results are found in the third variable with a volume of 4678.6 cm3 for 30 minutes = 0.15 kg of LPG.

Yahya [4], designed and fabricated a 5 kg waste metal (non-ferrous) smelting furnace construction using LPG gas as fuel for processing aluminum waste. From the results of this design the capacity of the designed tool is 5 kg with a crucible/ladel using a cylindrical pipe with a diameter of 10.5 cm, a height of 24.4 cm, with a large crucible furnace having a length of 50 cm, a height of 50 cm, using gas fuel LPG. In this design the crucible/ladle can accommodate as much as 5 kg of molten aluminum.

Istana [5], carried out the design, manufacture and testing of aluminum smelting furnaces fueled by used oil (used cooking oil). The resulting metal smelting furnace has a melting capacity of 10 kg of Aluminum. The outer dimensions of the furnace are cylindrical with a diameter of 36 cm, a height of 40 cm and an inner dimension of a diameter of 30 cm and a height of 35 cm. From the test results, it was found that the time needed to melt 1 kg of aluminum was 25 minutes at a temperature of 701 oC with a fuel consumption of 1.48 liters. This furnace is expected to be a learning tool for students in non-ferrous metal casting engineering lectures, especially aluminum.

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Yusuf [6], designed a metal smelting furnace that can support the smooth process of learning and research in the laboratory. Metal smelting furnaces are designed to smelt non-ferrous metals using gas as fuel. The combustion process is carried out by mixing LPG gas fuel and air from the blower. Furnace testing was carried out on locally sourced aluminum scrap material. The test results show that the ability of the furnace to melt 6 kg of aluminum scrap at a temperature of 645 ^{o}C for 52 minutes with 1.35 kg of LPG fuel.

A gas fired crucible furnace for melting aluminum scrap has been designed and fabricated by Esor. The furnace model is designed according to the needs of laboratories and workshops. The trial results show that the designed furnace can melt as much as 5 kg of aluminum scrap at a temperature of 660 ^{o}C for 300 seconds [7].

The design of an aluminum metal smelting furnace with an electric resistance mechanism has been carried out by Adi. According to Adi [8], the test results of an electric furnace with dimensions of T = 214 mm, with an outer diameter of 284 mm, resulted in the conclusion that this electric resistance furnace can produce temperatures up to 800 ºC, the melting process of 2 kg of Al metal with a temperature setting of 750 ºC This furnace actually takes a total of 58 minutes while theoretically it only takes 54.24 minutes, the furnace efficiency is 64.05% with an electric power of 3385.3 W.

Arianto [9], built an aluminum smelting furnace to develop casting competence at the Mechanical Engineering Vocational High School, which measures Ø 600 x 500 mm. The furnace requires 2.7 kg of LPG gas and 55 minutes to melt 8.6 kg of aluminum. Crucible capacity of 15 kg of molten aluminum. Prambanan Muhammadiyah Vocational School teachers have been able to operate aluminum smelting furnaces, make sand molds and carry out general and special maintenance.

Winarno [10], conducted a furnace test with furnace dimensions P = 600 mm, L = 600 mm and T = 600 mm, furnace wall plate thickness 0.8 mm, using an insulator of ash from burning husks, crucible with a thickness of 5 mm, width 20mm. Producing the conclusion among other things, the designed furnace can be used to smelt aluminum with a melting rate of 2.6 kg of aluminum scrap per hour and a fuel consumption rate of 3.25 kg of fuel/hour, the rate of burning this fuel is smaller when compared to the furnace diesel fuel smelting, used oil fuel and kerosene-fired smelting furnaces, the fuel requirement for smelting aluminum is 1.3 kg of fuel per kg of aluminum scrap, the efficiency of the designed aluminum smelting furnace is 5.45% because the heat losses that occur are still quite large.

A comparative study between diesel-fired furnaces and butane gas-fired furnaces for smelting aluminum has been carried out by Akhaze. The results of his study found that butane gas-fired furnaces were more suitable for aluminum smelting. Butane gas furnaces have lower operating costs and faster pouring temperatures when compared to diesel furnaces [11].

Magga [12], conducted an analysis of the design of a portable charcoal-fired non-ferrous metal smelting furnace as a learning tool. The planned smelting furnace is in the form of a box with a cylindrical inner diameter and crucible cylindrical in shape, the dimensions of the furnace are 50 cm x 50 cm and the volume of the crucible is 1.85 liters. From the results of the analysis that has been done it is known that the amount of heat used to melt 5 kg of aluminum requires a heat of 3,030,600 J.

LPG gas-fired aluminum smelting furnaces are widely sold in the market, but the price is very expensive, capacity, fuel efficiency, depending on the manufacturer that issued it. For small scale aluminum stoves it is still rare and difficult to obtain.

This study designed a furnace for smelting non-ferrous metals using gas as fuel to support the smooth process of learning and research in the Manufacturing Engineering Laboratory of the Bali State Polytechnic. By making this laboratory-scale furnace, the authors get a practical, efficient, cheap and easy-to-make stove model and can be widely produced to help overcome the problem of aluminum waste.

II. MATERIALS AND EXPERIMENTALS PROCEDURES

2.1 Materials

The materials used in this study were sourced locally and selected based on thermal properties, insulating ability and availability. The materials selected for the furnace components and their specifications are as follows:

Furnace

- Used Freon gas cylinder, diameter 25 cm, height 50 cm
- Fire retardant cement (technocast 16), able to withstand temperatures up to 1400 ^{o}C
- Iron pipe for burner inlet, diameter 2 inches, length 20 cm
- Iron pipe for exhaust gas, 2 inches in diameter, 10 cm long

Burners

- LPG gas cylinder 3 kg and its contents

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- LPG gas hose with a diameter of 3/8 inches and a length of 2 meters
- LPG gas regulator with faucet
- Galvanized iron pipe for the burner, ¾ inch in diameter and 40 cm long
- Galvanized iron pipe reducer ¾ x 1 inch, two pieces
- T-connection 1 inch galvanized iron pipe
- 1/8 inch inner diameter brass nozzle with 1mm outlet diameter
- Brass shock inner diameter ¼ inch long 22 mm
- Brass reducer ¼ x 1/8 inch
- Elbow brass diameter in ¼ inch
- Brass shock inner diameter ¼ inch long 60 mm
- ¼ inch diameter brass nuts, 2 pcs
- Brass unidirectional faucet with an inside diameter of ¼ inch
- Faucets open and close brass ¼ inch

Support equipment

- 2 inch blower
- AC 220V dimmers
- Cylindrical crucible with a diameter of 9 cm and a length of 12 cm, using an iron plate with a thickness of 2 mm
- Clamp with a length of 50 cm
- Ladle

2.2 Experimental Procedures

The research was conducted at the Manufacturing Engineering Laboratory, Department of Mechanical Engineering, Bali State Polytechnic. This research was conducted in several stages: (1) Furnace construction model design, (2) Furnace fabrication, (3) Furnace testing.

The furnace is made according to calculations and draft drawings. The outer wall of the furnace is made of cylindrical steel plates, using used Freon gas cylinders with a diameter of 250 mm and a height of 500 mm, the bottom is given legs using steel plates. The furnace walls are covered with fire-resistant cement (technocast 16 which can withstand temperatures up to 1500 ^{o}C) on the inside, with a thickness of 50 mm. The size of the inside of the furnace, 14 cm in diameter and 20 cm in height. The furnace is equipped with a cover and a chimney is installed in the middle position which is made of steel pipe with a diameter of 50 mm and a height of 150 mm. The burner is mounted horizontally on the side of the furnace. Crucible furnace construction as shown in Figure 1.

The combustion process is carried out by mixing LPG gas fuel and air blown by a blower. Aluminum metal is used as a material for furnace testing.

In this design the use of LPG is an alternative because the gas does not generate ash, has good heat efficiency and sufficient availability of LPG gas as fuel in crucible furnaces has been widely applied and developed [13].

Figure 1: Crucible furnace construction

III. RESULTS AND DISCUSSIONS

3.1 Design and Manufacturing of Furnace

The design of the stove pays attention to economic and aesthetic aspects but does not leave safety and construction aspects that are safe and easy to move.

The furnace was made from used freon tube Ø 25 cm, 50 cm high, and cut into two parts, the bottom and the top. The lower part is reinforced to be able to support refractory stones and crucible. The bottom is perforated on the side for heat input from the gas burner, while the top is perforated as a residual combustion gas output. The inside of the tube is covered with a ceramic blanket and castable ceramic (Figure 3) as a heat insulator. The inner insulator is a ceramic blanket and fire-resistant stone/technocast in the form of TNC-16 type powder with a maximum temperature of 1400 °C. (Figure 4). Technocast powder type TNC-16 is mixed with sufficient water, stirred, and mounted on the inside of the tube with a thickness of 5 cm.

Figure 2: Castable for furnace wall

Figure 3: Insulator in a furnace

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3.2 Heater or Burner Design Results

The design of this heater is based on tools and materials that are easy to get on the market and cheap, if a device breaks down, replacement is not hampered by the search for replacement components. Then the design of the heater or burner design is obtained as follows:

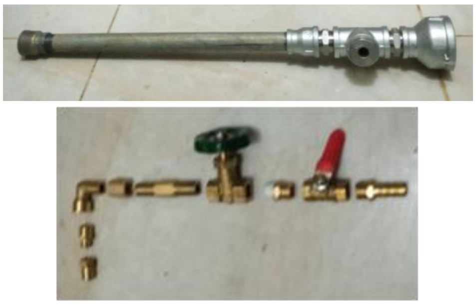

Figure 4: Heater (Burner)

3.3 Results of the Crucible Design

In this design the crucible material is a 304 steel pipe with a thickness of 2 mm with an outer diameter of 9 cm and an inner diameter of 89.6 cm, a height of 12 cm, because it has a fairly high melting point of 1398 - 1454°C, while the melting point of aluminum is 660 °C, of course, is capable enough for this aluminum smelting process. This design calculation aims to determine the needs and specifications of the materials needed for the design of crucible furnaces.

a) Calculation of crucible volume can be found by using the following formula.

Is known :
π = 3.14
t = 12 cm
ø = 8.96 cm
r = 4.48 cm
Asked: $v \ldots \ldots \ldots \ldots$. ?

$v = \pi . r^2 . t$
= 3.14 . 4.48 2. 12 = 756.25 cm^3

b) Calculate the capacity of the furnace

The capacity of the furnace can be calculated using the multiplication formula between the volumes of the cylinders with the specific gravity of aluminum, where the specific gravity of aluminum is 2.7 g/cm^3.

$Q_{Maks} = v_c . \rho_{al}$

Where :
ρ_{al} = density of aluminum
v_c = crucible volume

Is known :
v_c = 756.25 cm^3
ρ_{al} = 2.7 g/cm^3

Asked :Q_{maks}……… ?

$Q_{maks} = v_c \, . \, \rho_{al}$
= 756.25 cm^3. 2,7g/cm^3
= 2041.9 g/cm^3
= 2.1 kg/m^3

Then the design of a tube with a tube diameter of 89.6 cm with a height of 12 cm can accommodate as much as 2 kg of aluminum.

Figure 5: Crucible design

3.4 Furnace Assembly

The gas burner system circuit (Figure 5) consists of: (1) LPG gas, (2) regulator with pressure regulator, (3) gas flow pressure gauge in Bar units, (4) filter, (5) gas pressure regulator in mBar units , and (6) pressure gauge in mBar units. Then, the gas burner series is assembled with the melting furnace.

Figure 6: Melting furnace system circuit

3.5 Test Results and Analysis

Data collection in this test is done by installing a measuring device temperature in the center of the furnace which functions to measure the temperature of the combustion chamber. Data collection was carried out every 5 minutes for 30 minutes for each nozzle hole size variable. The data written is the temperature obtained by attaching a type k Thermocouple probe cable placed in the middle of the furnace:

Testing the nozzle to one with a diameter of 0.5 mm, can be seen as follows:

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Table 1: Test nozzle 1 (diameter 0.5 mm)

No	Minutes	Temperature (°C)	Information
1	0	33,7	Room temperature
2	5	335,7	At 5 minutes
3	10	460,3	At 10 minutes
4	15	537,6	At 15 minutes
5	20	603,0	At 20 minutes
6	25	635,8	At 25 minutes
7	30	639,8	At 30 minutes, the aluminum has not melted

Testing nozzles with a diameter of 0.5 mm for 30 minutes.

- Aluminum hasn't reached its melting point so it hasn't melted yet.
- Weighing is carried out before testing the initial weight of the cylinder + 8 kg of LPG gas.
- Weighing was carried out after the test, the final weight of the cylinder + LPG gas was 7.635 kg.

Furthermore, testing of the second nozzle with a diameter of 0.8 mm can be seen as follows:

Table 2: Test nozzle test 2 (0.8mm diameter)

No	Minutes	Temperature (°C)	Information
1	0	33,7	Room temperature
2	5	479,4	At 5 minutes
3	10	625,8	At 10 minutes
4	15	692,8	At 15 minutes, the aluminum starts to melt
5	20	696,5	At 20 minutes, start stirring
6	25	642,1	At 25 minutes, the aluminum has completely melted
7	30	711,3	At 30 minutes, aluminum is completely molten and shiny

Testing of nozzles with a diameter of 0.8 mm for 30 minutes of scrap

- Aluminum has completely melted and is ready to be printed.
- Weighing is carried out before testing the initial weight of cylinder + LPG gas 7.635 kg.
- Weighing was carried out after the test, the final weight of the cylinder + LPG gas was 7.31 kg.

Furthermore, testing of the third nozzle with a diameter of 1 mm can be seen as follows:

Table 3: Test nozzle 3 (diameter 1 mm)

No	Minutes	Temperature (°C)	Information
1	0	33,7	Room temperature
2	5	572,5	At 5 minutes
3	10	631,5	At 10 minutes
4	15	703,1	At 15 minutes, the aluminum starts to melt
5	20	660,4	At 20 minutes, start stirring
6	25	647,1	At 25 minutes, the aluminum has completely melted
7	30	936	At 30 minutes, aluminum is completely molten and red like fire

Testing nozzles with a diameter of 1 mm for 30 minutes.

- Aluminum gets excessive heat in a short time, it melts completely in 30 minutes, the liquid is red in color.
- The initial weight of the cylinder + LPG gas is 7.31 kg.
- And the final weight of cylinder + LPG gas is 7.025 kg.

From the above data it can be presented in a table which will be made a line graph by comparing the time and temperature of each nozzle hole size variable. From each graph the author will combine it so that the data obtained can be compared. The following tables and graphs have been created based on the test data:

Table 4: Test Data for the Diameter of the Nozzle Hole

No	Test Equipment	Minutes							Amount of gas (kg)
		0	5	10	15	20	25	30	
1	Nozzle 1	33,7	335,7	460,3	537,6	603	635,8	639,8	0,365
2	Nozzle 2	33,7	479,4	625,8	692,8	696,5	642,1	711,3	0,325
3	Nozzle 3	33,7	572,5	631,5	703,1	660,4	647,1	936	0,285

From the data table testing the size of the nozzle hole, the writer can present it in the graph as follows:

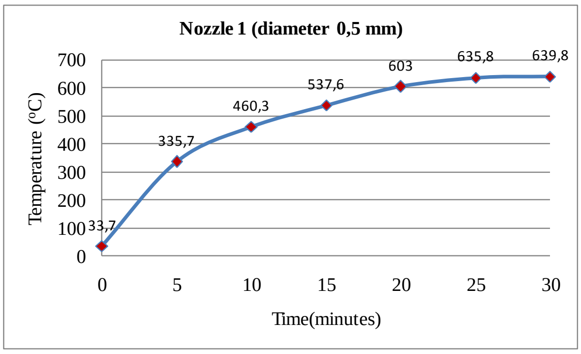

Figure 7: The effect of time on the temperature rise for nozzle 1

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From the graph of the test results for nozzles with a diameter of 0.5 mm, the temperature has not yet reached the melting point of aluminum, only reaching a temperature of 639.8°C, so the use of these nozzles is less effective and efficient in terms of time.

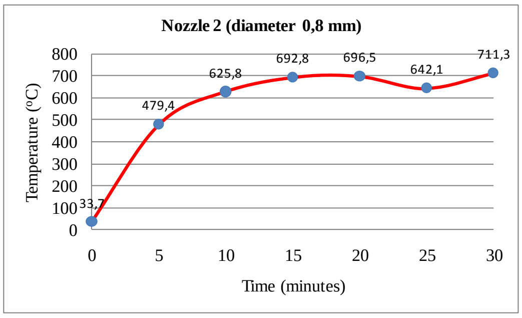

Figure 8: The effect of time on the temperature rise for nozzle 2

In this second graph the test uses a 0.8 mm diameter nozzle, the melting point temperature is reached between 10 to 15 minutes, between 20 to 25 minutes there is a decrease in temperature due to the accumulation of temperature in the aluminum material with the temperature of the combustion chamber.

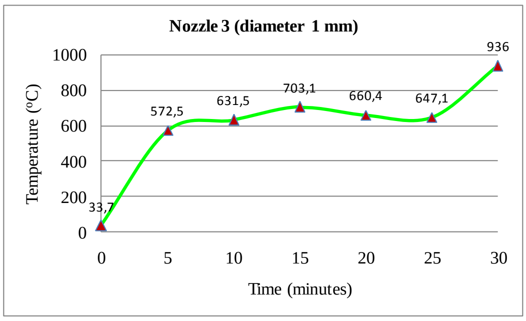

Figure 9: The effect of time on the temperature rise for nozzle 3

In this second graph the test uses a 0.8 mm diameter nozzle, the melting point temperature is reached between 10 to 15 minutes, between 15 to 25 minutes there is a decrease in temperature due to the accumulation of temperature in the aluminum material with the temperature of the combustion chamber.

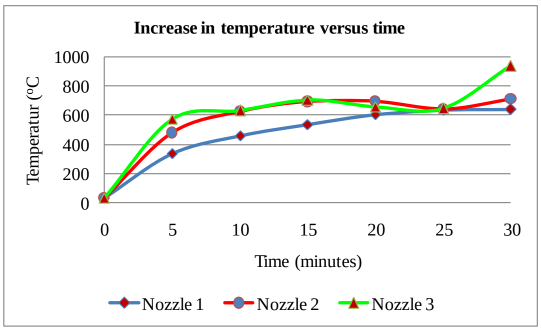

Figure 10: Comparison of temperature rise for nozzles 1, 2 and 3

In this graph, nozzles with a diameter of 1 mm reach the melting point temperature the fastest, which is between 10 and 15 minutes. Referring to the aluminum phase diagram, the author can present it in the following graph:

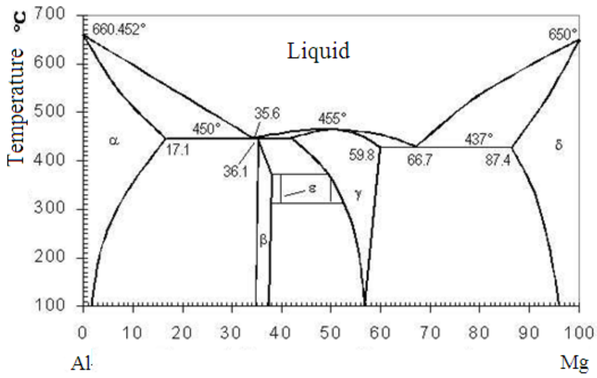

Figure 11: Aluminum alloy phase diagram

So it can be seen in the test results of the stirring stage until complete melting, there is a decrease in temperature from the aluminum melting temperature of 660 °C until all the aluminum becomes completely liquid, the temperature will continue to rise until 30 minutes. According to the phase graph above according to the aluminum content melted and its composition can be seen in the phase liquid-alloy . The content of the used aluminum used for the test contains different compositions. The melting temperature and temperature decrease when it is completely melted until the temperature rises can be seen from the test chart above. The presence of flux or dirt contained in the aluminum used as a test also affects the speed of temperature rise and aluminum liquefaction. It can be seen in test 3. The separation of aluminum impurities is carried out to obtain pure aluminum liquid.

3.6 Fire And Explosion Risk Analysis

In order to avoid and prevent fire hazards in smelting furnace installations, it is necessary to understand the following points:

a) The gas leak occurred in the rubber seal of the LPG regulator. This gas leak occurs if the rubber seal is deformed or torn and is no longer elastic, marked by a pungent smell of gas and a hissing sound on the regulator. To prevent leaks, each replacement of a new tube must be checked for rubber seals and ensured that they are in good condition.

b) Gas leak at the Flashback arrester connector. This tool is installed to prevent backfire from burning the furnace so that it does not enter the gas cylinder, in practice this tool is connected to a regulator with a threaded nozzle which is covered in Teflon plastic inside as a seal. To prevent leaks, seals must be in good condition and tightly installed.

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c) Gas leak in the connecting hose from the regulator. Installation of hoses with iron clamps. To avoid leaks, what must be done is to check the condition of the hose, it must be good, nothing is torn. Installation of clamps must be tight.
d) Gas leak in the connecting hose of the burner set. Installation of hoses with iron clamps. To avoid leaks, what must be done is to check the condition of the hose, it must be good, nothing is torn. Installation of clamps must be tight.
e) Gas leak in burner set. This tool consists of a valve that functions as a valve that adjusts the release of gas to the tip nozzle. Valve must be in a non-leaking condition.
f) Release of gas on the ventury burner. The release of gas at the ventury burner occurs because it is opened first before being ignited at the tip of the burner nozzle.

From the analysis above, the use of this tool must be according to the usage procedure.

IV. CONCLUSION

Based on the results obtained from the data analysis, it can be concluded that the performance of the smelting furnace is as follows:

1) The smelting furnace that has been designed and fabricated is capable of operating properly to smelt aluminum with a capacity of 2 kg.
2) Crucible with 304 steel pipe material with a thickness of 2 mm, an outer diameter of 9 cm and an inner diameter of 89.6 cm, a height of 12 cm takes 25 minutes to reach the perfect melting point, in 30 minutes it can be printed properly.
3) By using nozzle 2 (diameter 0.8 mm) and nozzle 3 (diameter 1 mm), aluminum takes 15 minutes to reach the perfect melting point, in 30 minutes molten aluminum metal experiences excessive heat so it needs cooling when it is printed.
4) The larger the diameter of the nozzle hole, the smaller the number of turns of the gas valve opening, to raise the temperature in the smelting furnace.
5) To obtain an optimum combustion flame, a good combination of LPG gas output and air from the blower is required.

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REFERENCES

[1] Groover, M.P. "Fundamentals of Modern Manufacturing: Materials, Processes, and Systems", John Wiley & Son, Fifth Edition, United States of America, 2010.
[2] Sundari, Ella. "Rancang Bangun Dapur Peleburan Alumunium Bahan Bakar Gas", Jurnal Austenit, Vol. 3, No. 1, hal: 17– 26, April 2011.
[3] Shaleh, M. & Tulloh, M.H., "Volume Ruang Bakar Pada Rancang Bangun Tungku Peleburan Aluminium Skala Laboratorium Bahan Bakar LPG", Ekliptika, Vol. 1 , No 1, Juli, 2020.
[4] Yahya, A., "Rancang Bangun Tungku Pelebur Logam Bekas (Non Ferro) Dengan Kapasitas 5 kg Dengan Menggunakan Bahan Bakar Gas LPG", Artikel Skripsi Universitas Nusantara PGRI Kediri , 2018.
[5] Istana, B. & Lukman. J., "Rancang Bangun dan Pengujian Tungku Peleburan Aluminium Berbahan Bakar Minyak Bekas", Surya Teknika, Vol. 2, No. 4, hal. 10 – 14, Desember, 2016.
[6] Yusuf, M. & Faisal, "Rancang Bangun Dapur Peleburan Logam Non Ferro Berbahan Bakar Gas Sebagai Sarana Pembelajaran di Laboratorium Teknik Manufaktur", Seminar Nasional Sains dan Teknologi, Fakultas Teknik Universitas Muhammadiyah, Jakarta, 8 November 2016.
[7] Esor, E. E., Babatunde, Y. S., Felix, A., & Mustapha, F. O., "Design and Fabrication of Aluminium Melting Furnace using Locally Available Materials", Journal of Scientific and Engineering Research, Vol. 2, No.3. , pp. 36-43, 2015.
[8] Adi, I.M., Raharjo, W.P., & Surojo, E., "Rancang Bangun Tungku Pencairan Logam Alumunium Berkapasitas 2 kg dengan Mekanisme Tahanan Listrik (Pengujian Performansi)", Mekanika, Vol. 13, No. 1. September, 2014.
[9] Arianto L.S., Tiwan, & Mujiyono, "Pengembangan Tungku Peleburan Aluminium Untuk Mengembangkan Kompetensi Pengecoran di SMK Program Studi Keahlian Teknik Mesin", Inotek, Vol. 18, No. 1, Februari, 2014.
[10] Winarno, J., 2012, "Rancang Bangun Tungku Peleburan Aluminium Berbahan Bakar Padat dengan Sistem Aliran Udara Paksa", Jurnal Teknik, Vol. 2, No. 2, Oktober, 2012.
[11] Akhaze, M. N., "Comparison of Diesel with Butane Gas in Firing Crucible Furnace for Melting Aluminium", International Journal of Engineering Research & Technology, Vol. 1, Issue 4, June, 2012.
[12] Magga, R., "Analisis Perancangan Tungku Pengecoran Logam (non-Ferro) Sebagai Sarana Pembelajaran

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Volume 7, Issue 7, pp 134-141, July-2023
https://doi.org/10.47001/IRJIET/2023.707021

Teknik Pengecoran", Jurnal Ilmiah Matematika dan Terapan, Vol. 7, No.1, hal: 54 –60, Mei 2010.

[13] Endramawan, T., "Perancangan Burner dan Tungku Peleburan Pembakaran Dengan Gas", Seminar Nasional Teknologi Terapan (MESIN), Vol. 5, No. 1, hal: 69–74., 2019.

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The areas of interest that are in demand are manufacturing process, manufacturing technology, materials science, product design, composite materials, and several topics related to material characterization.

I Ketut Suherman, lecturer at Department of Mechanical Engineering, Bali State Polytechnic, Jimbaran, Bali, Indonesia.
The areas of interest that are in demand are manufacturing materials, material science, workshop technology, composite materials, and several topics related to material processing.

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