Manufacturing of Aluminum Metal Smelting Furnaces with LPG Gas Fuel to Support Student Practicums

Subarjo, Triwidodo, and Feni Setiawan

Education Laboratory Institution of Agricultural Mechanization Study Program, Department of Technology

*E-mail: subarjo@polinela.ac.id

Abstract. Work in aluminum metal casting includes several stages: preparation of raw materials, mold making, smelting process, the casting of castings, dismantling, cleaning, and inspection of castings. Students are ready to compete in the industrial world or entrepreneurship with these hands-on skills. To achieve this goal, the Polytechnic provides adequate learning and practice experiences to form professional abilities in science and technology. Competence in one field, for example, in material knowledge (metal casting). Because the tools for the metal smelting process are not available yet, this research aims to design and manufacture an aluminum smelting furnace fueled by LPG gas, which can also be helpful and contribute to the process of making aluminum metal smelting furnaces. The test results show that the aluminum metal smelting furnace with LPG gas fuel and aluminum metal raw materials for motorcycle brake canvas can operate and work well. The need for LPG gas fuel to melt aluminum canvas motorcycle waste material is 0.6 to 1 kg. The temperature required to melt aluminum metal is 658 °C to 784 °bC with a melting time of 10 to 18 minutes. The maximum capacity that can be smelted raw materials is 1000 grams.

1. Introduction

Aluminum metal is found in many homes as a material for pots, soft drink bottle caps, and milk can lids, and so on. Aluminum is also used to coat electronic equipment such as compact discs and car lights. Quality and competitive aluminum casting work will produce good aluminum to compete in the increasingly stringent metal industry. Work in aluminum metal casting includes several stages: raw material preparation, mold making, smelting process, casting castings, demolition, cleaning, and inspection of castings.

Aluminum can be forged into sheets, drawn into wire, and extruded into bars of various cross-sections. In addition, aluminum is also resistant to corrosion. Aluminum is used in many ways, generally used in high-voltage cables. In addition, it is also used in window frames and airframes.

The development of industry in Indonesia makes the need for the metal industry to increase. One of them is the aluminum metal industry as a substitute for non-ferrous metals. Aluminum is soft, light, and a good conductor of electricity and heat. Various efforts have been made to assist entrepreneurs in the non-ferrous metal foundry industry, especially aluminum, by developing furnaces or furnaces for smelting. The development of the furnace/kitchen is generally carried out to improve the furnace's performance so that its combustion efficiency can be increased.

The smelting process is melting the material (cast iron) by heating it in a smelting furnace; after the material has melted, it is poured into a mold (Arifin, 1976). In the aluminum smelting process, a crucible-type furnace is used. The Crucible kitchen is the oldest used kitchen. This kitchen is the most

straightforward construction and uses a fixed position where the molten metal is taken using a ladle or dipper. This kitchen is very versatile and versatile for minor and medium-scale melting. Krusibel's kitchen is in the form of a pot made of clay mixed with sand. According to fuel, there are three kinds of crucibles: gas, oil, and coke. The burning rate of used fuel oil is the same as that of a used oil-fueled smelting furnace (Palace & Lukman, 2016).

Some of the aluminum smelting furnaces that have been developed include gas-fired furnaces reported by (Sundari 2011). The stove or kitchen designed is a crucible kitchen with LPG gas fuel in the form of a cylinder with a diameter of 220 mm and a height of 300 mm with a capacity of 30 kg. The test results show that it takes 1 hour 37 minutes to smelt aluminum scrap weighing 30 kg, and the fuel used is 3.60 kg. The results of previous studies also designed a crucible furnace with LPG gas fuel to work well(Irvan & Suryadi, 2017).

The metal industry, especially metal casting, has a significant role in supporting current development. Furnace/kitchen is needed for the smelting process of non-ferrous metals, especially aluminum. Casting is one of the most critical areas of expertise and must be mastered by students, especially students of Agricultural Mechanization. In the subject of knowledge of engineering materials, technical material lectures are only limited to theory, so competence is lacking in mastering skills in casting, especially metal casting. With skills and direct practice in the field, students will be able to explore or add insight to be ready to work in industry or entrepreneurship. In terms of completeness of the Laboratory, Metal and Automotive do not yet have this equipment, with skills and direct practice in the field, students will explore or add insight to be ready to work in the industrial world or entrepreneurship.

The smelting process is melting the material (cast iron) by heating it in a smelting furnace; after the material has melted, it is poured into a mold. (Arifin, 1976). In the aluminum smelting process, a crucible-type furnace is used. This kitchen has a straightforward construction and uses a fixed position where the molten metal is taken using a ladle or dipper. This kitchen is very versatile and versatile for minor and medium-scale melting. According to fuel, there are three kinds of crucibles: gas, oil, and coke. Krusibel Kitchen with coke fuel is rarely used because it is less efficient.

From the test results of the aluminum smelting furnace, it is known that the furnace designed can melt aluminum scrap on average 2.5 kg per hour with a fuel-burning rate of 3.25 per hour. This means that the fuel requirement for smelting aluminum is 1.3 kg of fuel per kg of aluminum scrap. The burning rate of this fuel is smaller than that of diesel-fueled smelting furnaces, which reach 1.4 liters per kg of aluminum scrap, smelting furnaces fueled by used oil, which comes 1.5 liters per kg of aluminum scrap and kerosene-fueled smelters. which reaches 1.6 liters per kg of aluminum scrap (Sudjana, 2008)

Polytechnic is a professional education directed at the readiness to apply specific skills. To achieve this goal, the Polytechnic provides adequate learning and practice experiences to form professional abilities in science and technology. Competence in one field, for example, in material knowledge, especially metal casting. So students are required to do metal casting, one of which is aluminum metal. In contrast, the tools for the metal smelting process are not yet available, both simple tools and more modern tools. So based on these problems, we will make a simple aluminum metal casting (smelting) device so that the learning activities of engineering material knowledge can be achieved. With this metal smelting furnace, students are expected to have competence in metal smelting in general and aluminum. In addition to practicum mechanical technology for CNC Milling machines.

This research aims to design and manufacture an aluminum metal smelting furnace with LPG gas and to analyze the melting capacity, melting temperature, and melting time of aluminum. This research is expected to provide benefits and contribute to knowledge about making crucible furnaces and metal smelting processes, especially aluminum..

2. Methodes

2.1. Tool Design.

The design planning was blinded based on the tool specification data carried out in the literature study. At this stage, the output was a tool planning drawing.

2.2. Tool Making.

The manufacture of the tool is carried out based on the design drawings obtained, using the materials and equipment provided. The manufacture is carried out first by making the outer wall of the furnace with a diameter of 30 cm and an inner diameter of 15 cm and a height of 30 cm, materials from a plate, cauldron/power with size 10 cm, height 25 cm,(Meilana, 2018)In planning this smelting furnace will be made as follows:Result And Discussion

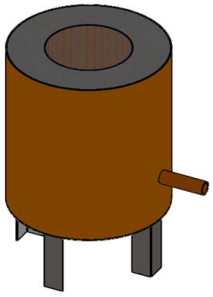

Figure 1. Aluminum smelting furnace/furnace

2.3. Crucible furnace/furnace.

Crucible kitchen is the oldest used kitchen. This kitchen is the most straightforward construction. Krusibel has a function as a kitchen where aluminum melts. Krusibel is made using low carbon steel material with 300 mm in diameter, 300 mm in height, and 3 mm in thickness. The crucible design that will be made can be seen in Figure 1.

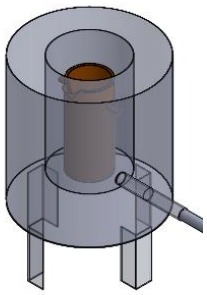

Figure 2. Furnace wall/blanket

2.4. Furnace Wall.

The material used to make the furnace walls is a steel plate with a thickness of 1.2 mm, which is rolled with an outer diameter of 300 mm, and an inner diameter of 153 mm with an overall height of 300 mm, and between the outer and inner walls is filled with refractory cement. The furnace wall design that has been made can be seen in Figure 3. (Rachmat & Sulaeman, 2020).

Figure 3. Kowie/material smelting cauldron

2.5. Kowei/cauldron.

This Kowei is a place for cooking/melting material with a diameter of 100mm and a height of 250mm. The aluminum material for motorcycle brake canvas waste is inserted into the Kowei and then heated until it melts, as shown in Figure 3.

2.6. Furnace Testing.

The smelting furnace was tested three times using scrap aluminum as the material to be smelted and LPG gas as fuel. The test steps are as follows:

1. Prepare the smelting furnace with its equipment, energy, and smelting material;
2. Taking temperature measurements with an infrared laser thermometer to be used as a benchmark for the initial temperature;
3. To measure the initial weight of LPG gas fuel before it is turned on;
4. To calculate the importance of the waste aluminum material, motorcycle brake canvas shoes (waste) to be melted down, then put into a cauldron/crucible;
5. Igniting the fire is then followed by the ignition of the blower to raise the temperature faster;
6. Perform temperature measurements at each stage for 2 minutes;
7. Measure the temperature at which the material begins to melt;
8. Stir while removing the existing dirt;
9. After the material is melted, wait until the pouring temperature (700 0C)
10. Prepare the mold;
11. Lift the crucible and pour the melted material into the mold carefully, but it must not stop. It must continue until the material runs out (Palace & Lukman, 2016).

Observation Parameter; Material volume; Fuel requirements (LPG); and temperature every 2 minutes until the material melts

3. Results amd Discussion

Design Process. The design is carried out based on the plan drawings, the dimensions of the material are adjusted to what is planned. The results of the invention are shown in Figure 5. Furthermore, the performance test of the furnace is carried out, starting from the weight of the material 250 gr, 500 gr, 750 gr, and 1000 gr. Temperature changes were recorded every 2 minutes, and the results were obtained as shown in table 3. The table shows that in less than 15 minutes, the temperature has reached above 600 °C. In the performance test of the initial weight of 250 gr, the material begins to melt at a temperature of 675 °C with a time of 8 minutes and is aged into a mold at a temperature of 707 °C with a time of 10 minutes. For material weights of 500 gr, 750 gr, and 1000 gr, it begins to melt at 705, 688, 705 °C, respectively.

Table 1. Measurement of time and temperature for different quantities of materials

Time (min)	250 (g)	500 (gr)	750 (gr)	1000 (g)
0	32	46	58	100

2	360	450	320	320
4	385	532	360	380
6	490	600	430	430
8	675	625	460	460
10	707	653	570	470
12		705	610	600
14		752	688	658
16			710	705
18				784

There is a difference in the melting point of each of these performance tests due to differences in the material being melted down because it comes from various brands and types of motorcycle canvas waste. It can also be seen that dirt and other metal mixtures affect the melting temperature and time, as shown in Table 1.

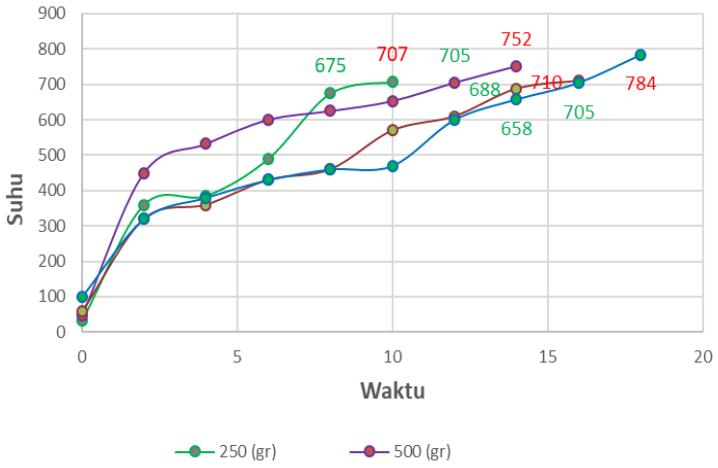

Figure 4. Graph of Melting temperature and time at volume 250, 500, 750 and 1000 grams of waste aluminum metal

Figure 4. shows a very rapid increase in temperature that occurs in the early minutes before the ingredients are put into the cauldron/kowie. The heat propagation possibly influences this from the furnace to the kowie, and there is no obstacle. Still, after the material is put into the kowie, there is a slight slowdown in the increase in temperature. Because the energy is absorbed into the material to be smelted, from the graph, it can also be seen that it takes the least time to melt 250gr of fabric (8 minutes) and the longest time to melt 1000gr of material (16 minutes).

The smelting furnace performance test results show that to smelt 250gr aluminum (waste) material, 0.6kg of LPG gas is needed, 0.8 kilograms of 500gr of LGP is needed, 750gr and 1000gr of LPG are 1.0 kilograms needed. From these data, it can be seen that to smelt 750gr and 1000gr materials, we need the same LPG, which is 1.0 kg. This shows that the more material we melt, the less LPG is required. This is possible because the smelting furnace room is already conditioned to heat. With the addition of the melted material, only a slight effect on the decrease in temperature is shown in Figure 5.

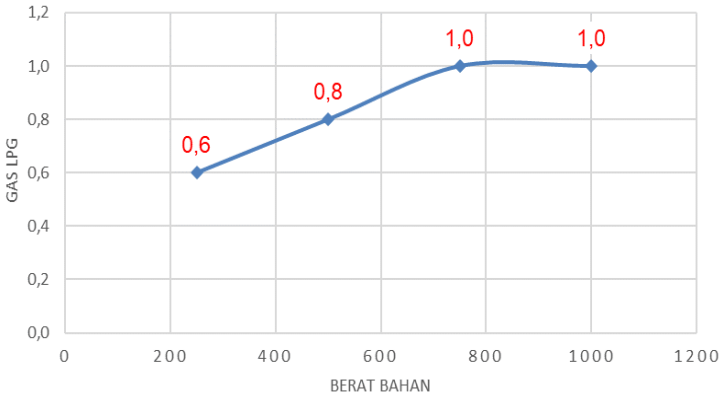

Figure 5. Graph of LPG gas consumption on the melted/melted material

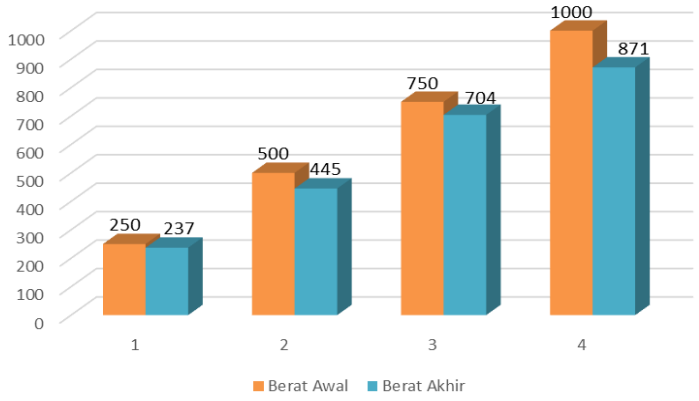

Figure 6. Graph of depreciation of raw materials into materials after being smelted/melted

The performance test results can also be seen in the yield of each tested material (figure 6.). The percentage yield of the tested materials was 94.80%, respectively; 89.00%; 93.87%, and 87.10%. The performance test results of the highest product were on a fabric with a weight of 250gr, and the average product was 91.19%.

The results of the furnace design and performance test, the specifications of this smelting furnace are 30 cm high furnace, 30 cm outer diameter, 7.38 cm furnace wall thickness, 4560 cm3 combustion chamber volume, the capacity of the cauldron/kowie 1963, 5 cm3 and a temperature of 848 °C. The test results with the waste material of the motorcycle brake canvas can accommodate 1000 grams of material by reducing the size of one canvas and cutting it into two parts.

4. Conclusion

The results of the aluminum smelting furnace's design and performance test can be concluded as follows: (1) Aluminum metal smelting furnace with LPG gas fuel and aluminum metal raw materials for motorcycle brake canvas can operate and work well.; (2) The need for LPG gas fuel to melt aluminum canvas motorcycle waste material is 0.6 to 1 kg. ; (3) The temperature required to melt aluminum metal is 658 °C to 784 °C with a melting time of 10 to 18 minutes.; and (4) The maximum capacity that can be smelted raw materials is 1000 grams.

References

[1] Arifin, S. (1976). Metal Science (Volume 1). Indonesian Ghalia.

[2] Irvan, A., & Suryadi. (2017). Gas-Fired Metal Smelting System For Small And Medium Industries. Elektra Journal, 2(1), 50–57. https://pei.e-journal.id/jea/article/view/20

[3] Istana, B., & Lukman, J. (2016). Design and Test of Aluminum Smelting Furnaces Fueled by Used Oil. Surya Teknika Journal, 2(04), 10–14. https://doi.org/10.37859/jst.v2i04.42

[4] Meilana, E. (2018). The design and manufacture of crucible furnaces for smelting aluminum with gas fuel and the process of observing the stove and the casting test process using black sand molds with variations in pouring distance. Muhammadiyah Surakarta.

[5] Rachmat, A., & Sulaeman, M. (2020). Making aluminum smelting furnace by utilizing coconut shell waste as fuel. Incitec Journal, 07(01), 491–499.

[6] Sudjana, H. (2008). Casting Technique Volume 1 for SMK (1 (ed.)). Directorate of Vocational High School Development.

[7] Sundari, E. (2011). Design and build a gas-fuel aluminum smelting kitchen—Journal of Austenite, 3(April).

[8] Yahya, A. (2017). The Design Of Used Metal Melting Furnaces (Non-Ferro) With A Capacity Of 5 Kg Using Lpg Gas Fuel. Mechanical Engineering Study Program, Faculty of Engineering, Universitas Nusantara Pgri Kediri 2017, 01(08).