

Design and Fabrication of Portable Tilting Furnace for Aluminium Melting

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Abstract

Machining is a metal cutting process using machine tools. The machining process will produce the products and the chips or the scraps. The metal of machining chips made from machining processes can be recycled into new materials. The metal of machining chips can be recycled through the smelting process. This research aims to design and fabrication a crucible furnace that can support the recycling process of the metal scraps of machining chips into new material. The stove is designed to melt non-ferrous metals using gas fuel. The tilting-pot crucible furnace type was created in this research. The crucible furnaces are used for nonferrous metals such as bronze, brass, zinc, and aluminum alloys. The crucible furnace capacities are limited to 10 kg. Liquefied Petroleum Gas (LPG) was used as the fuel for the furnace. The construction of the stove is cylindrically designed. The burner was installed upright at the bottom of the stove. The combustion process is done by mixing fuel LPG gas and air from the blower. The stove was tested on the aluminum machining chips using locally available materials in Lhokseumawe Aceh. The thermometer Lutron TM-906A was used to measure the temperature inside the crucible. From the results of the design and testing of the furnace that has been done, it can be concluded that the aluminum machining chips of 6kg are melting at a temperature of 640°C for 52 minutes, and the LPG gas fuel required is 1.30kg. The crucible furnace was designed to attain a maximum temperature of 700°C.

Keywords: *Crucible Furnace, Aluminium Scrap.*

1. Introduction

Machining is a metal cutting process using a machine tool. The machining process will produce the products and the chips or the scraps [1] [2] [3]. The metal of machining chips made from machining processes can be recycled into new materials. The metal of machining chips can be recycled through the smelting process [4].

Metal casting is a process of making objects in which molten metal is poured into a mold where it solidifies in the shape of the mold cavity. The metal must be heated to the molten state to be poured into the mold in the casting process. Heating and melting are conducted in a furnace. The types of furnaces most commonly used to melt the metal; are crucible furnaces, electric arc furnaces, and induction furnaces [5]. The selection of the furnace type depends on factors such as melting temperatures, capacity requirements of the stove, costs, and environmental pollution considerations [6].

There are many experiments work which have been conducted to develop the crucible furnace. The electric crucible furnace was designed based on the induction concept and used the coil as the heater to melt the non-ferrous metals. The results show that the melting time for aluminum is only 45 minutes for the quantity of 1 kg at a temperature of 740°C [7]. The development of a crucible furnace fired with spent engine oil [8]. The developed crucible furnace was fired using spent engine oil, and when fired, it was used to melt Al-Si alloy scrap materials (automobile engine pistons). The total operation time is 20 minutes, during which the developed crucible furnace attained a temperature of 1500°C. Bandhani *et al.* designed and fabricated of crucible furnace by using a Black Smithy setup to melt nonferrous material. The crucible is fired with coke, the time to melt aluminum is 75 minutes, and the maximum furnace temperature was 1000°C [9]. This research aims to design and fabricate a portable tilting crucible furnace that can support the recycling process of the metal scraps of machining chips into a new material—the furnace designed to melt non-ferrous metals using gas fuel. The combustion process involves mixing fuel LPG gas and air from the blower [10].



2. Method

Three stages were conducted in the research; design of the furnace construction model, fabrication of the furnace, and testing of the stove. The tilting-pot crucible furnace type was designed in this research. The crucible furnaces are used for nonferrous metals such as bronze, brass, zinc, and aluminum alloys. The furnace capacities are limited to 10 kg. Liquefied Petroleum Gas (LPG) fuels the furnace [11] [12]. The materials used in this research were locally sourced and selected based on their thermal properties, insulation capability, and availability. Materials chosen for the furnace components and their specifications are shown in Table 1.

Table 1. The materials and the components of the furnace

No.	Materials/Components	Quantity	Specification
1	Steel plate	1	Carbon steel 2x1800x2400 (mm)
2	Steel pipe	1	Carbon steel dia. 2 x length 230 (inch)
3	Steel profile (L)	1	Carbon steel 3 x 230 (inch)
4	Refractory cement	100	100 kg Temperature < 1500°C
5	Crucible	1	Stainless steel Designed
6	Ladle	1	Stainless steel Designed
7	Burner	1	Designed
8	Air blower	1	2 inch
9	LPG gas bottle	1	12 kg
10	LPG gas regulator	1	0-6 kg/h
11	LPG gas hose	1	200 mm

2.1 Furnace Design

The construction of the furnace is cylindrically designed [13]. This cylindrical construction is so desired, technically due to its effectiveness in thermal distribution within the furnace chamber. The burner was installed upright at the bottom of the furnace. The conceptual design of the furnace construction is shown in Figure 1.

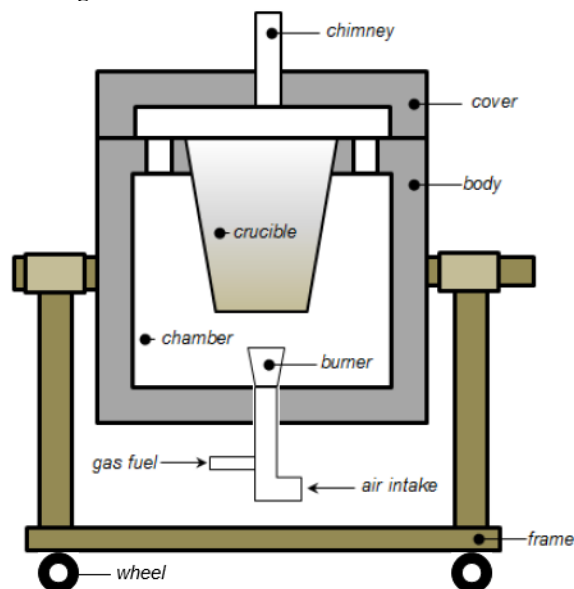


Fig 1. Conceptual design of the furnace

2.2 Furnace Fabrication

The furnace fabrication was conducted according to the conceptual design [14]. Figure 2 shows the fabrication process involved in constructing and assembling the crucible furnace according to conceptual design. The cylindrical shell of the stove was made of steel plates with a diameter of 450mm, and a height of 480mm mounted on the steel frame. The inside of the furnace was made of refractory cement, with a thickness of 50mm. The final completed furnace is shown in Figure 3 [15] [16].



Fig 2. The furnace fabrication process: (a) assembling the frame and body; (b) using the refractory cement; (c) testing the burner; (d) the body and the frame of the furnace assembled.

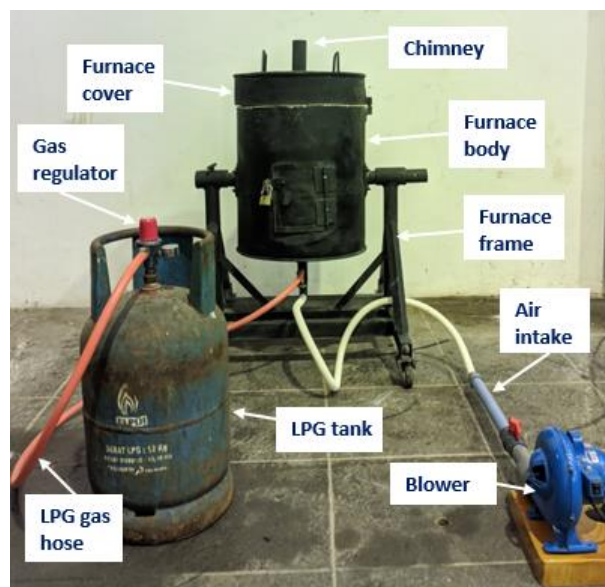


Fig 3. The wholly fabricated crucible furnace with the LPG gas and air blower fixed at the furnace

2.3 Performance Test

The performance test is to determine the fuel consumption and time required for the operation of the furnace [17]. Many factors affect furnace performance, such as capacity utilization of furnace, excess air ratio, final heating temperature, etc. The thermometer Lutron TM-906A was used to measure the temperature inside the crucible. The performance test process involved in melting and pouring is shown in Figure 4 [18] [19].

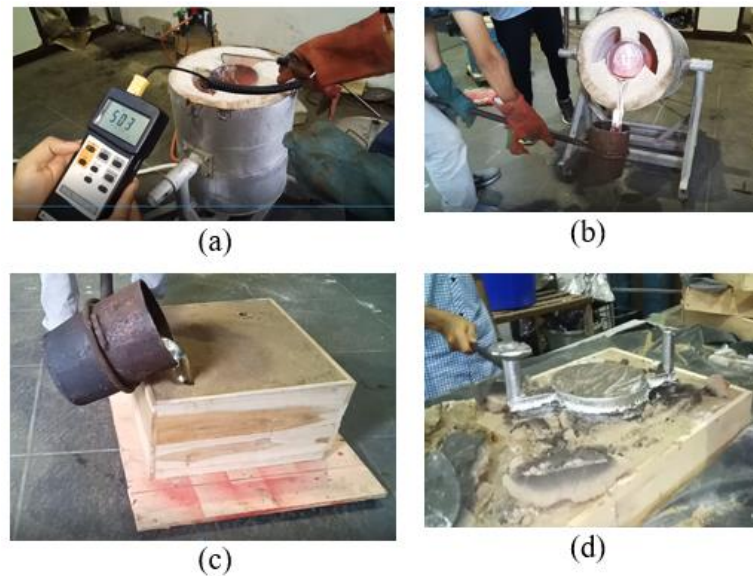


Fig 4. The performance test process: (a) melting the aluminum scrap; (b) pouring in the spoon; (c) pouring in the sand mold; (d) the casting product.

3. Results and Discussion

The furnace test was conducted by heating aluminum machining chips inside the crucible. Initially, the furnace was loaded with aluminum machining chips of 6kg, and as the temperatures rose, time and temperatures were recorded continuously. The results obtained were tabulated as indicated in Table 2. The characteristic curves of heating time vs. furnace temperature are shown in Figure 5. According to the results presented in Figure 5, the temperature of the crucible furnace was maintained at 700°C over a period exceeding 55 minutes. This shows that the stove was designed to attain a maximum temperature of 700°C. The aluminum machining chips are melting at a temperature of 640°C for 52 minutes, and the LPG gas fuel required is 1.30kg [20].

Table 2. The furnace performance

Temperature (°C)	Time (minute)
30	0
105	5
190	10
265	15
351	20
415	25
455	30
511	35
545	40
586	45
625	50
700	55
700	60

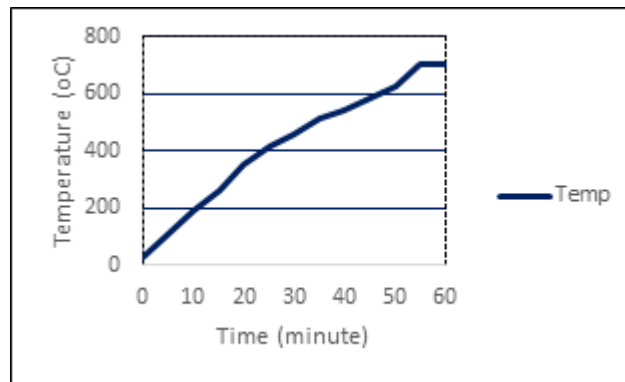


Fig 5. The heating trend of fabricated furnace

4. Conclusion

From the results of the design and testing of portable tilting furnaces for aluminum melting that has been done, it can be concluded that the fabrication and assembly of melting furnaces are made according to their design.

The furnace was tested on the aluminum machining chips using locally available materials in Lhokseumawe Aceh. The aluminum machining chips of 6kg are melting at a temperature of 640°C for 52 minutes, and the LPG gas fuel required is 1.30kg. The crucible furnace was designed to attain a maximum temperature of 700°C.

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