Analysis of the Effect of Comparative Air and Fuel Gas (LPG) on Metal Melting Furnace Temperature

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Abstract: ***Aluminum is the most common non-ferrous material and is widely used in society, in fact the annual use of aluminum is second only to iron and steel. Aluminum is a light metal that has good corrosion resistance properties. Gas use (Liquefied Petroleum Gas) as fuel because it is easy to find and also has an affordable price compared to gas on the market. The net calorific value obtained from gas (Liquefied Petroleum Gas) is 11,254.61 Kcal/Kg. The aim of this research is to obtain the appropriate temperature based on the ratio of excess air and fuel gas (Liquefied Petroleum Gas) and also to determine the actual value in the combustion process, which includes the time and temperature of aluminum melting. Based on the research results obtained, the combustion value with air exceeding 0% temperature can reach 998 ºC with a time required of 22 minutes, and the lowest temperature occurs with air exceeding 10% with a temperature of 787 ºC with a time reaching 30 minutes, to melt 500 g of Aluminum. The actual value of air that can be obtained from air exceeding 0% is 16.33 for 1 liter of fuel.***

Keywords: More air, Stoichiometry, Melting

1. Introduction

Aluminum is a metal with a non-ferrous material that is corrosion resistant and good. The specialty of this metal is that its mechanical strength can be increased by adding Cu, Mg, Si, Mn, Zn, Ni, etc., thereby increasing the performance of the material itself. In the household to small scale metal smelting industry generally use furnace equipped with burners. Fuels that are often used include liquid fuels and gas, and rarely use solid fuels such as coal briquettes, wood charcoal, etc. This is because using solid fuel is less practical and requires a relatively long melting time. The liquid fuel that is commonly used is kerosene. However, after the Government implemented a policy in the form of energy conversion, namely from kerosene to LPG gas in mid-2007, many home industries and small industries, including the aluminum casting industry, which had been using kerosene switched to alternative fuels which were more affordable. Based on The Aluminum Association reported in 1998 that 1/3 of the aluminum supply in the USA was recycled. Recycled aluminum production can also save 95% of the energy required compared to producing aluminum from bauxite ore. In previous research which studied combustion using gas (acetylene) which used sub-stoichiometric air ratios, this research examines the analysis of the effect of excess air and fuel ratios. gas (LPG) in the smelting furnace. Gas (LPG) is used as fuel because it is easy to find and also has an affordable price compared to gas circulating on the market. The net calorific value obtained from gas (LPG) is 11,254.61 Kcal/Kg. The research was carried out with the aim of Obtain the appropriate temperature based on the comparison of excess air and fuel gas (LPG), as well Looking for the actual value of the effect of excess air and gas fuel ratio.

2. Method

The designed metal melting furnace is used with a ratio of air and gas (LPG) as fuel. This method is used because the construction is not complicated, the material is easy to find on the market, the installation is easy and it is suitable for use at temperatures reaching 1325ºC. The smelting furnace is supplied with heat from the combustion flame based on the ratio of air to fuel gas (LPG) through a burner, such as in the image below.

2.1 Furnace

This furnace is made from a used freon tube coated with ceramic fiber and cement, in diameter 24 cm, thick 9 cm, and high 25 cm. In the lower wall of the kitchen there is a cavity (Ø3 cm) which functions as a chamber for the combustion flame to enter from the burner, lid diameter24 cm, thick60 cm with cavity (Ø7 cm) which functions as a place for exhaust gas to escape. The shape of the kitchen is as in Figure 3.

2.2 Burners

Burners is the most important part, because the burner can function as a place to mix air with fuel gas (LPG), so that it is mixed evenly and can burn completely.

2.3 Thermocouple

There are 2 thermocouples used, namely as a tool to measure the temperature of the combustion fire in the kitchen and also to measure the melting temperature of the aluminum material being melted.

2.4 Flowmeter

Used to control the flow capacity rate of the fuel cylinder, there are 2 flowmeters used, one of which is used as an air flow controller and the other is used as a gas fuel flow controller.

2.5 Displays

Connected to a thermocouple to read the temperature of the combustion flame and the temperature of the liquid material.

2.6 Gas cylinders

Liquefied petroleum Gas (LPG) storage container which will be used as fuel.

2.7 Compressor

To store air (O_2 + 3.76 N_2) which will be used as a fuel mixture. The compressor used is the VA90-90L model.

2.8 Gas Regulators

A gas pressure regulator is a device used to reduce the available gas pressure to the gas pressure required by the heater and by the heating controller. The gas supplied to the pressure regulator can come at different pressures and is fluctuating in nature

3. Result and Discussion

3.1. Calculation of Air- Fuel Ratio (AFR)

To obtain the air requirements for 1 liter of natural gas (LPG), the balance number of C, H and O atoms in a combustion reaction must be calculated. The ideal equation for gas fuel (LPG) is as follows:
0.5 C_3H_8 + 0.5 C_4H_{10}+ + 5.75 (O_2 + 3.76 N_2)
$\rightarrow$3.5 CO_2 + 4.5 H_2O + 21.62 N_2

Propane+ Butane + air → carbon dioxide + water vapor + nitrogen
$AFR_{stoichiometry} = M_{air}/M_{Fuel}$
$AFR_{stoichiometry}$ =(5,75(2 x 16+ 3,76 x 14 x 2))/({0,5(12 x 3 + 8)}+0,5(12 x 4+ 10))
$AFR_{stoichiometry}$ =789,36/51=15,47

The results above are the result of ideal air requirements for 1 liter of gas fuel (LPG), but more air assumptions are needed to get the correct actual air. So the assumption used for excess air capacity is to use three variations, namely 0%, 5% and 10%. Where, actual air (assuming Excess Air0%) = 1 × 16.33 = 16.33. On the actual air assumption (5% Excess Air assumption)= 1.05 × 16.33= 17.14. And the assumption on actual air (10% Excess Air assumption) = 1.1 × 16.33 = 17.96.

3.2 Influence AnalysisAir- Fuel Ratio(AFR) Against Fire Temperature

The data displayed in Table 2 is data from tests on the effect of the ratio of excess air and fuel gas (LPG) on the temperature of the fire in the metal melting furnace.

Table 3.1: Effect of AFR Over Air on Fire Temperature

Excess Air (%)	AFR (Liter)	Flame Temperature (ºC)
		Aluminum
		Bars
0	16.33 : 1	998
5	17.14 : 1	880
10	17.96 : 1	787

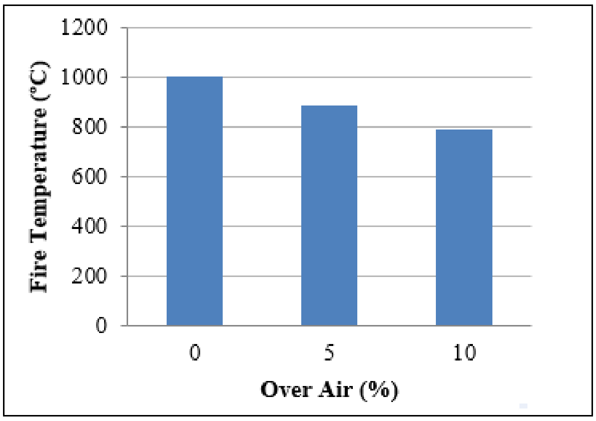

Figure 1: Graph of the relationship between AFR Over Air and Fire Temperature

It can be seen that the highest fire temperature is found in air combustion of more than 0% with a fire temperature reaching 998ºC, while the lowest fire temperature is found in air combustion of more than 10% with a fire temperature of 787 ºC. Through the results that have been shown, it can be concluded that the smaller the percentage of excess air combustion, the higher the flame temperature will be, and the combustion will be stoichiometric. Thus, the disadvantage of adding a higher percentage of air is that it can result in fuel-poor combustion.

3.3 Analysis of the Effect of AFR on Liquid Material Temperature

The effect on the ratio of air and fuel gas (LPG) in the metal smelting kitchen has been carried out, so the liquid material temperature results are obtained as shown in table 3.2 and depicted in graph 2.

Table 3.2 Effect of AFR Over Air on Liquid Material Temperature

Excess Air (%)	AFR (Liter)	Liquid Material Temperature (ºC)
		Aluminum
		Bars
0	16.33 : 1	675
5	17.14 : 1	669
10	17.96 : 1	660

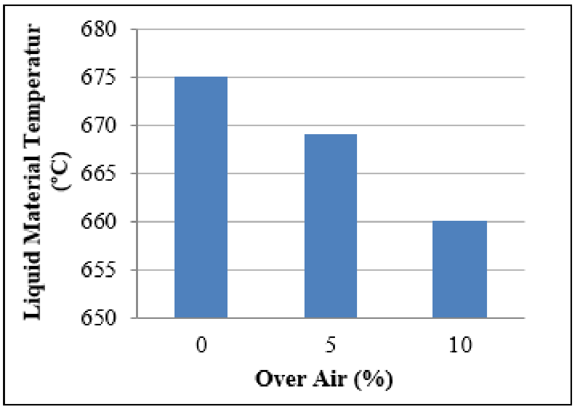

Figure 2: Graph of the relationship between Air AFR and Liquid Material Temperature

3.4 Analysis of the Effect of AFR on Melting Time

As for the results that have been obtained through the influence of the ratio of air and fuel gas (LPG) that has been carried out, the melting time is obtained based on the material that has been tested as shown in table 3 and depicted in graph 3.

Table 3: Effect of excess air AFR on melting time

Excess Air (%)	AFR (Liter)	Time (Minutes) Aluminum Bars
0	16.33 : 1	22
5	17.14 : 1	26
10	17.96 : 1	30

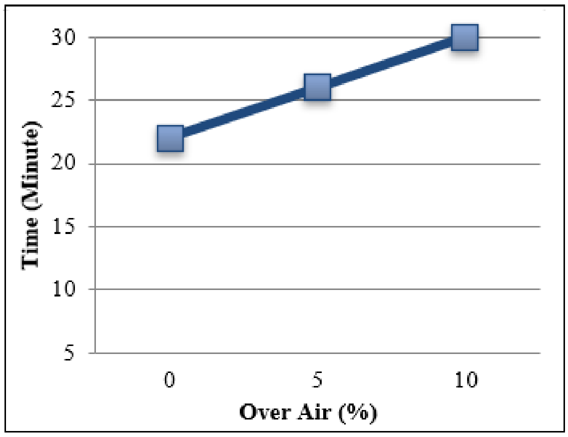

Figure 3: Graph Relationship between AFR Air and Melting Time

The graph above shows that the average time required to melt aluminum material is at a percentage of more than 10% air. In fact, it takes 30 minutes to melt 500 grams of aluminum, because the minimum fuel used in burning the air percentage is more than 10%. At an air percentage of more than 0% and 5% the time required is shorter. Therefore, it can be concluded that a ratio of 0% and 5% more air can speed up the melting time and make fuel use more efficient.

4. Conclusion

The effect of the ratio of excess air and fuel gas (LPG) actually gets the highest flame temperature at 0% excess air which reaches a temperature of 998 °C, and the lowest temperature at 10% excess air which reaches a temperature of 787 °C, the effect of the ratio of excess air and fuel (LPG) Actually, the fastest time was obtained to melt 500 grams of aluminum in more than 0% air with a duration of 22 minutes during the material melting process. Efficiency relative to the ratio of excess air and fuel gas (LPG), that is, the less excess air given, the more combustion results will be close to stoichiometric combustion. As well asThe casting temperature of aluminum alloys is usually found at660-790°Cand must be maintained during the casting process so that the aluminum casting results comply with the required standards.

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