Comparison of Diesel with Butane Gas in Firing Crucible Furnace for Melting Aluminium

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Abstract

The high cost of fuel is one of the reasons why alternatives are sought. Furnaces used for melting aluminium are being fired with diesel or butane gas on industrial scale, because of epileptic power supply in most developing countries like Nigeria. The cost of the fuel and the earliest time the aluminium can melt and reach its pouring temperature, using diesel and butane gas individually, to fire the furnace have not been the parameters used for selection. So this paper examined the aforementioned parameters and discovered that butane gas in comparison with diesel, when used to fire the furnace, melt and bring aluminium to its pouring temperature faster, with a minimal cost.

Key words: Aluminium, Butane gas, Diesel, Melting furnace. Pouring temperature.

1. Introduction

Aluminium has a huge number of uses. Its good electrical conductivity is an important property and is widely used for overhead cables[1]. The high resistance to corrosion and its non-toxicity make it a useful metal for cooking utensils. It is extensively used in aircraft and automobile components where saving of weight is an advantage. Aluminium may be blanked, formed, drawn, turned, cast and die cast into the desired product.

Prior to the casting of the aluminium, into the desired product, the scraps or blanks are melted in crucible furnaces. These furnaces are fired with either electricity or fossil fuels or Biofuels. On industrial scale, biofuel fired furnaces have been found not to be suitable because of the long periods they take in melting non-ferrous metals such as Aluminium . More often than not, Diesel or butane gas or propane gas are used to fire Aluminium melting furnace, on both laboratory and industrial scale.

The choice of either butane gas or diesel for firing furnace has been adduced to little or no reason, and not to the cost of the fuel and the earliest possible time of melting and bringing the metal to its pouring temperature. These are evident in the opinions and works of notable researchers which are highlighted as follows: The use of butane gas for firing furnace is one of the measures of reducing gas flaring problem, which results in colossal waste of both natural resources and energy in developing countries like Nigeria[2]. A non-ferrous melting furnace fired with butane gas was modelled [3]. The reason for considering butane gas instead of other types of fuel such as diesel, was not stated by the researcher. The design of furnace, fired with diesel was embarked upon by [4]. There reason was to eliminate the use of heating element that required electric power which is poorly supplied in Nigeria. A furnace fired with diesel was considered by [5], in their experimental investigations and CFD study of temperature distribution during oscillating combustion in a crucible furnace. The reason for their consideration was not however stated. It was stated by [6] that in the foundry laboratories, a furnace fired with diesel had been used for studies of sand casting in the mechanical field. The view expressed by [7] was that the furnace fired with diesel is more synonymous with the duty of non ferrous melting. In the work of [8], he considered the axis metrical furnace for his calculation of flow properties with a view to finding out, the extent to which the local flow properties and wall heat flux in an axis metrical reversed flow furnace, can be controlled by furnace geometry, and consequent effect on local temperature and combustion efficiency. The furnace was fired with jet of butane. The researcher did not state why consideration was given to butane instead of diesel for firing. Neuro-fuzzy technique was used by [9] to model a rotary furnace parameters to predict the melting rate of molten metal required to produce homogenous castings, they considered light diesel oil fired furnace. They did not state the reason for their consideration.

So the aim of this research is to find out between diesel and butane gas fired furnace, the one that is more suitable in terms of minimal cost of fuel and earliest possible time of melting and bringing aluminium to its pouring temperature.

2. Materials And Methods

The diesel fired furnace and butane gas fired furnace in the foundry shop of Auchi Polytechnic, Auchi, Edo State, Nigeria, were used to carry out the tests.

The two furnaces were individually charged with 12kg of aluminium blanks having the following compositions 99.59% (Al), 0.03% (Cu), 0.04% (fe) and 0.34% (Si).

They were respectively fired with 20 litres of diesel and 12.5kg of butane gas. The combustion temperatures, melting temperatures of aluminium and flue gas temperatures were measured with type K thermocouple in an interval of 5 minutes, until the pouring temperatures of aluminium were obtained. Figure 1 shows the opened diesel fired furnace after melting aluminium and bringing it to its pouring temperature. Figure 2 shows the opened butane gas fired furnace after melting aluminium and bringing it to its pouring temperature.

Figure 1: An opened diesel fired furnace after melting Aluminium and bringing it to its pouring temperature

Figure 2: An opened butane gas fired furnace after melting Aluminium and bringing it to its pouring temperature

The variations of the combustion, melting and the flue gas temperatures with time for the respective diesel and butane gas fired furnaces are shown in figures 3 and 4.
The quantity of fuel used, the cost as well as the burn rates in each case were determined, and depicted in Tables 1 and 2 respectively.

3. Results and Discussions

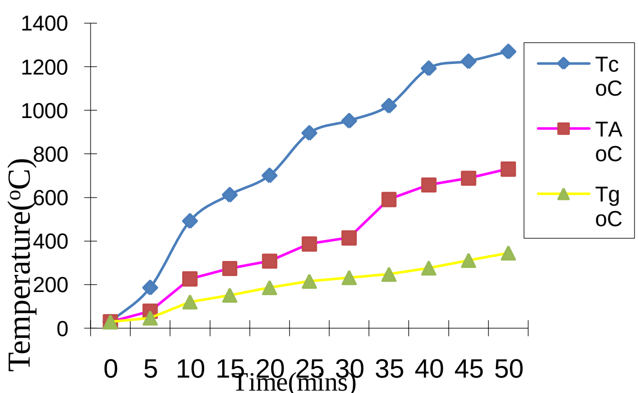

Figure 3: Variation of combustion, Aluminium melting and flue gas temperature with time using Diesel

From Figure 3, as the combustion temperatures (Tc) increased, the melting temperatures and flue gas temperature (TA and Tg) also increased, that is between 0 and 50 minutes. Drops in temperatures were not experienced. This is because, there was no refueling of the furnace. The furnace was able to melt aluminium and bring it to its pouring temperature of 731^{0}C in 50 minutes.

Table 1: Quantity and cost of diesel for firing the melting furnace to melt Aluminium

	Volume of diesel fed into the tank (m^3)	Volume of diesel left in the tank (m^3)	Volume of diesel used (m^3)	Cost of diesel used (Naira)	Duration (mins)
1st	0.02	0.0108	0.0092	1380	50
2nd	0.02	0.0105	0.0095	1425	50
3rd	0.02	0.0105	0.0095	1425	50
Average	0.02	0.0106	0.0094	1410	50

From Table 1, it can be seen that an average of 9.4 litres of diesel was consumed by the burner of the furnace to melt 12kg of aluminium at the cost of One Thousand, Four Hundred and Ten Naira (₦1410) which is about 8.9 US dollar.

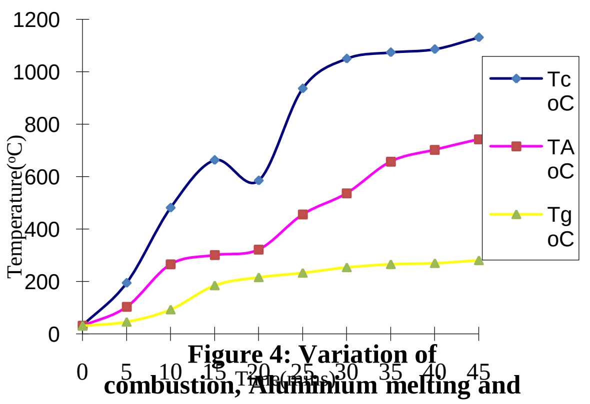

Figure 4: Variation of combustion, Aluminium melting and flue gas temperature with time using Butane gas

Figure 4, revealed that as the combustion temperatures (Tc) increased, the melting and flue gas temperatures (TA and Tg) increased. There were no drops in temperatures. This is as result of uniform combustion of the gaseous fuel. The furnace using butane gas for firing, was able to melt aluminium in 35 minutes and raised it to its pouring temperature of 743^{0}C in 45 minutes.

Table 2 Weights and Cost of Butane gas used for firing the melting furnace

	Initial weight of the gas (kg)	Final weight of the gas (kg)	Gas used (kg)	Cost of gas (Naira)	Duration (Mins)
1st	12.5	11.16	1.34	375.2	45
2nd	12.5	11.14	1.36	380.8	45
3rd	12.5	11.21	1.29	361.2	45
Average	12.5	11.17	1.33	372.4	45

From Table 2, it can be seen that the average weight of butane gas used to fire the furnace that melted aluminium was 1.33kg at the cost of Three Hundred and Seventy-Two Naira, Forty Kobo(₦372.40) which is about 2.4 US dollar.

4. Conclusion

On the basis of the overall result and in line with the aim of this research work, the following conclusions can be made. Butane gas has been found to be viable for use in firing furnace for melting aluminium. This is as a result of the low cost of the gas and the earliest possible time of bringing aluminium to its pouring temperature compare to diesel.

It is therefore recommended that on industrial scale, the use of butane gas should be explored in melting aluminium.

5. References

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