Technical and Economical Study of Using Used Oil as Fuel for Aluminium Smelting Furnace

Teguh Suprianto, Muhammad Kasim, Darmansyah and Muhammad Hasbi
Departmnt of Mechanical Engineering, Politeknik Negeri Banjarmasin, Kayutangi, Banjarmasin, Indonesia

Keywords: Used Oil, Oil-Fired Furnace.

Abstract: Used oil is liquid waste generated from the use of vehicle and industrial engines. Waste oil can be used as a fuel in metal smelting. This study discusses the technical aspects and costs of using used oil as fuel for Aluminium smelting furnaces. This research uses a spray gun to mix used fuel oil and air. The mixed fuel and air are then burned in a nozzle burner to melt 3 kg of Aluminium. As a comparison, experiments with LPG fuel were also carried out. Temperature and flame measurements were carried out in this study. The burner flame fuelled by used oil produces a higher maximum temperature than the LPG flame, which is 950 and 1100 C, respectively. From the results of the study, the comparison of the cost of smelting 3 kg of Aluminium using used oil is 0.12 USD while the cost of smelting with LPG is 0.6 USD.

1 INTRODUCTION

Waste is the residue of a business and/or activity. Meanwhile, Hazardous and Toxic Waste is the residue of a business and/or activity containing Hazardous and Toxic Materials. Hazardous waste is known because its nature, concentration, or amount, either directly or indirectly, can pollute and damage the environment, and endanger health. It also endangers the survival of humans and other living things. Used Oil or Used Lubricating Oil is a type of dangerous waste that is commonly found around us. Used oil waste is generally generated from the use of lubricating oil or oil. Lubricating oil is generally used by equipment that is moving, or machines, or motorized vehicle engines such as motorcycles, cars, trucks and electric generator engines. The ever-increasing use of motorized vehicles will cause the amount of used oil to also increase and the potential for pollution to also increase

Used engine oil, however, has a relatively high calorific value so that it is interesting to be used this waste as a renewable fuel for heat generation. One alternative that can be used as fuel in the metal casting process is used oil (Osarenmwinda, 2015). Used oil can be obtained from motorcycle and car repair shops. So far, used oil has not been widely used and the price is cheap. This has the potential to be used as a substitute for metal casting fuel.

Many previous studies have used oil as a fuel. Study conducted by Tamaki made a high effective and stable combustion of waste oil combustor design which was achieved with low energy (Tamaki, 2003). Another study stated that the combustion zone of the two-stage burner was higher than those in the single-stage type as a result of a better mixing of air and fuel (Lekpradit & Namkhat, 2017). Study by Elnajjar, Al Omari, Hamdan, Ghannam, & Selim, 2021) showed better combustion quality with the addition of diethyl ether additive.

One of the most popular types of metal casting is aluminium casting. Aluminium casting is used by the community and small industry to make household appliances, ship propellers and so on. (Yulianti & Wahdah, 2019).

So far, many small industries use LPG (Liquified Petroleum Gas) as fuel for aluminium smelting. This is because it tends to be easy to obtain and easy to use even though the price is expensive.

The use of used oil, in addition to utilizing waste, is also to look for cheaper alternative fuels so as to reduce casting production costs. Research on used oil fuels has often been done, but it is still rare to show a comparison of costs with other fuels. This research intends to design an aluminium smelting tool fuelled by used oil and carry out a cost comparison study between using used oil and LPG.

Suprianto, T., Kasim, M., Darmansyah, . and Hasbi, M.
Technical and Economical Study of Using Used Oil as Fuel for Aluminium Smelting Furnace.
DOI: 10.5220/0012002100003575
In *Proceedings of the 5th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES 2022)*, pages 1001-1005
ISBN: 978-989-758-619-4; ISSN: 2975-8246

2 METHODOLOGY

2.1 Experiment Setup

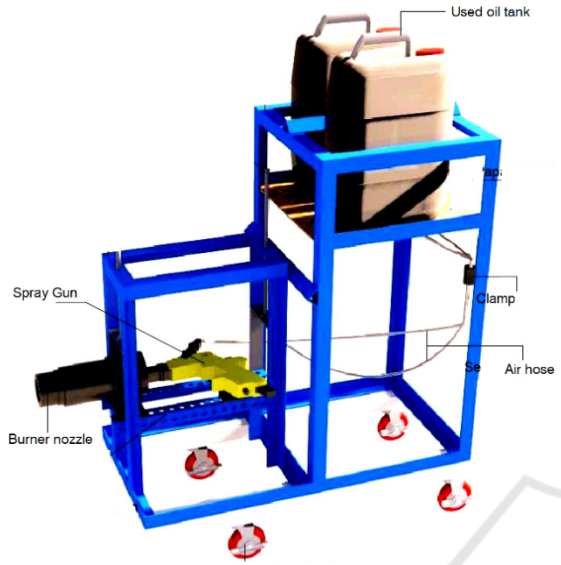


Figure 1: Experiment setup and design.

The test is carried out using a burner fuelled by used oil. Tests using LPG were also carried out as a comparison. Used oil is placed in the tank at the top. Oil is supplied by an 8 mm diameter pipe to the spray gun. Used oil flows by gravity. Spray gun is used for mixing used oil and air before combustion.

Figure 2: Spray gun for mixing oil and air.

The specifications of the spray gun used are as follows:

Table 1: Specification spray gun.

Standard nozzle:	1.4 mm
Operating pressure	2-3.5 bar
Air flow control	119-200 l/min

The nozzle of the spray gun is aimed at the burner to produce a flame that is directed to the aluminium smelting furnace. The cone-shaped burner is made of stainless steel with a diameter of 70 mm at the back and a diameter of 50 mm at the front.

Figure 3: Burner nozzle.

Figure 4: Aluminium melting furnace.

The furnace used has a diameter of 40 cm, a height of 25 cm and a thickness of 5 cm. The furnace is made of refractory cement and is used to melt 3 kg Aluminium

2.2 Experiment Material

In this experiment, Aluminium ingots were used as the metal to be melted. Aluminium ingot is a material that is re-melted to make various products.

Table 2: Characteristics and properties of Aluminium.

Density	2,70 gram per cm^3
Melting point	660,32 ^{0}C,
Boiling point	2519 ^{0}C

At 660^{0}C the aluminium was completely molten and the temperature increased more rapidly (Furu, Buchholz, Bergstrøm, & Marthinsen, 2010).

Furnaces with two different fuels are used to melt the Aluminium. The first experiment was using used oil, the second experiment was using LPG. The specifications of used oil are as follows (Saputra, I. Guhhri, Ainul. Septiadi, 2017):

Table 3: Used oil specifications.

Flash point	77^0C
Fire point	90^0C
Kinematic Viscosity	15.921 centistoke
LHV	39.316MJ/kg
HHV	41.855MJ/kg

Meanwhile, the LPG used is the production of PT Pertamina. The composition of LPG contains 50% Propane and 50% Butane. The LPG specifications used are as follows (ESDM, 2020):

Table 4: LPG specifications.

Steam pressure	5,0 – 6.2 kg/cm2
Specific gravity	2,01
HHV	48.836,27 kJ/kg
LHV	46.043, 37 kJ/kg

2.3 Test Procedure

This study uses a burner that has a spray gun, burner and smelting furnace. An air flow of 119-200 L/min is directed to the spray gun. Before entering the spray gun, the air is compressed by a compressor with a pressure of 3 bar. Setting the spray gun is done to produce an optimal air and oil mixture. The optimal mixture produces the flame with the longest burst. The ignition of used oil is preceded by a heat trigger that comes from the combustion of a mixture of used oil and gasoline. The used oil and gasoline mixture is ignited for 30 seconds to heat the burner nozzle. The flame from the burner nozzle is directed to the smelting furnace.

The temperature measurement was carried out using an Amprobe IR 750 thermo gun. The temperature was measured at the edge of the melting container. Temperature is recorded every 2.5 minutes. Oil and gas consumption is measured during the smelting process.

3 RESULT AND DISCUSSION

3.1 Heating Rate

The results of temperature measurements are presented in Figure 4.

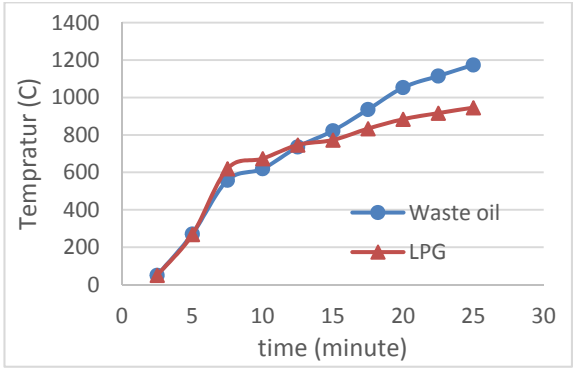


Figure 5: Furnace temperature with used oil vs LPG.

Figure 2 shows the experimental results of used oil and LPG. The maximum temperature of used oil is higher than that of LPG. This happens because the design of the used oil burner produces a larger fire. In terms of combustion energy, burning used oil produces more energy. This is because the mass flow rate of used oil is greater than the mass flow rate of LPG (Table 5). Heating with LPG produces a higher rate at the beginning but then decreases. This is because the fire from LPG is hotter than the fire from used oil. The lower energy rate causes the heat increase not to be proportional to the increase in the amount of heat wasted.

The consumption of used oil and LPG is measured during the smelting process. Table 5 below is a comparison between the mass of gas and oil burned. The energy produced from burning used oil is also shown in table 5.

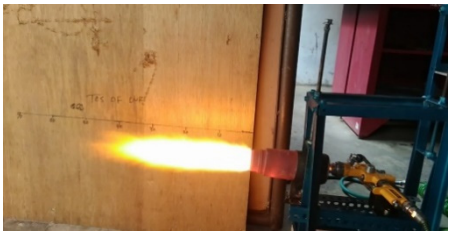
Table 5: Combustion energy.

Fuel	Mass flow rate (gr/s)	Heating value (kJ/g)	Power Equivalent (kW)
Used oil	0.513	41.855	21.471
LPG	0.333	48.836	16.279

3.2 Combustion in Smelting Furnace

Figure 5 shows the combustion of LPG and used oil. Judging from the colour of the fire, burning with LPG produces a blue white flame while the used oil flame is orange. This shows that the fire from LPG has a higher temperature than the fire that comes from burning used oil. The colour of the flame indicates the temperature, the blue flame has a higher temperature than the red color.

(a)



(b)

Figure 6: Combustion results at the nozzle burner (a) LPG, (b) Used oil.

Figure 6 shows the colour temperature chart. Based on the colour match of the flame, the flame colour of LPG gas has a temperature of around 1500 C while the flame of used oil is around 1100 C.

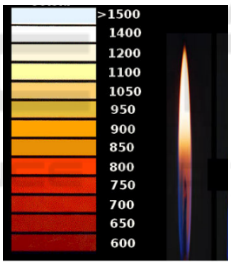
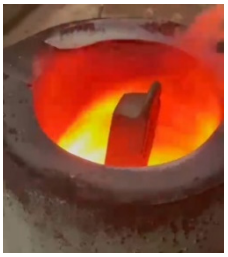


Figure 7: Colour temperature chart.

Figure 7 shows a fire surrounding an aluminium crucible. Flames from used oil tend to be darker, while flames from LPG are lighter. This is because of the different characteristics of fire as discussed earlier.



(a)

(b)

Figure 8: Flame surrounding crucible (a) used oil, (b) LPG.

3.3 Fuel Cost Comparison

The cost comparison between 3 kg aluminium smelting with gas fuel and used oil is presented in the table 6 and 7:

Table 6: Used oil cost.

Used oil			
Description	Usage amount	Unit price	Cost
Used oil	950 gr	0.16 USD/kg	0.15 USD
Electricity cost for compressor	0,75 kW x 25 min	0.1 USD/kWH	0.03 USD
Total			0.18 USD

Table 7: LPG cost.

LPG			
Description	Usage amount	Unit price	Cost
LPG	500 gr	1.2 USD/kg	0.6 USD

Based on tables 6 and 7, the use of used oil is much cheaper than using LPG, which is 330% cheaper. Although the resulting heating rate is lower. This condition can be overcome by increasing the capacity of the spray gun used so as to increase the rate of energy being burned.

4 CONCLUSIONS

From the research and discussion that has been done, it can be concluded as follows:

1. The heat generated by the combustion of used oil can reach a higher temperature than LPG, but the heat increase from LPG is faster than used oil.
2. The cost of smelting Aluminium with used fuel oil is much cheaper than using gas fuel.

ACKNOWLEDGEMENTS

Thank you to the Banjarmasin State Polytechnic for funding this research.

REFERENCES

Elnajjar, E., Al Omari, S. A. B., Hamdan, M. O., Ghannam, M., & Selim, M. Y. E. (2021). Characteristics of external furnace combustion of used lube oil with different percentages of diethyl ether additives burned with liquefied petroleum gas. *Biofuels*, *12*(10), 1233–1243. https://doi.org/10.1080/17597269.2019.1608035

ESDM, K. (2020). *Keputusan Direktur Jenderal Minyak dan Gas Bumi Nomor 116.K/10/DJM/2020 tentang Standar dan Mutu (Spesifikasi) Bahan Bakar Gas Jenis Liquefied Petroleum Gas yang Dipasarkan di Dalam Negeri.* Jakarta.

Furu, J., Buchholz, A., Bergstrøm, T. H., & Marthinsen, K. (2010). Heating and melting of single Al ingots in an aluminium melting furnace. *TMS Light Metals*, 679–684.

Lekpradit, T., & Namkhat, A. (2017). Two-stage combustion burner using used engine oil as fuel. *Key Engineering Materials*, *751 KEM*, 442–448. https://doi.org/10.4028/www.scientific.net/KEM.751.442

Osarenmwinda, J. O. (2015). Fabrication and performance evaluation of oil – fired crucible furnace using locally sourced materials, *5*(3), 29–33.

Saputra, I. Guhhri, Ainul. Septiadi, W. (2017). Daur Ulang Oli Bekas Menjadi Bahan Bakar Diesel Dengan Proses Pemurnian Menggunakan Media Asam Sulfat Dan Natrium Hidroksida. *Logic : Jurnal Rancang Bangun Dan Teknologi*, *17*(1), 73–79. Retrieved from http://ojs.pnb.ac.id/index.php/LOGIC/article/view/509

Tamaki, N. (2003). Study on Development of Waste Oil Combustion Burner for Energy Saving and Low-Pollution (II). *Journal of the Japan Institute of Energy*, *82*(10), 780–785.

Yulianti, F., & Wahdah, R. (2019). Pengembangan Kewirausahaan Berbasis Potensi Lokal Pada Usaha Kerajinan Tanggui Kelurahan Alalak Kecamatan Banjarmasin …. In ... *Manajemen Indonesia (FMI ….* Retrieved from http://eprints.stiei-kayutangi-bjm.ac.id/1035/

Moore, R., Lopes, J. (1999). Paper templates. In *TEMPLATE'06, 1st International Conference on Template Production*. SCITEPRESS.

Smith, J. (1998). *The book*, The publishing company. London, 2nd edition.