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# Design and Fabrication of a Mobile Furnace Fueled by Waste Motor Oil

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**Abstract- The research focused on designing and fabricating a mobile furnace fueled by waste motor oil for melting aluminum in the mechanical engineering department workshop at the Federal University of Petroleum Resources, Effurun, Nigeria. Locally sourced materials were utilized in the fabrication process. A mild steel tank, with a thickness of 3mm, width of 450mm, and height of 860mm, served as the heating chamber of the furnace. Additionally, a steel tube, 10mm thick, 314mm high, and 100mm wide, was used as the crucible. The waste oil is ignited using a syphon nozzle, creating a fine spray of fuel and air. Compressed air is employed to atomize the liquids into fine droplets, serving as the fire source for the furnace. Refractory materials were developed using a composite of plaster of Paris, clay, and cement at a ratio of 2:1:1. A fiber blanket with a melting point of 1,400°C was utilized as an insulator. The waste oil was siphoned from the tank at an elevated height, utilizing the principle of gravity and centrifugal flow. The project was successfully completed at a total cost of #300,000, proving cost-effective compared to acquiring a foreign alternative. The furnace is mobile, aided by three rolling tires, facilitating flexible movement.**

**Index Terms- Design, Furnace, Mobile, Oil, Waste**

## I. INTRODUCTION

A furnace serves as a vital apparatus for converting the chemical or electrical energy into heat, thereby elevating material temperatures. Often, furnaces operating at lower temperatures are referred to as ovens, contingent upon their intended applications, while those designed for higher temperatures cater to various material and functional needs (Folayan, 2001).

These refractory-lined vessels hold the material slated for melting and supply the requisite energy for the process. Modern furnace variants encompass electric arc furnaces (EAF), induction furnaces, cupolas, and crucible furnaces. The selection of a furnace hinges upon the nature and volume of materials processed. Ferrous materials typically find processing in EAFs, cupolas, and induction furnaces, whereas crucible furnaces are popular for aluminum castings (Beeley, 2001).

A crucible furnace stands as one of the earliest and simplest furnaces employed in foundries, primarily tasked with melting smaller quantities of nonferrous metals, although it can accommodate ferrous metals as well. This furnace type finds prominence in smaller foundries or specialized alloy production lines. The crucible or refractory container undergoes heating within the furnace, typically fueled by natural gas, liquid propane, coke, charcoal, oil, or electricity. The improper disposal of waste motor oil constitutes a significant environmental hazard, posing threats to soil, water, and air quality, thereby impacting ecosystems and human health. Furthermore, traditional furnaces often exhibit a stationary, bulky nature, coupled with high costs, thereby restricting access to metalworking for artists, hobbyists, and entrepreneurs, especially in geographically remote regions or with limited resources. Additionally, conventional fuel sources utilized in furnaces can be both costly and contribute to greenhouse gas emissions. These critical considerations have underscored the necessity for undertaking this project

## II. LITERATURE REVIEW

Various studies have been conducted to explore the design and fabrication of furnaces for different purposes, focusing on efficiency, cost-effectiveness, and environmental sustainability.

Emifon iye U.E. et al (2020) designed and fabricated a furnace for plastic waste recycling, incorporating components such as a thermometer, mild steel, glass fiber, heating coil, outer and inner layers. The furnace was seasoned before use, achieving melting temperatures up to 1350°C. The study demonstrated the furnace's effectiveness in melting plastic waste, providing a cost-effective solution accessible to average Nigerians.

Onuchukwu Chike Godwin et al (2019) presented a portable Bale-out cast-iron crucible furnace fueled by diesel. The furnace, constructed using locally sourced materials, exhibited efficient performance in melting aluminum and cast-iron scrap, with recorded melting times and temperatures.

Ebenezer K. et al (2019) developed a crucible furnace fired with spent engine oil, aiming to reduce the cost of melting iron in Nigeria. The furnace, constructed mainly from locally sourced materials, demonstrated satisfactory performance with a designed operating temperature of 1400°C.

Adebayo O.I et al (2008) successfully utilized a crucible furnace fired by waste oil to melt aluminum scrap metals, achieving melting temperatures around 665°C. Onwuka O.B. et al (2015) scaled up the melting capacity to 100kg of copper, employing suitable materials and parameters to construct a furnace powered by waste oil. El-Sayed M. A. (2012) designed a crucible furnace utilizing waste oil, incorporating high-grade refractory lining and sturdy stainless-steel construction for efficient heat transfer and durability.

Garba Muhammad San (2015) developed a portable crucible furnace fueled by charcoal, utilizing locally available engineering materials and demonstrating efficient performance in melting aluminum scrap. Chukwudi.C. et al (2018) designed an oil-fired crucible furnace focusing on high efficiency in melting aluminum, employing a composite refractory material and diesel fuel atomization system.

Navaneeth Kashyap. K.V. (2019) fabricated a waste oil-fired furnace for aluminum melting, aiming for high efficiency by minimizing heat losses and maximizing heat generation. Akintayo et al (2015) focused on the design and fabrication of a melting furnace powered by waste oil, achieving successful melting of aluminum.

Okada, Sasaki, and Yoshikawa (2004) developed a continuous melting and holding crucible furnace for aluminum smelting, emphasizing energy efficiency and improved metal quality. These studies collectively contribute to the advancement of furnace technology, offering solutions for various melting needs while considering factors such as efficiency, cost-effectiveness, and environmental impact.

## III. MATERIALS AND METHOD

The materials obtained for the construction of the crucible furnace include a 3mm thick mild steel tank, mild steel rods with a thickness of 10mm, waste motor oil, scrap aluminum, plaster of Paris (POP), clay sand, cement, stainless steel hex cap, stainless steel tee, stainless steel street elbow, stainless steel pipe nipple, ball valve, air blower, angular rod, rubber tube, plastic tank, and refractory fiber blanket. These components collectively contribute to the assembly of the furnace, ensuring its functionality and durability.

In order to fulfill the objectives of this study, several factors were considered, including design criteria such as refractory wall thickness, working pressure, material availability, and furnace geometry (height, diameter, area, and volume). Additionally, considerations were made for combustion reaction, air compressor sizing, and heat supplied to the furnaces.

The choice of materials for the furnace was based on design calculations and specifications. A 3mm thick mild steel tank was selected due to its ability to meet the following requirements:

Ability to withstand internal pressure: Mild steel possesses high tensile strength, typically ranging from 276 MPa to 2070 MPa (Singh, 2003), which is more than sufficient to withstand the internal pressure developed during operations.

Ability to withstand high operational temperatures: Mild steel is capable of withstanding the relatively high temperatures experienced both in the furnace unit and combustion chamber.
Ease of machining and fabrication: Mild steel offers ease of machining and fabrication, facilitating the construction process.

For insulation purposes, materials with low thermal conductivities and high heat resistance were selected. These included fiber blanket, plaster of Paris (POP), clay sand, and cement. Fiber blanket, in particular, was chosen for its excellent thermal insulation properties and high-temperature resistance (up to 1,260°C – 1,400°C).

Clay, characterized by its fine-grained structure and high resistance to heat (up to 1,000°C – 1,300°C), was also incorporated into the furnace design. Clay's ability to form a tight bond when moistened contributes to its effectiveness as an insulating material.

The waste oil burner components were chosen for their resistance to high temperatures. These included stainless steel hex cap, tee, street elbow, pipe nipple, ball valve, and steel tube with a thickness of 10mm. The air supply system utilized an air blower with specifications of 230V, 50Hz, 400W power, a blowing rate of 3m³/min, and 14,000rpm.

Waste motor oil, comprising base oil, additives, and contaminants, served as the fuel for the furnace. Its composition includes lubricating oil drained from engines after use, with additives enhancing performance and contaminants including dirt and combustion byproducts.

The furnace, with a height of 550mm, was designed to be portable, occupying minimal space and enabling easy relocation for operations. Additionally, the waste oil tank was positioned on a high platform to facilitate gravity-induced flow and syphoning of the oil.

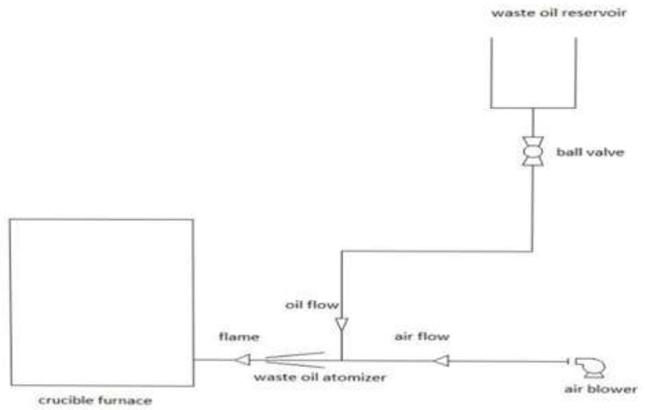

Figure 1: Schematic diagram of a working flow waste oil fired curable furnace

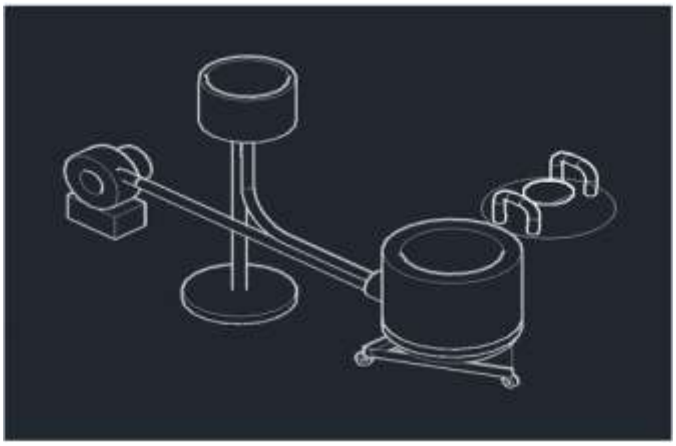
Figure 2: CAD design of furnace

Various factors were taken into account during the design process, including production cost, the type and availability of fuel (waste motor oil), material selection and availability, fabrication flexibility, ease of maintenance, durability, material costs, availability of fabrication tools and equipment, furnace dimensions (height and width), blower capacity, and furnace shape.

Figure 3.2 illustrates the general layout and profile of the crucible furnace, comprising components such as an air blower, syphon nozzle, waste oil tank, and the crucible furnace unit. Operating under high pressure and temperature, the furnace design adheres to heat-related criteria.

## IV. RESULTS AND DISCUSSIONS

After fabricating the furnace, it underwent testing using two distinct methods to ascertain the time required to achieve temperatures exceeding 660 degrees Celsius for aluminum melting. The tests conducted were as follows:

- No load test of the furnace
- Furnace with a 10kg load test

In the no load test, the furnace was tested empty without any aluminum loaded, following the prescribed testing procedures. The results obtained from this test revealed that it took 30 minutes to raise the temperature of the crucible to 660 degrees Celsius and above.

Subsequently, the load test was conducted with 10 kg of aluminum loaded into the furnace. The results obtained from this test indicated that it took 55 minutes to raise the temperature to 660 degrees Celsius. Furthermore, the aluminum required an additional 10 minutes of holding time to completely melt. Consequently, the total time taken for melting 10 kg of aluminum at once was 1 hour and 5 minutes.

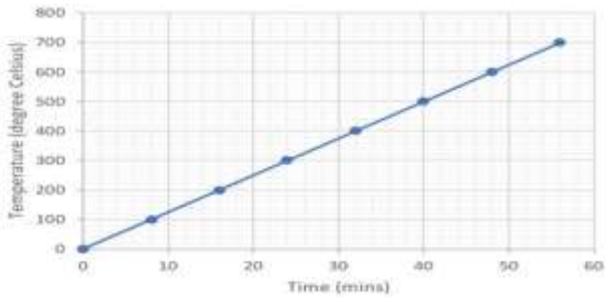

Figure 3: Value of temperature versus time for no load test of a furnace.

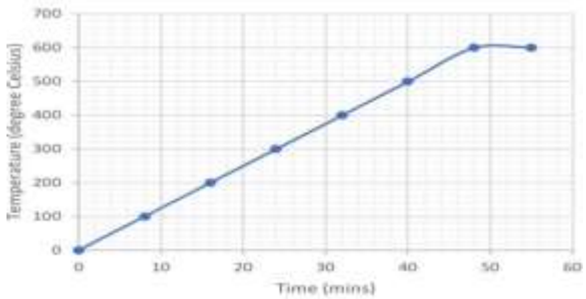

Figure 4: Value of temperature versus time for 10kg of aluminum.

## V. CONCLUSION

In conclusion, the performance test conducted on the fabricated crucible furnace successfully achieved the set objectives of the research, including fuel economy, reduction of health hazards, and operational time efficiency. It was observed that the furnace effectively melted aluminum, demonstrating its economic and time-saving advantages during operation. Therefore, it can be inferred that the device is well-suited for use in small-scale foundries and tertiary institutions. Notably, the fabricated crucible furnace achieved a temperature of 800°C within 55 minutes, further validating its suitability for practical applications.

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