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Title of Proposed Research
Development of Recuperator Waste Engine-Diesel Oil Mixtures Fired Crucible Furnace for Melting of Non-Ferrous Metals for Foundry Applications

Background to the Research
A crucible furnace is a mechanical device used for melting and casting metals that have a low melting point such as brass, bronze, and aluminum. They are one of the oldest types of melting ovens and among the most commonly used furnaces in the industry. Foundry technology is basic to economic development and self-reliance. In Nigeria however, little attention has been given to the development of the casting industry for too long. This is one of the reasons for our over dependence on imported spare parts and machine components such as machine tools, power plants, industrial machinery and equipment, automobile, agricultural and textile industry. UNIDO, (2022) shows how the National Demand of cast metal products in Nigeria steadily increased from 72, 000 tonnes to 292, 000 tonnes (1985) to 425,000 in (1990s) and 794, 000 tonnes by the turn of the century, required to meet industrial demand and at present only four foundries have managed to survive out of the sixty registered active ones as of 1995 to cater for this huge demand. This gap (over 70%) in casting products supply has only been met through importation over the years.

Statement of the Problem
So many problems are associated with the old type open crucible furnaces used in the local foundries. The foundry men are exposed to heat and combustion products which are harmful to health, more than half of the heat escapes due to the open nature of the local furnace, these open crucible furnaces contribute to environmental problems due to high demand of wood for charcoal production and the process consumes large quantities of fuel (charcoal) due to its low combustion efficiency and high heat loss. Also the poor performance of the manufacturing sector in Nigeria is indicative of the low state of the foundry industry. The market value of the annual casting shipments is quite very low compared to that in the US and other developed nations (UNIDO, 2022). These myriad of problems therefore, necessitated this research work; Design and Fabrication of such kind of equipment using locally available materials for use in our Tertiary institutions and foundry industries across the country

Aim and objectives of the Research

The aim of the work is to design and construct a Recuperator Waste Engine-Diesel Oil Mixtures Fired Crucible Furnace for Melting of Non-Ferrous Metals for Foundry Applications using locally available materials.

The specific objectives of this research are:

i. To design a Recuperator Waste Engine-Diesel Oil Mixtures Fired Crucible Furnace for Melting of Non-Ferrous Metals for Foundry Applications using relevant design equations
ii. To model and simulate the system using MATLAB and SOLIDFACE CAD software soft wares
iii. To develop the system using locally available materials.
iv. To subject the system to performance test
v. To validate both the simulated and experimental results and
vi. To carry out techno - economic analysis of the system

The objectives with Regard to the Commercializing the System and the Products to be Produced (Utensils and Machine Components) for business are as follows:

(i) Increase market share by capturing a significant portion of the local market and expand to regional or national levels
(ii) Burst revenue to generate substantial revenue through sales and distribution channels
(iii) Improve product quality by ensuring high quality products that meet customer's expectation and safety standard
(iv) Expanding distribution networks for establishing partnership with whole sales, retailers and online platforms to increase products availability.
(v) Optimizing product cost by streamlining production processes to reduce cost and improve profitability.
(vi) To meet customer needs or demands

Research Question

The design and construction of most Recuperator Waste Engine-Diesel Oil Mixtures Fired Crucible Furnace for Melting of Non-Ferrous Metals for foundry applications are not optimized for effective performance and higher efficiency. A number of design criteria are also yet to be standardized.

In this work, SOLIDFACE CAD and MATLAB soft wares are intended to be used in the design of the Proposed System so as to optimize performance of the system

Literature Review

Furnace design may vary according to its function, heating duty performed, heating method applied or type of fuel used as reported by Olalere et al. (2022). Ighodalo et al. (2023) improved on the gas fired crucible type method of melting by designing a coal fired crucible furnace. He further did a study evaluating the performance of a charcoal-fired furnace for recycling aluminium scraps. The efficiency of the furnace was 11.5%. This value was low as a result of the large quantity of energy wasted due to the open nature of the furnace. Titiladunayo and Fapetu (2022) designed electrically powered stationary pot crucible furnace for pyrolysis show and cased the benefits of electrically power furnaces but its cost of operation was exorbitant. Toshikazu and Ryoya (2023) investigated the use of kerosene crucible furnace which attained temperature of 750 ^{0}C. While this temperature was fairly sufficient for melting

aluminium, it was inadequate for other non-ferrous metals. Beneth and Martins (2024) carried out a design and construction of an oil-fired crucible furnace. The study focused on ensuring a high efficiency in melting of aluminium, by effectively minimizing heat losses, and maximizing heat generation was motivated by this challenge. Thus, the documented works of fuels for combustion in crucible furnace has shown that the need to obtain a fuel that is readily available and cheap remains a major challenge plaguing the foundry business in Nigeria

Theoretical Framework

Nigeria has a total of 160 foundries (foundry chronicles, 1995), of which only 5 are commercial in contrast with India, in which has 9000, registered foundries. The capacity of the country's foundry industry is put at 152,000 metric tones annually which is made up of about 59.1% (60,178 metric tones) cast iron, 27.3% (41,465 metric tones) of cast steel and 33.1% (51,370 metric tones) nonferrous all valued at about 19.6 billion naira (US $196.3 million). This is considered unimpressive with the 3 million metric tones per annum in India (Osanrenmwinda, and Iguodala 2022) and (NASENI 2024). This low capacity utilization is attributed to lack of appropriate foundry equipment. The need to locally redesign and develop the standard Recuperator Waste Engine-Diesel Oil Mixtures Fired Crucible Furnace for Melting of Non-Ferrous Metals for foundry applications according to international specification will go a long way to helping in the research and development of foundries, use in school workshops, to provide for both routing foundry control and development of new material

Research Methodology

The following method or approach is going to be used for the design and construction of the system.

- **Design Theories**
- **Design Considerations**
- **System Design Approach and Calculations**
- **Determination of Design Parameters**
- **Design Parameters Optimization**

Expected Result

Economic and Technological outcome of this research will include the followings:

i. An optimized system that will be capable of meeting the desired objectives
ii. It will contribute significantly in converting scrap nonferrous metals into useful products
iii. It is expected that the system will contribute significantly in the development of indigenous technology especially in the production industries
iv. It is expected that the system is going to be economical and made available for our tertiary institutions and foundry industries across the country thereby creating job opportunities
v. It is expected that the system will enhance casting quality by meeting precise surface finish requirement
vi. It is expected that the system will enhance or increase productivity through reduction of processing time
vii. It is expected that the system will improve working conditions of foundry men and encourage youths to venture into the foundry work.
viii. It is expected that the system will reduce manual labour by reducing drudgery that is involved
ix. The parametric study that is going to be carried out for different components and sizes of the system by utilizing MATLAB software would increase the system performance, consequently increasing the efficiency of the system

Expected Benefit with Regard to the Commercializing the System and the Products to be Produced (Utensils and Machine Components) for business are as follows:

(i) Profitable through significant revenue and profit margins generations due to demand for aluminium utensils and machines components
(ii) Job creation, serving as a potential to create employment opportunities in manufacturing, sales and distribution
(iii) Market growth serving as an opportunity to expand into new markets, both locally and regionally
(iv) Contribution to Nigerians economy growth and development
(v) Meeting local demand by providing quality aluminium utensils and machine components to meet local demand and reduce imports
(vi) Opportunities to innovate and development new products, improving competitiveness

Area of Focus with Regard to the Commercializing the System and the Products to be Produced (Utensils and Machine Components) for business are as follows:

(i) Product development through designing and manufacturing innovative functional and aesthetically pleasing utensil and machine component
(ii) Quality control by ensuring high quality product that meet safety standards and customer expectation
(iii) Marketing and sales by identifying target customers, promoting products, and establishing distribution channels
(iv) Supply chain management through sourcing of raw materials, managing inventory and optimizing logistics
(v) Cost optimization to reduce cost of product
(vi) Export and expansion by exploring export opportunities and expanding business reach to new market

Innovation

The design and construction of most Recuperator Waste Engine-Diesel Oil Mixtures Fired Crucible Furnace for Melting of Non-Ferrous Metals for foundry applications are not optimized for effective performance and higher efficiency. A number of design criteria are also yet to be standardized. In this work, SOLIDFACE CAD and MATLAB soft wares are intended to be used in the design of the Proposed System so as to optimize performance of the system

Project Budget.

Personnel (< 20% of Total)	=	₦ 6, 132, 925. 238
Equipment (< 25% of Total	=	₦ 7, 666, 156. 5475
Fabrication of the system	=	₦ 15, 080, 190.28
Data Collection, analysis/Testing	=	₦ 486, 023.6429
Travels / Transportation (< 9% of Total)	=	₦ 2, 759, 816. 3571
Dissemination of Results (< 3% of Total)	=	₦ 919, 938. 7857
Miscellaneous	=	₦ 2, 040, 575. 3388
GRAND TOTAL	**=**	**₦ 35, 080, 626. 19 k**

Research Team

S/N	NAME	HIGHEST QUAL.	RANK	AREA OF SPECIALIZATION
1	Engr. Gideon Ayuba Duvuna	PhD	Chief Lecturer/Principal Investigator	Mechanical (Energy Engineering)
2	Engr. Robinson .I. Ejilah	PhD	Professor	Production Engineering
3	Gwandi Opeyemi Offar (Mrs.)	B.Eng.	Assistant Lecturer	Metallurgical Engineering
4	Gyang Peace Gwom (Mrs.)	HND	Technologist II	Foundry Engineering Technology
5	Tenenbini .A. Njidda	HND	Chief Technologist	Welding and Fabrication Engineering Technology

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