Journal of Manufacturing Engineering, September 2026, Vol. 21, Issue. 3, pp 108-116
DOI. https://doi.org/10.37255/jme.v21i3pp108-116

DESIGN AND CONSTRUCTION OF A CHARCOAL POT INCORPORATED WITH A RECHARGEABLE BLOWER

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Abstract

The performance of traditional charcoal pots for home and small-scale commercial cooking applications needs improvement due to the high cost of cooking gas and rising energy prices in Nigeria. Designing and constructing a charcoal pot with a rechargeable blower was the goal of this project. The process included choosing the right materials, welding and fabricating the charcoal pot, and incorporating a rechargeable blower. Coal weighing 45.5 g and 117.355×10^{-3} m^3 of water were used. The project involved the design and construction of the exterior cover, combustion chamber, insulation, and gauze assembly to achieve optimal performance. A shear cutter, an arc welding machine, and an angle grinder were used during fabrication to cut the metal plate to the required sizes. The purpose of testing the charcoal pot was to compare its actual performance to its design value. In reality, boiling took 10 minutes with a blower, 60 minutes with a regular charcoal, and 25 minutes with a hot plate. The pot's ability to convert the chemical energy of charcoal into heat energy was confirmed by the results, which showed that burning efficiency increased in proportion to the air supply. The concept was a straightforward technology that could be used for cooking either on its own or as part of a small-scale food business. The project will help in reducing cooking time and smoke emissions. Compared with other cooking techniques examined, the charcoal pot proved to be the most effective and quickest, thereby supporting sustainable engineering initiatives in Nigeria.

Keywords. *Charcoal pots, Actual Performance, Design Value, Air Supply, Burning effectiveness.*

1. Introduction

Despite the pain caused by the smoke that either precedes or follows the use of firewood, some individuals in both rural and urban regions continue to use it for cooking. Other commercial fuels that African nations mostly use for cooking, including kerosene and cooking gas, are not only expensive but also hard to obtain. Additionally, the Power Holding Company of Nigeria (PHCN)'s erratic power supply had rendered the boiling rings and electric stoves in our homes worthless (Abdul et al., 2014). Daly and Morrison (2001) stated that Nigeria's ongoing fuel crisis has highlighted the need for energy specialists to focus even more on developing practical substitutes or supplements to electricity, kerosene, and cooking gas for home cooking. According to Komolafe et al. (2010), the relative quantities of wood and agricultural wastes in many regions of the nation throughout the year suggest that they could be a viable alternative energy source. Charcoal, as an alternative to other cooking fuels, has twice the energy content of wood, which is one of its principal attractions for consumers (Usman, 2017). A tiny quantity of it produces a strong, constant heat (Berko, 2018). In contrast to a conventional metal stove, this study reports on the design and construction of a charcoal pot with a rechargeable blower that may effectively and efficiently retain heat for cooking. Meat patties and other dishes must be cooked quickly in foodservice systems. The market for healthy fast food items has expanded dramatically in recent decades (Adeyeye and Oyewole, 2016). Curing, grilling, heating, drying, smoking, barbecue, and other procedures that involve applying heat to the food's surface are commonly used in food service companies. Grilling can also be done indoors in rotisseries or grill rooms. Grilling is one of the most popular outdoor cooking techniques for dishes that feature natural flavors. The side, bottom, or top of the grilling device is where the meat gets most of its heat (University of Kentucky, 2016). A heat source, usually from the bottom, must be employed to raise the temperature to a sufficient level (Drave and Mishra (2015). A common technique frequently promoted as a healthier alternative to oil-based cooking is grilling (Beckett, 2012). This is because the higher temperatures used in grilling allow more vitamins and minerals, such as calcium and iron, to be absorbed by the food. This increases the food's nutritional content and adds extra nutrients that are hard to get with other cooking methods, such as boiling or baking. A modern version of a traditional grilling appliance is an outdoor charcoal grill, sometimes referred to as a wood-fuel barbecue. A modern version of a traditional grilling appliance is an outdoor charcoal grill, sometimes

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referred to as a wood fuel barbecue. A grill that burns wood or charcoal is a basic type that can be used. Many studies have been conducted on the oven because of its importance in the cooking process. Rasheed et al. (2023) developed a low-cost home electric oven incorporating a fan for improved efficiency. Rasheed et al. (2023) described a major design in oven fabrication. Although these ovens have helped reduce the stress that comes with cooking outside, they are not very effective at releasing smoke, and although they have contributed to the growth of the nation's grilling industry, little to no effort has been made to improve the efficiency of the widely used traditional grilling oven through design and process. None of the aforementioned design materials includes an indirect-fired oven prototype that can be used to grill a range of dishes with charcoal and requires another heat source (gas or electricity). Using the sustainable design technique, an oven must be designed and manufactured to meet user needs.

Although many homes and businesses still use traditional charcoal pots for cooking and grilling, their use is frequently limited by excessive smoke, inefficient fuel combustion, and high energy consumption. While they have helped the grilling industry grow, there hasn't been much focus on improving their design to be more efficient and user-friendly. By increasing airflow, boosting combustion, reducing smoke emissions, and minimizing cooking time, incorporating a rechargeable blower into the charcoal pot offers a practical alternative. This design strategy supports sustainability principles while meeting consumer demands for safer, more hygienic, and energy-efficient cooking. To remain relevant in the field of food and hotel engineering, traditional grilling techniques need to be updated, according to Bello and Bello (2020). In a similar vein, (Kuś et al., 2023) highlights the use of premium, restaurant-grade charcoal in alternative and sustainable designs. By implementing these suggestions, the design and construction of a charcoal pot with a rechargeable blower will boost the market value of grilled goods and enhance the efficiency of grilling systems, empowering stakeholders in fast-food, hotels, and restaurants (Mokhtar et al., 2022).

1.1. Background of the Study

In Kenya, 477,000 tons (t) of charcoal were used for domestic cooking in 1980. Urban households used two thirds of the charcoal for cooking, while rural households used one third. Small-scale businesses and institutions used an extra 160,000 t of charcoal. The entire amount of charcoal produced in conventional earth kilns required 5,300,000 t of wood. In contrast, 12,900,000 t of wood were burned directly as fuel in 1980 (Eric, 2025). If government policy and stove types remain unchanged, charcoal use is projected to rise by 6.7% annually between 1980 and 2000. In 2000, households are expected to consume 2.1 million tons of charcoal annually. Just 35% of the demand for wood and charcoal fuels could be satisfied by the anticipated mean annual increase in wood production for the year 2000 (Sachia, 2020). This gap may be mitigated if households switch to more fuel-efficient charcoal stoves, but this would lead to unsustainable rates of tree cutting and reduced wood use (Eric, 2025). In Kenya, 17% of rural households and 83% of urban households have charcoal stoves. Charcoal stoves were owned by 1,070,000 households in mid-1985, with 490,000 in rural and 580,000 in urban areas. Charcoal is the main cooking fuel used by about 545,000 urban and 85,000 rural homes. Because they use different cooking fuels depending on the type of food, season, and time of day, many Kenyan homes have multiple types of stoves. A family that uses charcoal only for cooking and for heating water on a conventional burner may use between 0.7 and 1.1 t annually. However, urban households use an average of 0.662 t annually, while rural households consume an average of 0.405 t (Sherka, 2011). The study of matter in connection to energy is the focus of the scientific field of physics. It continually seeks to make it as simple as possible for people to access the energy they need for industrial and household use (Food and Agriculture Organization (FAO), 2025). It aims to pinpoint energy sources and provide the physical principles that will enable man to acquire mechanical, chemical, and thermal energy and to guarantee their efficient interconversion to address his daily needs. Man has made numerous advancements in the field of energy physics, thanks to his daily efforts in the scientific and technological realm. Electric lamps, pressing irons, fuels, and atomic energy from radionuclides like uranium and thorium are only a few examples of these countless achievements. Many organizations and initiatives have created models of firewood-saving stoves over the past few decades because the majority of West African households have been in dire need of better, more effective cooking stoves for their meals (Liana, 2014). Almost every human activity, including artificial intelligence programming, sophisticated robotics, medical biotechnology, heating and cooling systems, industrial output, and household tasks, requires energy. However, the sources and techniques of producing or transporting this energy pose an engineering problem that has drawn significant interest from engineers worldwide (Green et al, 2020). For example, energy is required for cooking and drying food, heating and cooling, moving people, and many other tasks in home settings. Solar heating and cooling systems compete with conventional fuel-based central heating and cooling systems in the business sector (Anderson, 2011). Millions of people rely on coal, petroleum, and natural gas to power their homes and businesses, which together make up the majority of the world's energy infrastructure (Liana, 2014). Solid fuels such as wood and charcoal remain the primary sources of energy for heating and cooking in many developing nations. Among these, the coal pot, a portable charcoal-burning burner, is a popular and essential item for both home and commercial cooking, particularly in areas with limited or expensive access to modern cooking fuels such as gas and electricity (Badyda et al., 2020). Even though they work well for simple culinary activities, traditional coal pots have drawbacks such as delayed ignition, high smoke emissions, and incomplete combustion. Indoor air pollution and carbon monoxide exposure not only increase fuel consumption and cooking times but also pose significant health hazards (Zhao et al., 2020). A workable way to overcome this restriction is to incorporate a rechargeable blower system into the coal pot design. A blower increases combustion efficiency, lowers smoke output, and uses less fuel by introducing a controlled supply of air (oxygen) into the combustion chamber. The rechargeable blower's design provides sustainability and portability by removing the need for frequent battery replacement or grid connectivity. To increase fuel efficiency, reduce environmental impact, and offer a more convenient and healthier cooking option, this project focuses on designing and building a modified coal pot that incorporates a low-power, rechargeable blower system.

1.2. Centrifugal Blowers

Centrifugal blowers move air and/or other gases by means of fast blades or impellers (Begovic, 2001). They provide several blade orientations, including radial forward and backward curvatures. According to fan affinity rules, a % decrease in speed will result in a corresponding decrease in flow in centrifugal blowers.

i. Radial fans: ideal for high temperatures and medium blade tip speeds, radial fans are industrial workhorses due to their high static pressure and capacity to manage highly polluted air streams.
ii. Forward Curved Fans: are used in clean environments and operate at lower temperatures. They work best when transferring huge amounts of air at comparatively low pressures.
iii. Fans with a backward inclination are more effective than those with a forward curvature. Because variations in static pressure do not overload the motor, backward inclined fans are sometimes referred to as 'non-overloading' (Wikipedia, 2025).

1.3. Concept of Charcoal Pot

As the principal source of heating and cooking in many low- and middle-income areas, charcoal and biomass cookstoves remain essential (Baldwin, 2025). But because conventional stoves are often inefficient and produce large amounts of pollution, research is underway on improved designs that use less fuel, perform better thermally, and emit fewer toxic emissions. Lao et al. (2018) showed that using designed charcoal stoves, rather than traditional open-fire methods, can significantly increase efficiency and reduce indoor air pollution. These studies demonstrate how fuel type, combustion chamber design, and air supply systems affect stove performance. The use of forced-draft systems, fans, or blowers that feed combustion air at regulated rates to increase fuel burning efficiency is a recurrent theme in cookstove innovation. The Bio Lite Home Stove is one of the early types. Ahmad et al. (2021) achieved cleaner combustion without relying on external power sources by using thermoelectric power generation to drive fans. Forced-draft gasification stoves can achieve high thermal efficiency when using a variety of biomass fuels, including agricultural briquettes, according to recent findings, such as those reported by Oke (2023). As discussed in Design and Performance Evaluation of Supplemental Air-Supplied Charcoal Stove, supplemental air-powered charcoal burners improve portability and user convenience by introducing detachable blower packs that can be charged independently. The thermal output, specific fuel consumption, and heat transfer efficiency of upgraded stoves have been quantitatively evaluated in several studies. By comparing flat-bottom institutional cook stoves with and without forced blowers, Hopkins (2021) showed that a forced-air supply significantly improves heat transfer to the cooking vessel while reducing cooking times.

2. Materials and Method

2.1. Design Considerations

The following elements were considered to guarantee cost-effectiveness, functionality, and safety:

i. Optimizing airflow to encourage full combustion is known as fuel efficiency.
ii. Thermal Insulation: Using the right liner and insulation to reduce heat loss.
iii. Portability: Small size and lightweight parts.
iv. Simple airflow control using a switch or knob makes it easy to use.
v. Safety: Reducing heat transmission from the outside and properly insulating electrical components.
vi. Power Source: A rechargeable battery with enough runtime, such as a 12V battery.

2.2. Materials and Components

Tables 1 and 2, respectively, list the materials and component parts utilized in the project to design and build a charcoal pot with a rechargeable blower. Plates 1, 2, 3, and 4 depict the blower, the fiber, the ash tray, and the charcoal pot, respectively.

Table 1 Materials needed for the Fabrication of the Coal Pot

Plate	Material	Function

Outer body shell	Iron plate	Structural support
Combustion chamber liner	Refractory clay or firebrick	Withstands high temperatures
Insulating layer	Fibre	Reduces heat loss
Ash tray	Iron plate	Collects ash and improves airflow
Grate (charcoal support)	Cast iron or steel rods	Supports fuel and allows air passage

Table 2 Components Parts of the Coal Pots

Part	Specification	Function
1. Blower fan	12V DC, 0.5–1 A	Supplies air to fire
2. Battery pack	12V rechargeable lead-acid	Powers the blower
3. Switch or potentiometer	Toggle or rotary dial	Controls blower speed
4. USB/solar charging port	5V input	For recharging battery

Fig. 1. Blower

Fig. 2. Fiber

Fig. 3. Ash Tray

Fig. 4. Charcoal Pot incorporated with a Blower

2.3. Design Description of the Charcoal Pot

The charcoal pot has the following layered design and is a cylindrical or slightly conical stove:

i. Outer Shell: Holds and shields internal parts.
ii. Insulation Layer: To maintain heat, it is packed between the liner and outer shell.
iii. Inner Combustion Liner: Charcoal is stored in this fire-resistant substance.
iv. Charcoal Grate: Placed above the ash tray so that air can rise.
v. Ash Tray: A detachable ash collection tray underneath the grate.
vi. Air Inlet Duct: Attaches the blower fan to the combustion zone's base.
vii. Rechargeable Blower Unit: This device, which can be installed above or below the stove, uses a duct to force air into the combustion chamber.
viii. Control Interface: The fan speed can be changed by the user using a switch or knob.

2.4. Working Principle of the Charcoal Pot

The fan forces air through the air duct into the combustion chamber when the blower is turned on and the charcoal is lit. By increasing the air supply, this regulated airflow encourages quicker and more thorough burning. Consequently:

i. There is less smoke.
ii. Less time is spent cooking.
iii. The use of charcoal declines.

Off-grid operation is enabled by the rechargeable battery, and users can adjust the flame intensity via the speed control.

2.5. Construction of Charcoal Pot incorporated with a Rechargeable Blower

i. Outer Shell Fabrication: The mild steel sheet was cut into a cylinder with a diameter of 25 cm and a height of 30 cm. The reinforced joints and the base plate were welded.
ii. Liner and insulation preparation: A smaller cylinder with a diameter of 22 cm was formed from the refractory clay. The shell was placed inside with an insulating gap of 1.5–2 cm. The gap was filled with perlite or clay-ash mixtures, cured, and dried.
iii. Grate and Ash Tray Installation: The liner's grate supports were joined via welding. The ash tray was positioned three to five centimeters below the grate.
iv. Blower System Integration: Angled upward into the liner base, the air intake pipe was positioned at the bottom of the shell. The inlet was where the DC blower was installed. A 12V rechargeable battery pack is connected to the blower. The outside casing has a switch and charging port attached to it.
v. Completing and Examining: Sand-paper was used on all edges, and high-temperature paint was applied externally. Fan speed settings were changed, airflow was examined, and the battery was charged.

To evaluate the charcoal's heat distribution and combustion efficiency, a fire test was conducted.

2.6. Design Calculation

To calculate the energy of coal used,
Mass of coal = 45.4g
Convert mass to kg:
45.4 g = 0.0454 kg
Energy from coal:
E = m × CV=0.0454 kg × 24 MJ/kg = 1.0896 MJ
E = m × CV = 0.0454kg × 24MJ/kg = 1.0896MJ
In kWh:
1.0896 MJ ÷ 3.6 = 0.3027 kWh
1.0896MJ ÷ 3.6 = 0.3027kWh (= 0.3027 kWh)
In joules:
1.0896 MJ = 1,089,600 J
1.0896MJ = 1,089,600J
Calorific Value, CV = $\frac{Energyreleased}{Mass\ of\ Fuel}$
CV = $\frac{1.0896}{0.0454}$
CV = 23.99 MJ/kg
Temperature Rise
ΔT = $\frac{Q}{m.C} = \frac{1089600}{1 \times 4186}$
ΔT = 260.2°C

2.7. Determination of the Quantity of Charcoal Needed for Cooking

The amount of charcoal necessary to cook the food must be determined in order to calculate the combustion chamber's volume. Table 3 summarizes the heat required to cook common household foods (Green et al., 2020). The average temperature required to cook typical foods is used to calculate the mean heat required for 1 kilogram of food.

Average temperature needed for cooking:

$$= \frac{100 + 74 + 68 + 100}{4}$$

= 85.5°C ≈ 358.6K

Assuming the initial temperature of the food T1 is at room temperature 25°C ≈ 298.1K
Mean specific heat capacity of the selected foods is

$$= \frac{1377 + 1993 + 1700 + 4200}{4}$$

= 2317.5 J/kg/K

Thus, the mean heat required for cooking 1kg of the foods above is:

Q = mc △ T …………………….. (1)
= 1 x 2317.5 x (358.6 − 298.1)
= 60.5 J

The total estimated energy required to cook any particular meal around 30 minutes is
= 60.5 x 60 x 30
= 108,900 J = 108.9 kJ

The amount of charcoal needed to produce this kind of energy is as follows:

Given that charcoal has a density of 103 kg/m^3. One kilogram of charcoal has a heating value of 28 MJ of energy according to (Amiebenomo et al, 2023). Therefore, the amount of charcoal needed to produce 145 kJ of heat is

Mass of charcoal required = $\frac{108.9 \times 10^3}{28 \times 10^6}$
= 0.0001889 kg
Volume required = Mass x Density
= 0.0001889 x 103

$= 0.01945\ m^3$ of charcoal

2.8. The Ash Tray

Fig. 1 depicts the ash pan or tray that gathers ashes from the burned charcoal. In order for the ash to fall into it by gravity, it is positioned precisely beneath the combustion chamber. It has enough padding to slide in and out of the combustion chamber and measures 10% of the frame's height.

2.9. Insulation

Conductive heat exchanges in the stove should be anticipated in two main areas:

1. The product to be fried, roasted, or boiled receives heat conduction through the utensil.
2. Heat transfer via the wall of the stove.

Table 3 Temperature Required for Cooking Common Food Types (Green et al., 2020)

S/N	Food type	Temperature (°C)	Specific Heat Capacity (J/kgK)
1	Carbohydrates and proteins	100	1377
2	Sea Foods and Eggs	74	1993
3	Vegetables and Processed foods	68	1700
4	Boiled water	100	4200

2.10. Rechargeable Blower

The blower is a mechanical device that produces or increases airflow. It uses pipes and wind channels to provide air to the combustion chamber. It helps speed up and improve the efficiency of cooking by fanning the charcoal flames to higher temperatures.

2.11. Determination of Heat Loss from the Surface

The formula for calculating heat lost is shown in Fig. 2, it was used to determine the heat lost from the charcoal fuel's surface.

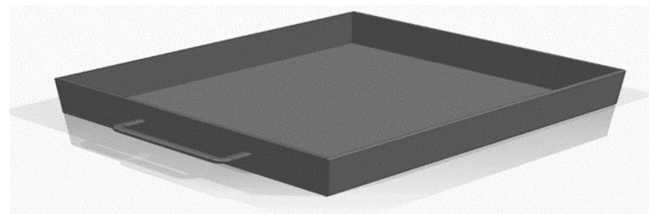

Fig. 5. The Ash Tray

The expression for heat loss or conduction via multiple walls or layers in thermal contact is as follows:

$$\text{Heat flow} = \frac{thermal\ potential\ difference}{thermal\ resistance}$$

$$Q = \frac{\Delta Toverall}{\sum Rth}$$

$$q = \frac{T_1 - T_n}{\left[\left(\frac{\Delta x_1}{K_1 A}\right)+\left(\frac{\Delta x_2}{K_2 A}\right)+\left(\frac{\Delta x_3}{K_3 A}\right)\right]}$$

Where:

q (Watt) is the heat loss from the surface,
T_1 (K) is the temperature inside surface,
T_n (K) is the temperature outside surface,
X_1 (m) is the inner layer thickness (mild steel plate) and thermal conductivity K_1 (W/m·K),
X_2 (m) is the middle layer thickness (refractory) and thermal conductivity K_2 (W/m·K),
X_3 (m) is the outer layer thickness (mild steel plate) and thermal conductivity K_3 (W/m·K), and
A (m^2) is the cross-sectional area of the combustion wall.

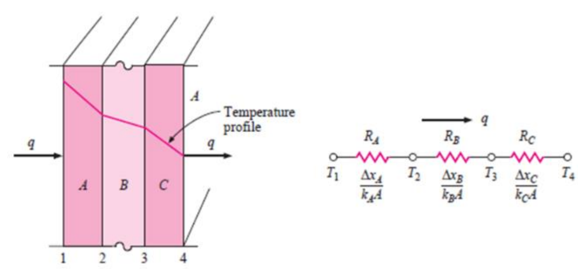

Fig. 6. Thermal Heat Conductivity through Multiple Materials (Amiebenomo et al, 2023)

2.12. Design Theory and Analysis

This design is intended for use in various applications that require compressed air. The pertinent equations governing the air compressor's operation and energy interactions at different locations will now be stated and applied.

2.13. Loss of Energy in the Piping System

1. Minor losses

Sudden expansion losses:

$$(h_1)\ exp = \frac{(v_{1-v_2})^2}{2g}$$

Exit loss:

$$(h_1)\ exit = \frac{v_1{}^2}{2g}$$

Sudden contraction loss:

$$(h_1)\ \text{con} = \frac{(v_{c-v_2})^2}{2g}$$

Where v_c = velocity at vena contracta

Entrance loss:

$$(h_1)\ \text{ent} = \frac{0.5 \times v_2^2}{2g}$$

Bend loss:

$$(h_1)\ \text{bend} = \frac{kv^2}{2g}$$

The bend's angle and curvature radius determine the value of 'k'.

2. Significant loss:

The head loss from friction is the main loss. Darcy's Weisbach equation states that: $h_1 = \frac{flv^2}{2gD}$

Where;
F is the friction factor
L is the length of pipe
V is the velocity of flow
D is the diameter of the pipe.

2.14. Heat Transmission from the Stove

The stove is exposed to three modes of heat transfer: radiation from burning charcoal, conduction through the stove wall, and radiation from the stove body to nearby objects. Because the stove is insulated, heat loss by convection and conduction has been assumed to be negligible for design simplicity.

3. Results and Discussion

3.1 Results

Table 4 depicts the results of the comparative test of the coal pot with blower, the coal pot without blower, and the electric hot plate.

Table 4: Test Results of the Charcoal Pots and Electric Hot Plate

S/N	Mass of Coal (g)	Volume of Water, $\times 10^{-3}\ m^3$
1	45.50 (Coal pot with blower)	117.3550
2	45.50 (Coal pot without blower)	117.3550
3	45.50 (Electric hot plate)	1173.550

Table 4 Test Results of the Charcoal Pots and Electric Hot Plate 'cont'd'

S/N	Result of boiling water	Start Time	Completion Time
1	Coal pot with blower	2:53pm	3:03pm (10mins)
2	Coal pot without blower	2:53pm	3:53pm (1hour)
3	Electric hot plate	2:53pm	3:18pm (25mins)

3.2. Discussion of Results

The performance of the charcoal pot with a rechargeable blower is amply demonstrated by the findings shown in Table 4. It demonstrated that in every attempt, a consistent volume of water $117.355 \times 10^{-3}\ m^3$ was heated by a fixed mass of coal (45.5 g). This consistency shows that the design is dependable and capable of sustaining steady performance over time. The system's comparative effectiveness is further demonstrated in Table 4. It took ten (10) minutes for the blower-assisted charcoal pot to boil water, compared to an hour (60 minutes) for the charcoal pot without a blower. The hot plate, on the other hand, brought the water to a boil in twenty-five (25) minutes.

These findings demonstrated that the blower's integration significantly increased the combustion rate by providing a constant airflow into the chamber, thereby improving air availability and intensifying the heat generated. In addition to reducing cooking time, the charcoal pot's enhanced performance demonstrated superior fuel efficiency compared to the conventional charcoal pot. This demonstrated that the rechargeable blower is essential for encouraging full combustion, which minimizes energy loss and reduces smoke. The design overcomes the drawbacks of traditional charcoal pots and offers a more effective, user-friendly cooking solution by enabling faster cooking with less fuel.

4. Conclusion

It was determined that adding a rechargeable blower to a charcoal pot greatly increases its efficiency. The test results also made it clear that the built-in charcoal pot with a rechargeable blower is dependable, long-lasting, safe, economical, and eco-friendly. Additionally, this creative endeavor shortens cooking times, minimizes smoke emissions, and promotes cleaner, more effective cooking techniques in Nigeria's rural and urban communities, as well as worldwide.

Acknowledgments

I would like to thank the following authors: Towoju, Olumide A., Ajayi, Ayomiposi I., and Alabi, Oluwaseyi O., for their tremendous contributions to this paper's success.

Funding

The authors did not provide any funding for the research, authorship, or publication of this work. The principal author (corresponding author) provided the funding.

Declaration of Competing Interest

No potential conflicts of interest were revealed by the authors with regard to the research, authorship, and publication of this study.

Credit Authorship Contribution Statement

*Atoyebi, Muyiwa. O: I, (corresponding author), organised the design and construction, started it, and other authors supported in completing the project.

*Atoyebi, Muyiwa. O., Towoju, Olumide. A., Ajayi, Ayomiposi .I., and Alabi, Oluwaseyi .O. Each author contributed to the manuscript's drafting as well as the design and construction of the project. All authors reviewed, approved, and discussed the final version of the paper.

Availability of Data and Materials

The datasets developed and/or analyzed during the current work will be made available by the corresponding author upon reasonable request.

Ethics Statement:

Neither human volunteers nor animal subjects were used in this investigation. Therefore, ethical approval was not necessary for this study.

Generative Artificial Intelligence Declarations

The authors affirm that this work was prepared without the assistance of generative AI or AI-assisted technology.

References

[1]. "Integrating photovoltaic systems in power system: Power quality impacts and optimal planning challenges," *International Journal of Photoenergy*, vol. 10, no. 3, pp. 123–130, 2014, doi: 10.1155/2014/321826.

[2]. S. A. Adeyeye and O. B. Oyewole, "An overview of traditional fish smoking in Africa," *Journal of Culinary Science and Technology*, vol. 14, no. 3, pp. 198–215, 2016, doi: 10.1080/15428052.20215.1102785.

[3]. R. K. Ahmad, S. A. Sulaiman, S. Yusup, S. S. Dol, M. Inayat, and H. A. Umar, "Exploring the potential of coconut shell biomass for charcoal production," *Ain Shams Engineering Journal*, vol. 6, no. 3, pp. 203–230, 2021, doi: 10.1016/j.asej.

[4]. S. O. Amiebenomo, F. O. Udeji, and J. I. Aigbokie, "Design and fabrication of an industrial charcoal cooker," *International Journal of Science, Engineering and Technology*, vol. 4, no. 3, pp. 2348–4098, 2023. [Online]. Available: Scribd.

[5]. J. Anderson, "Metal stoves," *Journal of Energies*, vol. 32, no. 10, pp. 1723–1738, 2011, doi: 10.3897/rio.7.e67379.

[6]. Badyda, P. Krawczyk, J. S. Bihałowicz, K. Bralewska, W. Rogula-Kozłowska, G. Majewski, P. Oberbek, A. Marciniak, and M. Rogulski, "Are BBQs significantly polluting air in Poland? A simple comparison of barbecues versus domestic stoves and boilers emissions," *Energies*, vol. 13, no. 23, Art. no. 6245, 2020, doi: 10.3390/en13236245.

[7]. S. F. Baldwin, "Biomass stoves: Engineering design, development, and dissemination," Volunteers in Technical Assistance, Arlington, VA, USA, 2025.

[8]. F. Beckett, "Exploring the coconut shell biomass for charcoal production sausage and mash," *Journal of Engineering and Technology*, vol. 10, no. 4, pp. 23–53, 2012. [Online]. Available: ResearchGate.

[9]. M. Begovic, "Sustainable energy technologies and distributed generation," in *Proc. IEEE Power Engineering Society Summer Meeting*, 2001, pp. 540–545, doi: 10.1109/PESS.2001.970089.

[10]. Y. O. Bello and M. G. Bello, "Basic of food production food and beverage service," *Journal of Energies*, vol. 42, no. 10, pp. 1713–1718, 2020. [Online]. Available: Google Scholar.

[11]. E. Berko, "Design, construction and assessment of an improved hybrid charcoal-LPG cookstove," *Journal of Culinary Science and Technology*, vol. 13, no. 11, pp. 1743–1748, 2018. [Online]. Available: Afribary/AGRIS.

[12]. P. A. Daly and J. Morrison, "Understanding the potential benefits of distributed generation on power delivery systems," in *Proc. Rural Electric Power Conf.*, 2001, pp. 21–213, doi: 10.1109/REPCON.2001.949510.

[13]. G. Drave and E. K. P. Mishra, "Historical review of biomass cookstove development," *Mechanical Conference*, vol. 1, no. 2, pp. 20–41, 2015. [Online]. Available: Semantic Scholar.

[14]. L. H. Eric, "The strategy of production and distribution of improved charcoal stoves in Kenya," *World Development*, vol. 15, no. 3, pp. 375–386, 2025, doi: 10.1016/0305-750X(87)90019-2.

[15]. Food and Agriculture Organization (FAO), "Indian improved cookstoves: A compendium," *FAO Regional Wood Energy Development Programme Archive*, 2025. [Online]. Available: FAO.

[16]. T. Green, O. I. Miria, R. Crook, and A. Ross, "Energy calculator for solar processing of biomass with application to Uganda," *Energies*, vol. 13, no. 6, Art. no. 1470, 2020, doi: 10.3390/en13061485.

[17]. J. Hopkins, "Renewable energy versus sustainable energy: What's the difference?" *International Journal of

Environmental and Science Engineering, vol. 10, no. 5, pp. 212–240, 2021. [Online]. Available: Johns Hopkins University.

[18]. C. A. Komolafe and O. Awogbemi, "Fabrication and performance evaluation of an improved charcoal cooking stove," *The Pacific Journal of Science and Technology*, vol. 11, no. 2, pp. 112–126, 2010. [Online]. Available: ResearchGate.

[19]. S. Kuś, I. Jelonek, and Z. Jelonk, "Effects of thermal treatment of food using barbecue fuels on ambient air and beach sands within recreation facilities," *Scientific Reports*, vol. 13, no. 1, Art. no. 7621, 2023, doi: 10.1038/s41598-023-45023-4.

[20]. J. Y. Lao, C. C. Wu, L. J. Bao, L. Y. Liu, L. Shi, and E. Y. Zeng, "Size distribution and clothing-air partitioning of polycyclic aromatic hydrocarbons generated by barbecue," *Science of the Total Environment*, vol. 609, pp. 1283–1289, 2018, doi: 10.1016/j.scitotenv.2018.05.215.

[21]. M. Liana, "A review of firewood saving stove," *Sci-Hub Journal*, vol. 10, no. 5, pp. 373–379, 2014. [Online]. Available: eScholarship.

[22]. N. M. Mokhtar, M. A. Bappu, W. N. A. S. W. M. Fazli, L. W. S. Wilson, J. Thorairajoo, N. F. M. Yunus, R. M. Ramli, and M. S. Hadi, "Design, fabrication and performance evaluation of charcoal barbecue with air ventilation system," *Journal of Engineering*, vol. 10, no. 6, pp. 20–43, 2022, doi: 10.1007/978-981-19-2890-1_24.

[23]. P. K. Oke, "Development of a multi-purpose roasting machine," *Pacific Journal of Science and Technology*, vol. 14, no. 2, pp. 48–52, 2023.

[24]. O. A. Rasheed, A. A. Nurudeen, K. O. Olaniran, and A. A. Emmanuel, "Design and development of a dual powered grill oven for application in higher institution of learning," *International Journal of Science, Engineering and Environmental Technology (IJOSEET)*, vol. 10, no. 11, pp. 1–7, 2023.

[25]. S. B. Sachia, "Construction of a two pot forced air charcoal stove powered by 6V battery," *World Journal of Innovative Research*, vol. 9, no. 5, pp. 113–116, 2020.

[26]. S. Y. Sherka, "Design and performance evaluation of biomass gasifier stove," M.S. thesis, Dept. Chemical Engineering, Institute of Technology, 2011, p. 45, doi: 10.20372/nadre:1797.

[27]. University of Kentucky, "Heat in cooking," 2016. [Online]. Available: University of Kentucky. Accessed: Sep. 2, 2025.

[28]. O. Y. Usman, "Experimental performance evaluation of charcoal-stove," *Journal of Science and Technology*, vol. 34, no. 9, pp. 50–62, 2017.

[29]. Wikipedia, "Gas stove," *Wikipedia, The Free Encyclopedia*, 2025. [Online]. Available: Wikipedia. Accessed: Sep. 1, 2025.

[30]. Y. Zhao, P. Tao, B. Zhang, and C. Huan, "Contribution of Chinese hot pot and barbecue restaurants on indoor environmental parameters," *Aerosol and Air Quality Research*, vol. 20, no. 5, pp. 2925–2929, 2020, doi: 10.4209/aaqr.2020.04.0141.