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RESEARCH ARTICLE

Design and Manufacture of a Biomass Stove Using Palm Kernel Shells as Fuel to Promote Environmental Sustainability

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Abstract
Cooking has been integral to mankind's survival and through that, there has been many efforts put in place to facilitate it. This study investigated the utilization of palm kernel shells as fuel for a specially manufactured stove known as the Biomass stove. Aware of the problems associated with the burning of wood fuel, the Ghanaian society is in exploration for cleaner and greener alternatives; one of these alternatives is the use of palm kernel shells as fuel for the biomass stove. The qualitative research approach was fundamental, in this research as descriptive, experimental and studio-based research methods were

Keywords

Biomass stove
Cooking stoves
Environmental sustainability
Green house
Palm kernel shells

employed in collecting useful data from a sample size of 30 out of an accessible population of 100 participants using cooking stoves in KNUST campus in Kumasi. Data gathered from the experiments conducted proved vital in the designing of the stove and selection of suitable fuel to use. It was found that biomass resources must be explored to discover alternative fuels for efficient cooking. Also, the principles of heat transfer should always be critically analyzed so that designs for cooking stoves can be energy efficient, while promoting environmental sustainability in their use.

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Introduction

Traditionally, firewood and charcoal are the main sources of fuel in Ghana (Annan et al., 2011). According to a research undertaken by African Rural Energy Enterprise Development (AREED), about seventy-five percent of people burn firewood for domestic cooking and water heating; this is by far the most significant type of biomass in use. Cooking stoves are basically equipment made of high temperature materials which fall within the range of metals like iron, cast iron, steel and other materials like formulated ceramic bodies that is designed for a particular fuel either solid or liquid to be used for all or most cooking processes as asserted by Hayatt et al. (2024). Sometimes a design of a stove could incorporate other fuels rather than using its originally designed application of fuel but may not be of its full potential. Firewood stove may not be suitable for rice husk stove (Mande, 2009).

The development of stoves in Ghana can be seen as occurring for over five periods of time. The first period began with the birth of the three stone stoves locally known as "bukyia" in the local dialect (Twi), and continued until the discovery of kerosene where single unit stoves were designed for the application of the liquid fuel for household cooking (Piedrahita et al.,2016). Even though this stove curbed some of the defects of the three stove stone, its period didn't last long as the processing of charcoal grew steadily since its usage was more economical but in defect, stressful. Designs of stoves were made for the application of 'charred coal' charcoal. A typical variation of the coal pot stove is the 'gyapa', which made use of a ceramic coating to retain more of the heat produced to reduce the rate of the fuel combustion (Dickinson et al., 2019). Even though this was an improvement it still couldn't counter the fact that one couldn't beat ahead of time when cooking since it takes a longer

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period for the charcoal to totally distribute the heat that is accompanied by vigorous fanning. This is based on the fact that charcoal takes longer time to combust but when it does; it doesn't take long to last since it has a faster heat distribution due to its particle sizes and calorific value. This made the work of commercial food vendors who use coal pots in cooking very stressful because instead of setting the charcoal and leaving the stove to do the cooking on its own to go and attend to other chores, they would have to go through the pain of fanning it over time for the cooking to actually commence. In present day charcoal is still being used, but its dominance ended in about 1990s where gas was introduced in Ghana (Anang et al., 2011). Previous studies were delved into by researchers. Najmi (2006) study findings derived from locally designed under-fire inclined grate combustion tests with palm kernel shells.

There is no doubt that all the existing stoves in Ghana thus charcoal stoves, gas stoves, firewood stove and electric stove served their purpose in all its strengths to execute the task for which they were made for but regardless of these, the facts of their inefficiency in terms of time and cost of cooking still remain as an inefficiency. Cooking is woven into our culture but it should not be seen as a burden since users of existing stove find it time consuming and expensive to cook on a daily basis. The stoves powered by both LPG and electricity are already in existence and is really thriving, but it is quite expensive to operate such stoves since demand for such fuels are high. Hence there is the need for a substitute fuel and if so a stove for this fuel with modifications to achieve improved results such that it would be low cost and efficient in the time of cooking since cooking is an everyday activity that humans cannot live without. This will help in waste reduction and lower emissions. Therefore, this research seeks to design and fabricate a stove that is efficient and uses low cost fuel for cooking.

Literature Review

Theoretical Framework

The study employed Shi's et al. (2019) sustainable development theory. Sustainable development theory is one of the fundamental frameworks that need to be evaluated in using biomass stoves fueled by palm kernel shells, as it emphasizes balancing economic growth with environmental and social responsibility. This is an idea based on the definition that development should be such as to meet their own needs without destroying those natural resources of which man depends.

Since palm kernel shells are used as fuel, they also reduce the use of fossil fuels and waste production: this result in an environmental benefit. It helps reduce CO_2 generation obtained

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from conventional fuel sources. In addition, biomass stoves delivered in the right way are better for climate action. They can be designed to do a more complete job of burning fuel that leads to less emissions and helps us fight off CO2 build-up.

Economic issues are also emphasized under sustainable development theory. Communities can lower energy costs and stimulate their local economy by sourcing palm kernel shells locally. The end result not only generates jobs the biomass supply chain, but also improves energy independence as communities become less dependant on imported fossil fuels. The socio-economic benefits of adopting biomass stoves may enhance livelihoods and provide a buffer against energy price volatility.

Stoves

According to Gill-Wiehl (2021), a stove is any place where one roasts, bakes, or does any cooking activity is in effect a kitchen. Brewer (2000) adds that since humans need food to obtain their energy, whereas most of the edible foods of humans ought to be cooked, there came about the invention of kitchen stoves as a more effective way of cooking. Cooking Stoves are not new innovations to man, they have been with man in different forms ever since prehistoric man harnessed the power of producing fire. Johnson et al. (2019) concurs that, the reason why stoves were invented was because open fires were dangerous, produced too much smoke, and had bad heat efficiency.

Through studies, inventors dived into various way of making cooking more delightful rather than a chore around the 14th century and this brought about various inventions that have lived on through modifications and adaptations to form newer stoves to meet the changing trends in fuels till this century. Basu et al. (2024) agree that the earliest record is of a case in 1490 in Alsace, France. It is all made of bricks and tiles, including the chimney. This was used until the construction of the first iron furnace. Around 1740, Benjamin Franklin built the Franklin stove, which burned wood on a grate, with sliding doors that controlled the flow inside. Due to the small size of this gas stove, unlike its predecessors which are very large and require a separate burner to operate, it is easily installed in most kitchens. When the flat-panel gas furnace was introduced as a gas furnace, it was used in many homes across America.

Industrialization in the early 19th century became a vital tool for the reforming of a lot of inventions and this was seen as a new age and era hence alternatives and newer ways of doing things were needed. Olsen, (2020) ascertains that, as the Age of Invention waxed in the 1880's and 1890's, stove manufacturers began a search for heat sources beyond wood and coal, and an unlikely combination of forces let them to gas. Just like any new invention before it sees the break of light, gas stoves were studied in literatures and was revealed that,

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inventors from Europe had be experimenting cooking with gas in the early 1800's but the nature and exploitation of gas was not as developed as they desired and hence, the risk was very high to bear till today.

The Environmental Impact of Biomass Fuels

One of the most significant advantages of biomass fuels is their ability to lower greenhouse gas emissions when compared with fossil fuels. While burning biomass for energy does emit carbon dioxide (CO2), it all stems from the CO2 that is captured by plants in their life cycles (Yemshanov et al., 2018). This forms a closed carbon cycle and if managed correctly could be used for climate change mitigation. To realize the potential of biomass fuels while mitigating natural and social impacts, Wymann (1994) suggested improving fuel efficiency by using local heating systems instead of imported fossil-based solutions. That said, the sustainability that has improved environmental qualities of biomass fuels is not absolute. There is also deforestation, loss of biodiversity and land degradation if the cultivation of biomass crops is not sustainable. For instance, those massive bioenergy crop productions can significantly change land use and harm local ecosystem or wildlife habitats (Wwang & Azam, 2024). Additionally, chemicals in fertilizers and pesticides that biomass crops produce may also seep into the soil or ground water causing regional contamination effect on the ecosystem. An additional worry is the impact on air quality from burning biomass (Sebastian & Gomez, 2011).

Although biomass fuels can be less polluting for smog and toxic air pollutants in comparison to coal or oil, they do emit particulate matter VOCs (volatile organic compounds), carbon dioxide, as well health-damaging toxics such a heavy metals (Smith, 1994). Near biomass energy facilities this can lead to respiratory and other health problems, most felt keenly in more vulnerable communities. Furthermore, the transportation of biomass fuels can also impact on the environment. These life-cycle emissions are particularly relevant when biomass needs to be transported over long distances from rural areas to processing facilities, and can in certain cases result on an even bigger climate impact of using bioenergy (Klass, 2004). Lastly, Wang et al. (2012) indicate that this highlights the need to consider full lifecycle performance of biomass fuels when evaluating their environmental footprint. Biomass fuels are a promising source of sustainable energy and reduced GHG emissions, but their potential environmental impacts have to be considered. Innovation programmes will help the implementation and equation of these sustainable practices in biomass production, processing.

The Economic Viability of Biomass Stoves

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Biomass stoves need to be affordable, particularly in contexts where the current energy demand is not met or there is a desire for cleaner fuel and cooking options. Biomass stoves made of woody fuels, agricultural residues and other biomass crops can be an economical substitute for the less sustainable fossil fuel in heating and cooking applications (Shimali et al., 2011). Biomass (such as dried dung) is in abundant supply, and because it usually costs nothing but the effort to collect it, processing biomass has strong appeal for low-income families. While this access may yield a great savings in the energy spends of families who need every day to cook, especially by consuming bio mass-generated fuels. Furthermore, biomass stoves have the potential to be more efficient than open fires saving in the use of fuel (Bot et al., 2023).

For a household, improved efficiency means the need to collect less biomass or energy carrier from natural resources which saves time and labour. In addition, implementing cleaner burning stoves by using improved advanced biomass stove technologies can have economic benefits from lowered healthcare costs when indoor air quality is better due to reduced smoke emissions. But there are roadblocks to making biomass stoves profitable (Kargbo et al., 2021). Some households cited the up-front costs associated with more advanced stove designs as a barrier. Though these stoves may pay for themselves with less fuel use, the high up-front cost can put off anyone from adopting. Moreover, the resource availability and sustainability of biomass are location specific meaning that not all regions around the globe possess renewable resources for long-term utilization as an energy carrier. For example, the biomass stoves market is subject to influence by external factors including government funding and policy measures, as well as substitute options for energy. Where cleaner or more efficient energy alternatives become available, the demand for biomass stoves may fall.

Methods

In this study, the qualitative research asserted by Cresswell (2014) involved testing of the efficiency of palm kernel shells as fuel to be used in a stove for cooking against other stoves of different fuels. This research employed the descriptive research method by using observation as a tool in understanding the opinions of people about the different types of stoves available and observing their reactions to how matters out of their control affect their daily use of such stoves and its fuels. Puadi, (2020) raises the point that studio-based research, the creative act is an experiment (whether or not the work itself is deemed "experimental"), one designed to answer a directed research question about art and the practice of it, which could not otherwise be explored by other methods. The sole aim is to experiment with art in order to push boundaries, to ask questions, to educate more of art and

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the emphasis we put in it.
The population of the study was the users of traditional and modern cooking stoves for both domestic or household and commercial purposes in Kumasi. For the purpose of this study, the assessable population is the food vendors at the canteens of KNUST and then traditional halls and household users surrounding homes under the parameters of commercial use and household use respectively. In the study, selecting users of various stoves in the Kumasi metropolitan was necessary; the purposive sampling asserted by Campbell (2020) was employed. The researchers without being bias, focused on the accessible population, thus stove users for both household and commercial purposes on both KNUST campus and the surrounding areas of KNUST campus. A total number of 100 people were attained for the population. The sample size for the research was 30 people of which 8 are students who are stove users in the traditional halls of KNUST for household purposes, 8 food vendors in the traditional halls for commercial purposes and 9 from surrounding places of KNUST for household purposes and 5 from commercial food vendors surrounding the campus. These sample size were based on assertion by Cresswell (2014), that 30 percent is a fair representation of a study. This made up the sample size for the research. The study adopted interview and observation for data collection. Due to the limited time of the participants thus the food vendors, hence the semi-structured interview gave room for them to be asked questions whiles they attended to their chores.
Data was also gathered from users of cooking stoves through observation of the process they undertook before cooking mostly associated with the preparation of the fuel types and its storage. Further data was gathered from the researcher's preliminary experiments to substantiate was gathered through the observations made through and ascertaining to the systematic description of procedures and tests conducted. All ethical considerations were observed gaining consent of the participants for transcription.
To make the study hold water, the complied data, thus all primary obtained data was thematically analyzed (Braun & Clarke, 2012). Every little detail was paid attention to from feedback gotten from the semi-structured interviews, description of all procedures by both the researchers through the tests and experiments conducted and the population on the other hand through the type of stoves selected, the fuel, consumption rates cost and time consumed, its preparation and storage in respect to the usage of the various stoves employed. All these parameters were laid out and critically analyzed, evaluated and then thoroughly discussed to weigh out resulted pros and cons of the various cooking stoves for which conclusions were then made.

Results and Discussion

Pre-Manufacturing Stage

Making the Test Pieces for the Clay Compartment

In order to identify the most appropriate clay body to be used to manufacture the clay compartment of the biomass stove, a series of test were conducted on a variety of compositions. They included;

- Kaolin [white clay] plus saw dust
- Kaolin [white clay] plus Palm fiber
- Kaolin [white clay] plus Ball Clay plus saw dust
- Kaolin [white clay] plus Ball Clay plus Palm fiber
- Ball Clay plus saw dust
- Ball Clay plus palm fiber
- Kaolin [white clay] plus Anthill clay plus saw dust
- Kaolin [white clay] plus Anthill Clay Palm fiber
- Anthill clay plus saw dust
- Anthill Clay Palm fiber
- Ball Clay plus Anthill clay plus Kaolin [white clay] plus saw dust
- Ball Clay plus Anthill clay plus Kaolin [white clay] plus palm fiber

Grinding and Sieving Process

Each clay composition was ground fine and sieve using an 80 mesh then a 120 mesh. Each composition (clay body) was mixed with water separately whiles observing the reactions. During the mixing of the clay bodies, variations of each ingredient were made to ascertain the most suitable clay body which will possess adequate heat resistance and shrinkage properties. The following are the ratios for mixing the clay bodies.

- 1 Kaolin: Saw dust ratio = 2:1.5

Observations

- The clay body was stiff due to less water content
- Excess water made the clay overly sticky
- The saw dust in the body made the body easily workable.
- Despite the ease in kneading and wedging, the clay body still felt gritty.
- 2 Kaolin: Saw dust ratio = 3:1

Observations

- The body was fairly sticky
- The body was fairly gritty but easily workable
- The clay body was less stiff

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- 3 Kaolin: Saw dust ratio = 2:1

Observations

- The clay body was stiff and very dry
- The body was very gritty and hardly workable
- Difficulty in kneading and wedging
- 4 Kaolin: Saw dust ratio = 4:1

Observations

- The clay body was stiff and very dry
- The body was very gritty and hardly workable
- Difficulty in kneading and wedging
- 5 Anthill clay: Saw dust ratio 2:1

Observations

- Ease in kneading and wedging
- High plasticity
- The body was fairly gritty but easily workable
- 6 Anthill: Red Clay: palm fiber ratio = 2:1.5:1

Observations

- Difficulty in kneading and wedging
- Very sticky
- 7 Anthill: Red Clay: saw dust ratio = 1.5:1.5:1

Observations

- Difficulty in kneading and wedging
- Less plasticity

- 8 Anthill: Red Clay: palm fiber: Saw dust ratio =1.5:2:0.5:0.5

Observations

- Adequate plasticity
- Less difficulty in kneading and wedging
- 9 Anthill: Kaolin: palm fiber ratio =2:1:1
- Extremely plastic
- Extremely sticky
- Extreme difficulty in kneading and wedging
- 10 Anthill: Kaolin: Saw dust ratio =2:1:1

Observations

- Clay body was very plastic
- Ease in kneading and wedging
- 11 Kaolin: Palm Fiber ratio = 2.5:1

Observations

- Less plasticity
- Ease in wedging
- Difficulty in kneading
- 12 Kaolin: Anthill: Red clay: Palm fiber ratio = 2:1:0.5:0.5

Observations

- Extremely sticky
- Difficulty in kneading and wedging
- Moderate plasticity
- 13 Anthill clay: Saw dust ratio 3:1

Observations

- Ease in kneading and wedging
- The body was easy to work with
- Adequate plasticity
- 14 Kaolin: Anthill: Red clay: Palm fiber ratio = 1:1.5:1.5:1

Observations

- Difficulty in kneading and wedging
- Less plasticity
- 15 Anthill clay: Saw dust ratio 2:1.5

Observations

- Ease in kneading and wedging
- Adequate plasticity
- The body was easily workable

Shrinkage Testing

A frame of square wood was use to cast the various clay bodies into slabs. Lines were inscribed on each slab having a specific measurement. These lines were to help correctly measure the shrinkage percentage of each slab both before drying and firing stage of the slabs.

The Lines made on the slabs to measure the shrinkage before drying were as follows;

- 5cm Breadth
- 7cm length
- 2cm height

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Idea Development

This section deals with series of sketches and drawings from the beehive concept made by the researchers, before executing the main work. After that a final sketch was selected for the manufacture of the biomass stove (Figure 1). The various materials for the process were taking into consideration before the sketches were made.

- Stainless steel to be used for the fabrication of the biomass stoves.
- The clay body, its constituents, weight, size as it made to fit inside the biomass stoves.
- Steel pipes to be used to create the air duct for the bellows.

Figure 1: Sketch of Biomass Stove

3D Rendering

Before starting the actual work, a 3D computer aided rendering was made using software known as Rhinoceros (Figures 2 to 4). Based on these developments a fair knowledge of how the work is going to be done and how it will look like after is complete was gained.

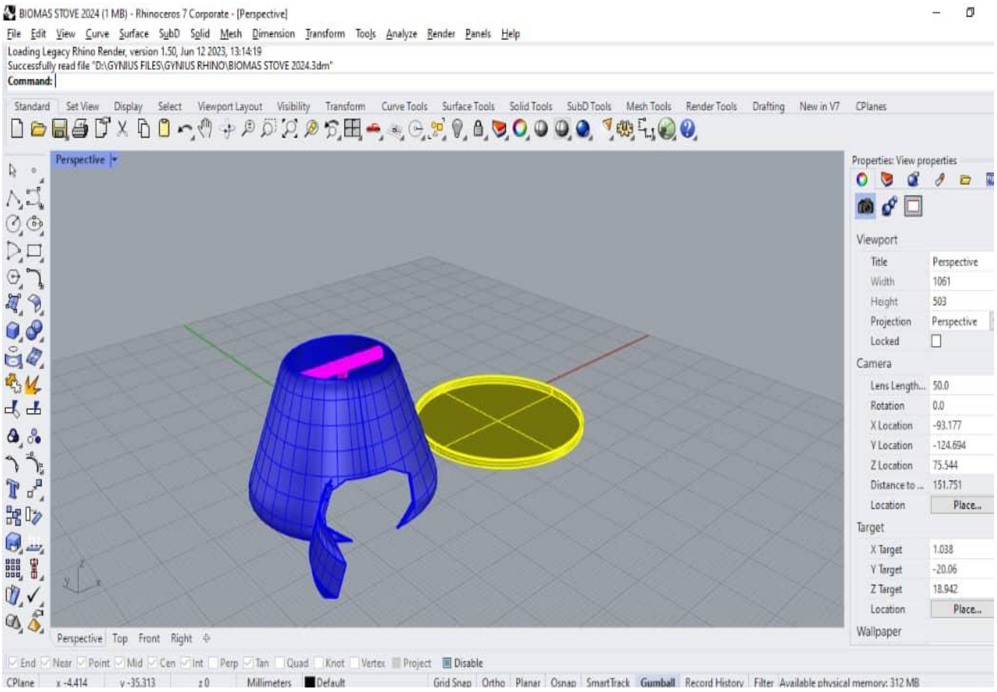

Figure 2: Rendering of base of biomass

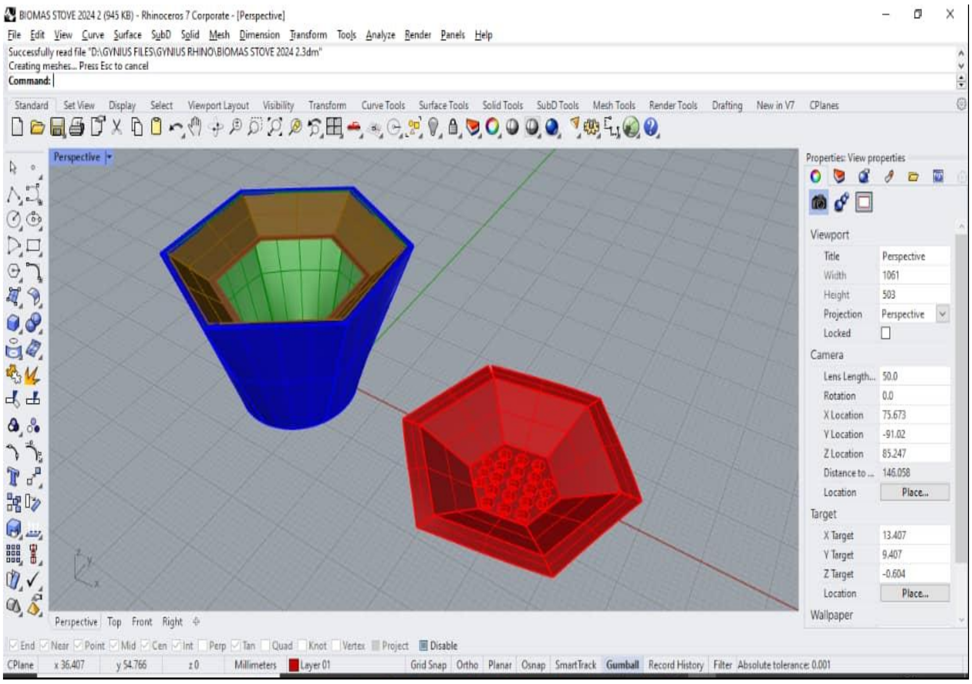

Figure 3: Rendering of top part of biomass

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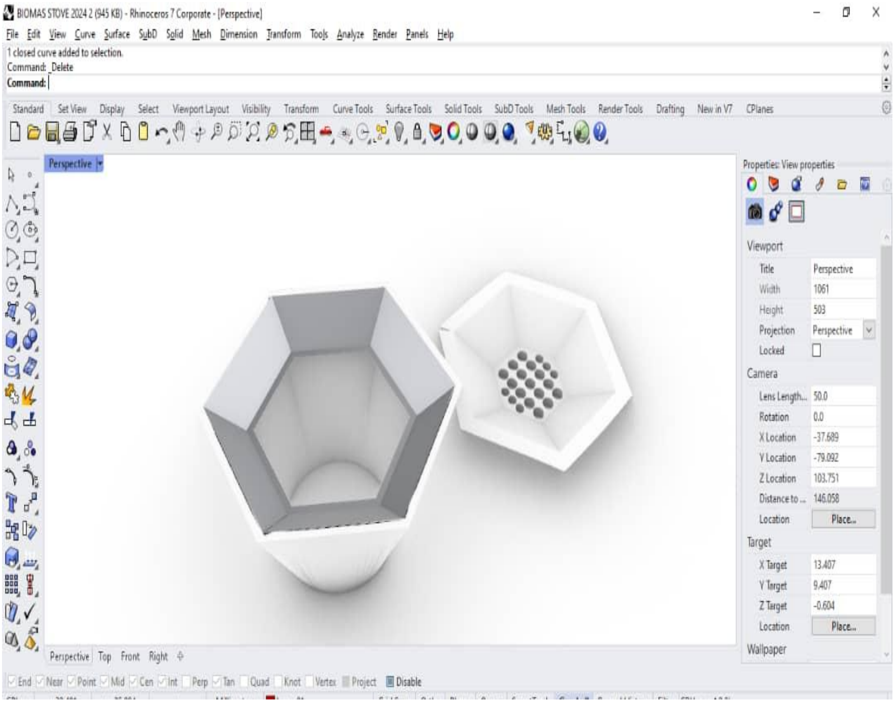

Figure 4: Biomass Stove in rendered form

Rendering the biomass stove began with importing a detailed 3D model into software like KeyShot (Figure 5). Applying realistic materials, such as metal for the body and ceramic for the combustion chamber. Setting up lighting using HDRI environments to enhance the stove's features. The researchers positioned the camera to capture the best angles, adjusting depth of field for focus. Before rendering, the resolution and quality settings was checked. Initiating the render process to create a high-quality image. Finally, the researchers considered using image editing software for post-processing adjustments to enhance the final output and achieve a polished look.

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Figure 5: 3D rendering (keyshot) of Biomass Stove

Manufacturing Stage

Constructing the Biomass Stove

In order to achieve an accurate measurement of the biomass stove to be constructed, a technical drawing of the pattern was constructed. After constructing the technical drawing, a copy of the patterns was cut and transferred onto the metal sheet and then the corners were bent using the bending machine after bending the patterns to meet the adjoining edges squarely, the meeting points were welded together. After fully welding the joints, the resulting effect was sanded away using a power grinder. The grinder was used to remove excess welding material.

As an alternate trajectory for air to enter and enhance the fire in the stove, an air duct was fabricated which will be used in conjunction with a bellow if one is available or preferred over the regular opening created in front of the lower part of the stove (Figures 6 and 7).

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Figure 6: Construction of air duct of biomass
Source: Researchers Own (2024)

Figure 7: Construction of cover of air duct
Source: Researchers Own (2024)

Figure 8: Construction of top part of biomass
Source: Researchers Own (2024)

Perforation was made in the tube so air will be dissipated in to the firing chamber of the stove. After completing each part of the stove separately, the various parts to be joined were welded together (Figure 8). As a primary target to get the stove to be taken apart easily, it

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was characteristic that the stove had a couple of parts which were fabricated to fit squarely but were not joined permanently (Figure 9).

Figure 9: Finished Biomass Stove
Source: Researchers Own (2024)

Findings from the Study

The researchers were able to come out with some findings based on their objectives of the study.

- The researchers were able to identify the various existing stoves and the challenges associated with them and then through series of idea development, suitable designs for a locally compactible biomass stove. Most of the existing stoves are heavy and such they are almost impossible to move about as regular as one might desire. The researchers therefore designed a biomass stove that can be taken apart without destroying the work piece and later assembled with ease.

- For a biomass stove that would be suitable for the use of a low cost fuel for efficient cooking, the researchers developed a biomass stove that would be powered by dried palm kernel shell. This fuel source is cheap and in abundance as compared to LPG or Petrol. Palm kernels have been tested and approved as a safe source of energy additionally it provides adequate energy for efficient cooking.

- To attain a suitable design for a biomass stove capable of efficient cooking, the researchers through various testing of clay bodies compactible with various metals, discovered a clay body comprising of anthill clay in ratio with saw dust if properly dried and fired over 1000 degrees Celsius would be prove to be impervious to extreme temperature even above the normal temperature used for efficient cooking. The clay body describe was tested and proved to compactible with stainless steel. Stainless Steel is a family of iron-based alloys that contain minimum approximately 11% chromium, a composition that prevents the iron from rusting as aw well providing heat-resistant properties.

Shrinkage Test Results Analysis

After complete drying of the various slabs, the lines on the slabs were measured to document the shrinkage percent. These were the result the chosen one for the biomass stove:

- **Anthill: Red Clay: palm fiber ratio = 2:1.5:1**

4.9cm breadth [originally 5cm Breadth] 6.68cm length [originally 7cm length] 1.8cm height [originally 2 cm height]

After firing of the various slabs, the lines on the slabs were measured to document the shrinkage percent. These were the results:

- **Anthill: Red Clay: palm fiber ratio = 2:1.5:1**

4.85cm breadth [originally 5cm Breadth] 6.65cm length [originally 7cm length] 1.78cm height [originally 2 cm height]

Conclusion and Recommendation

The quest to design and fabricate a biomass stove that is fueled by dried palm kernels led to a series of reviews and idea developments that were eye opening and provided alternate trajectories for fabricating other biomass stoves fueled by other sources. The researchers were successful in designing and fabrication of a biomass stoves fueled by dried palm kernels which served its purpose adequately and have excellent aesthetic qualities. In conclusion, the distinction of domestic and non-domestic promotion strategies for household Biomass Stove may provide a base to present that how these should be used as an alternative on can consider this wood-fired cook stove sheds light.z76. It is a strong business case to install them since they have the potential of reducing fuel costs, lower emissions and as we saw in this trend ; free upgrades over their life-time. But there are two important qualifiers: the sustainability of biomass sourcing and the role of government policy in making sure the stoves make sense over time.

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Based on the findings, the following recommendation are made for the implementation of designers of biomass stoves to enhance their eco-friendliness and environmental sustainability:

- Clay bodies are recommended for use to serve the feature of heat resistance must be sieved following the mesh grading system to obtain the best result.

- Careful consideration should be given to the idea development and the construction of the technical drawing stage of such a project to avoid unnecessary try-and-error during the fabrication of the actual work.

- Thick metal sheets should be used in the manufacture of locally manufactured biomass stove to enhance its life span and efficiency.

- Proper welding [joining] and grinding of metal parts should be done to avoid the instance of injury to the user.

- Excellent finishing should be given to metal works of such nature to enhance its qualities and tend fusible with the local market.

The research presents a series of recommendations that suggest ways in which stakeholders, including governments, NGOs and local communities can work collectively to encourage the uptake of biomass stoves through educational programs and with financial incentives. In the case of biomass resources, measures should also be taken to ensure that relevant harvesting is done sustainably particularly where those efforts risk degrading local ecosystems. With supportive policies designed to encourage the use of biomass stoves, not only can we help address global energy poverty and improve human health but also reduce environmental impact.

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Emmanuel Bonsu is a lecturer at AsanSka University College of Design and Technology in the Department of Jewellery Design. Emmanuel is recognized as an outstanding jeweller, known for his exceptional craftsmanship and innovative designs. His ability to blend traditional techniques with contemporary aesthetics sets him apart in the jewelry industry in Ghana. Emmanuel's attention to detail and commitment to quality are evident in every piece he creates, whether it's intricate metalwork or stunning gemstone settings. His passion for jewellery design extends beyond aesthetics; Emmanuel is also dedicated to sustainability in his work. He seeks to use ethically sourced materials and environmentally friendly practices, ensuring that his creations not only look beautiful but also align with responsible production standards. This dedication to both artistry and sustainability has earned him a reputation as a leading figure in the jewelry community, inspiring others with his vision and skill.

2. **Mustapha Baba- joecrack455@gmail.com**

Mustapha is a metal smith in the metal industry, Ghana. Mustapha's research interest in welding and sustainability focuses on exploring innovative techniques that minimize environmental impact while maintaining high-quality welding practices. He is particularly interested in the development of eco-friendly materials and processes that reduce waste and energy consumption in welding operations.

3. **Samuel Kissi Baah- samuelkissibaah@yahoo.com**

Samuel Kissi Baah is a lecturer at KNUST and a practising artist in metals under the pseudonym Kisbone de Blacksmith. His drive for fine cast works has led him to develop a new core composition for traditional lost wax casting, which he uses for all his lost-wax cast objects. Samuel's research interest in metal casting coupled with Gemmology and his desire to solve challenging needs compelled him to research local Materials that can be used as gem simulants in traditional lost-wax casting when he pursued Doctor of Philosophy in African Art and Culture

4. **Nii Lantey Golightly- niilantey160@gmail.com**

Nii is a jeweller at Shanti jewellery and also a metal smith, Ghana. Nii aims to investigate the integration of sustainable practices within the welding industry, such as the use of renewable energy sources and the recycling of materials. His goal is to contribute to the advancement of sustainable welding technologies that not only enhance efficiency but also promote environmental responsibility. Through his research, Nii seeks to bridge the gap between traditional welding methods and modern sustainability goals, making a positive impact on both the industry and the environment.

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Technology and a PhD student in African Art and Culture at the Department of Painting of Sculpture, KNUST. He holds a master of fine art in Jewellery and Metalsmithing from KNUST. He takes inspiration from biomimicry and manipulates complex designs into metal products by fabricating and casting them. As a jeweller and metal product designer, he works with different, precious, ferrous and scrap metals bringing them into the light by recycling and forming artwork out of it. Kwame believes there is nothing impossible under this sun, just find who you are and do it on purpose.

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