IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 7, April 2025
Impact Factor: 7.67

Smokeless Stove without the Harm

Akash Nagare[1], Rohan Sonkamble[2], Shreeyash Chaughule[3], Vaibhav Datir[4], Prof. M. D. Deshamukh
Department of Mechanical Engineering
JSPM's Bhivarabai Sawant Polytechnic, Wagholi, Pune

Abstract: *Traditional biomass stoves used in rural and low- income communities contribute significantly to indoor air pollution, leading to severe health issues and environmental degradation. This study focuses on the design, development, and performance evaluation of a smokeless stove aimed at reducing harmful emissions while maintaining fuel efficiency. The stove utilizes improved combustion techniques and optimized airflow design to ensure more complete fuel burning, thereby minimizing smoke generation. Experimental results demonstrate a significant reduction in particulate matter and carbon monoxide emissions compared to conventional stoves. Additionally, the smokeless stove offers better thermal efficiency and fuel savings, making it a sustainable and cost-effective alternative for clean cooking. This research contributes to the ongoing efforts in promoting cleaner energy solutions and improving public health in developing regions*

Keywords: air pollution

I. INTRODUCTION

In many parts of the developing world, especially in rural and semi-urban areas, cooking is still primarily done using traditional methods such as open fires or basic mud stoves. These stoves typically use solid biomass fuels including firewood, agricultural waste, and cow dung. While these materials are often easily available and affordable, their combustion in conventional stoves is highly inefficient. Incomplete combustion leads to the release of a large amount of smoke and harmful pollutants such as carbon monoxide (CO), particulate matter (PM), hydrocarbons, and other toxic gases. According to the World Health Organization (WHO), indoor air pollution caused by traditional cooking methods is a major health hazard, contributing to respiratory diseases, cardiovascular problems, and even premature death, especially among women and children who are more exposed.

In addition to health risks, these stoves also contribute to environmental issues such as deforestation, greenhouse gas emissions, and climate change. The inefficiency of traditional stoves also results in higher fuel consumption, which further burdens already resource- constrained families and communities.

To address these challenges, there is a growing need for alternative cooking technologies that are clean, efficient, and affordable. One such solution is the development of smokeless stoves. A smokeless stove is designed to ensure more complete combustion of fuel, which significantly reduces smoke and harmful emissions. These stoves often feature improved air flow design, insulated combustion chambers, and materials that enhance heat retention and fuel efficiency. This research paper focuses on the design, fabrication, and experimental analysis of a low-cost, user-friendly smokeless stove suitable for rural households. The primary objectives of this study are to reduce indoor air pollution, minimize fuel consumption, and improve overall thermal efficiency. The paper also explores the socio-economic benefits of adopting smokeless stoves and their potential to improve the quality of life in underprivileged communities.

II. LITERATURE REVIEW

The issue of indoor air pollution caused by traditional cooking methods has been widely studied over the past few decades. Several research studies have highlighted the health, environmental, and economic challenges associated with the use of open fires and inefficient biomass stoves in rural and developing regions.

According to global health reports, indoor air pollution is among the top causes of premature deaths in countries where solid fuels are predominantly used for cooking.

Numerous efforts have been made to improve stove technology in order to achieve cleaner combustion and higher thermal efficiency. Early designs of improved cookstoves focused mainly on enhancing the combustion chamber shape to promote better airflow and combustion. Research has shown that introducing secondary air supply can significantly reduce smoke and improve fuel burning efficiency. Some models, such as the rocket stove, utilize a vertically insulated combustion chamber to achieve higher temperatures and more complete combustion.

Studies have also explored the use of different materials for the stove body, such as cast iron, stainless steel, clay, and refractory bricks, to improve durability and heat retention. In many cases, locally available materials have been utilized to reduce production costs and make the stoves more accessible to low-income communities.

Performance evaluation of smokeless stoves is typically based on parameters like thermal efficiency, fuel consumption rate, emissions of CO and PM, and time taken to cook food. Various testing protocols, such as the Water Boiling Test (WBT) and Controlled Cooking Test (CCT), have been developed and standardized by organizations like the Global Alliance for Clean Cookstoves to assess stove performance under laboratory and field conditions.

Several researchers have emphasized that while technical improvements are crucial, user behavior, cultural preferences, and affordability also play significant roles in the adoption of smokeless stoves. Therefore, modern stove development now often includes user feedback in the design process to ensure practical usability and long-term adoption.

This review of existing literature highlights the ongoing need for stove designs that are not only efficient and low-emission but also affordable, durable, and suited to the needs of local communities. The current research builds upon these studies by developing and testing a customized smokeless stove aimed at optimizing combustion efficiency while remaining economically viable for rural households

III. METHODOLOGY

The methodology for this research involved a systematic approach covering the design, fabrication, and performance testing of a smokeless stove. The aim was to develop a low-cost, efficient, and user-friendly stove suitable for rural households, using locally available materials.

1. Design and Conceptualization:

The initial phase involved literature review and analysis of existing stove models to identify key design flaws in traditional stoves. Based on this, a conceptual model of a smokeless stove was developed with the following key features:

- Improved combustion chamber with insulation
- Primary and secondary air inlets to enhance combustion
- Chimney for effective smoke removal
- Fuel chamber optimized for biomass

2. Material Selection:

Locally available and cost-effective materials such as mild steel sheet, fire bricks, and ceramic wool were selected for fabrication. The materials were chosen based on their thermal properties, durability, and resistance to high temperatures.

3. Fabrication:

The stove was fabricated in a small-scale workshop using conventional tools and fabrication techniques such as cutting, welding, bending, and assembling. Special care was taken to ensure proper alignment of the combustion chamber and airflow paths to maximize efficiency.

4. Performance Testing:

The performance of the smokeless stove was evaluated using standard protocols. The following parameters were tested:

- Thermal efficiency: Measured using the Water Boiling Test (WBT).
- Fuel consumption rate: Determined by weighing the biomass before and after the test.
- Smoke emission: Observed qualitatively and measured using a basic particulate matter sensor and carbon monoxide detector.
- Boiling time: Time taken to bring a fixed volume of water to boiling point.

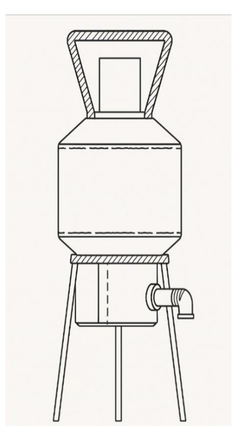
5. Comparison with Traditional Stove:
A conventional mud stove was used as a baseline for comparison. Both stoves were tested under similar conditions to compare thermal performance, smoke emission, and fuel efficiency.

IV. WORKING PRINCIPLE

The smokeless stove operates on the principle of improved combustion through optimized air flow and efficient heat retention. The main objective is to achieve complete combustion of biomass fuel, thereby reducing smoke and harmful emissions such as carbon monoxide (CO) and particulate matter (PM).

The stove is designed with two types of air inlets:
Primary air inlet: Located at the base of the combustion chamber, it supplies oxygen directly to the burning fuel to initiate combustion.
Secondary air inlet: Positioned above the fuel bed, it introduces pre-heated air to the upper part of the flame, helping in burning the unburnt gases and volatile compounds.
As the biomass fuel burns in the insulated combustion chamber, the heat is retained for a longer duration, raising the temperature and promoting more complete combustion. This high-temperature environment ensures minimal smoke production.
A chimney or flue pipe is attached to the upper part of the stove to direct any remaining smoke or gases away from the cooking area. The chimney also creates a natural draft, pulling fresh air through the combustion chamber, which further improves efficiency.
In some designs, a rocket stove principle is used, where the fuel is fed horizontally and the flame travels vertically through a narrow insulated chamber, increasing velocity and temperature. This ensures that the combustion is more efficient and nearly smokeless.
Overall, the stove uses controlled air flow, insulation, and proper fuel feeding techniques to reduce smoke generation, improve thermal efficiency, and offer a cleaner cooking experience.

Diagram



V. FUTURE SCOPE

The development of smokeless stoves presents significant opportunities for further improvement and wider application. Although the current design demonstrates effective smoke reduction and fuel efficiency, there remains substantial scope for enhancement in both technology and implementation.

1. Material Optimization:
Future designs can explore the use of advanced insulating and heat-resistant materials to further improve thermal efficiency and durability while reducing the overall weight of the stove.

2. Incorporation of Renewable Energy:
Hybrid models that combine biomass combustion with solar energy or thermoelectric generators can be developed to produce electricity for small appliances or lighting in off-grid areas.

3. Emission Monitoring Systems:
Integration of low-cost sensors to monitor carbon monoxide and particulate matter levels in real-time could help users ensure safer indoor air quality and adjust usage accordingly.

4. Automation and Smart Controls:
Smart airflow control mechanisms using fans or dampers, powered by thermoelectric energy or solar panels, can be developed to optimize combustion without requiring manual adjustment.

5. Mass Production and Cost Reduction:
Further research can focus on simplifying the manufacturing process to make the stove more affordable and suitable for large-scale production, especially for government and NGO distribution programs.

6. Field Testing and User Feedback:
Long-term field testing in various climatic and cultural settings can provide deeper insights into user behavior, fuel types used, and maintenance challenges, leading to better user-centric designs.

7. Policy and Awareness Programs:
Collaboration with local governments and organizations to raise awareness about the health and environmental benefits of smokeless stoves can enhance adoption rates in rural and low-income areas.

VI. CONCLUSION

The smokeless stove developed and analyzed in this research represents a significant step toward cleaner, healthier, and more efficient cooking solutions for rural and low-income households. By incorporating improved combustion techniques, proper air flow management, and insulation, the stove successfully reduces harmful smoke emissions while enhancing thermal efficiency and conserving fuel.

Experimental results and performance comparisons with traditional stoves indicate a noticeable improvement in terms of reduced indoor air pollution, faster cooking times, and lower biomass consumption. These improvements not only contribute to better health outcomes but also support environmental conservation by reducing the pressure on firewood resources.

Furthermore, the use of locally available and cost- effective materials in the stove's construction ensures affordability and promotes the possibility of large-scale adoption in rural communities. While the current model shows promising results, there remains scope for further refinement through technological advancements, user feedback, and broader implementation strategies.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 7, April 2025
Impact Factor: 7.67

REFERENCES

[1]. Smith, K. R., et al. (2000). "Indoor air pollution in developing countries and acute lower respiratory infections in children," Thorax, vol. 55, no. 6, pp. 518–532.

[2]. Bhattacharya, S. C., Albina, D. O., & Salam, P. A. (2002). "Emission factors of wood and charcoal-fired cookstoves," Biomass and Bioenergy, 23(6), 453–469.

[3]. Venkataraman, C., Sagar, A. D., Habib, G., Lam, N. L., & Smith, K. R. (2010). "The Indian National Initiative for Advanced Biomass Cookstoves: The benefits of clean combustion," Energy for Sustainable Development, 14(2), 63–72.

.