THERMAL ANALYSIS OF COOKSTOVE (CHULHA) USED FOR COOKING PURPOSE

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ABSTRACT

Half of the world's human population cooks their food on an open fire inside their homes by burning various forms of biomass such as wood, charcoal, dung and crop residues. Burning each of these biomass fuels emits harmful chemicals and large amounts of particulates, each of which have adverse effects on human health, global climate and regional ecosystems from which the fuel is extracted. In the year 2000, it was estimated that the combustion of biomass fuels was responsible for 13 % of global energy consumption. A large majority of this consumption occurs in developing countries where 90% of rural households rely upon biomass as a means to provide for their heating and cooking needs. Unfortunately, most of these people use very inefficient traditional cooking methods that cause excessive air pollution and use more fuel than necessary Index Terms : Cook stove, Bio fuel,

Keyword : *Cook stove, Bio fuel,*

1. Introduction

Energy is a vital input for economic and social development. In most of the developing countries, wood and other biomass fuels are still the primary source of energy for the majority of people, particularly the poor for cooking, heating and their small cottage business [1] domestic cooking task in isolated rural village are commonly completed on traditional three stone open fire, whereas the stoves have several negative consequences and improved cooking technology have been found to reduce fuel wood used and time spend gathering wood, reduce deforestation, improve user health, and reduce emission and affect climate change.[2] the exposure to the particulate matter in ambient air has been associated with effect on the pulmonary as well as cardiovascular system. These effect include exacerbation of asthma and allergy, chronic obstructive pulmonary dieses, pulmonary fibrosis, increased risk of lung cancer , and acute cardiac effect.[3]

2. Background

The World Health Organization estimates that

: i. "Around 3 billion people cook and heat their homes using open fires and simple stoves burning biomass (wood, animal dung and crop waste) and coal

ii. Over 4 million people die prematurely from illness attributable to the household air pollution from cooking with solid fuels.

iii. More than 50% of premature deaths among children under 5 are due to pneumonia caused by particulate matter (soot) inhaled from household air pollution.

iv. 3.8 million premature deaths annually from no communicable diseases including stroke, heart disease, chronic obstructive pulmonary disease and lung cancer are attributed to exposure to household air pollution." [3]

The different operating conditions applied during the different domestic cooking stove tests will have a great influence on the ratings of thermal efficiency, gaseous and particulate emissions, which will of course influence the performance rating of any stove. A rigorous scientific review, both conceptual and mathematical, should be conducted for all methods, whether new, whether generally accepted, or whether enforced as legal requirements.[6]

The overall results indicate a preference for larger stoves in both regions, which indicates the ability to cook with two pots simultaneously is an important attribute to consider. Furthermore, the availability of credit only became a factor for higher priced items, but did not seem to influence customer preferences to the degree expected. Respondents were willing to pay for adequate durability; thereafter they became price sensitive.[8]

"One size fits all" types of stove cannot meet the diverse and fluctuating need of cook stove user. Therefore, it is recommended that adaptable cook stove to be developed. Adaptable cook stove have the potential to increase the satisfaction of the end user and provide a technological solution that can be distributed at larger scale [4].
This study conducted on the stoves used in Benin showed that the criteria of performances targeted depend on the type of stove, the type of meal and the delivery price of the fuel. It also made it possible to detect the modifications needed in order to improve the performances of certain stoves; this constitutes one of the goals of this study. The research continues, with the objective to define a global criterion of appreciation of the stoves, also including the cost of the stoves. It has been also pointed out that the improved "3 stones" stoves are not economic. Further studies to improve their technology and a possible government intervention in the form of tax reduction on fossil fuels and electricity could arouse interests to the kerosene, the gas and the electric cookers with the target to decrease the pressure on the vegetal formations and to stop the advancing desert. [5]

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3.1. PROBLEM FORMULATION OR PROBLEM DEFINATION

Most rural household in world use wood energy for various purposes such as cooking, heating, drying etc. In India, some households still rely on three stone fire cook stove and build up cook stove for household and industrial cooking. This is because of various reasons such as availability and accessibility to fuel wood source, cultural tradition and practices and of its low cost.

This is evident: despite the problem associated with the use of such stoves such as;

- Loss of heat energy from the furnace of cook stove to the surrounding
- Continuous deforestation due to increased amount of wood harvested from surrounding environment, increasing use of time for collection of fue

With this outlook on unhealthy and unsustainable conventional cooking method, thermal analysis of cook stove can alleviate some of the problem associated with the use of traditional cook stove.

3.2. OBJECTIVE OF PROJECT

- The general objective of the study was to thermal analysis of traditional clay cook stove and Concrete cook stove used for cooking, heating purpose in rural area.
- The study aimed to:
- To find the performance of traditional clay stove and concrete stove using water boiling test.
- Effect of using refractory material (Ceramic) in furnace of cook stove on temperature distribution and heat transfer distribution.
- To compare the performance of traditional clay stove and concrete stove.

3.3. EXPERIMENTATION

Water boiling test that simply simulates the cooking process. Here water in cooking pot is heated to evaluate the thermal efficiency and associated emission generation during the combustion. Water boiling test helps an initial assessment of stove performance, design evaluation during the development, compare the effectiveness as compare to different design for performing the same task and ensure to meet design specification. Two kind of cook stove are used in water boiling experiment. One is traditional clay stove which is made by villager and other is concrete stove, which is made by ARTI Institute. The water boiling test is conducted for the both cook stove in Village – Mandwa, Ta & Dist- Wardha, Maharashtra. The objective of experimentation to find out efficiency, temperature and heat flux distribution in cook stove.

Fig.1.Experiment on Clay Cook stove

Fig.2 Experiment on concrete cook stove

3.4. COMPARATIVE THERMAL ANALYSIS OF COOK STOVE

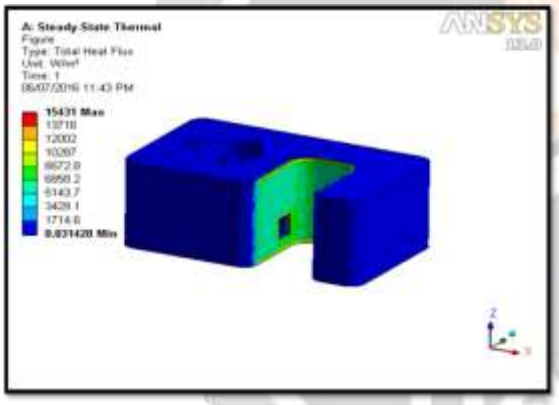


Fig.3. Heat flux distribution in Clay stove

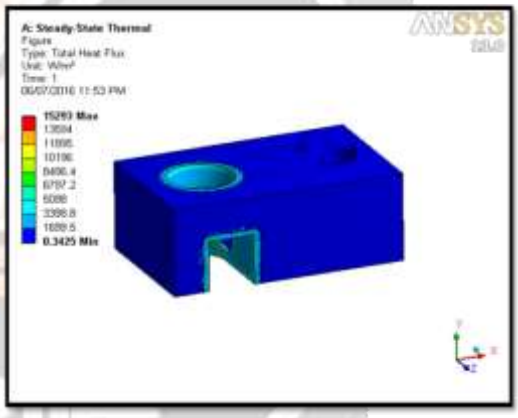


Fig.4.Heat flux distribution in concrete stove

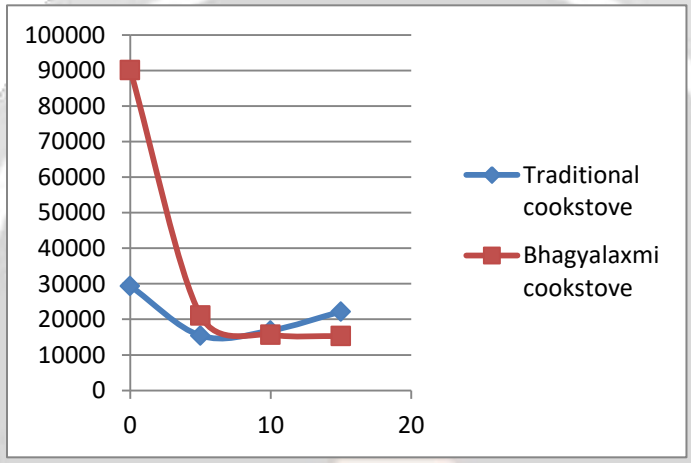
3.5. RESULT AND DISCUSION

The key element used to evaluate the thermal performance of cook stove with or without refractory lining of ceramic.

The thermal efficiency however often much lower. The maximum thermal efficiency obtain during the experiment 18.50%. This means that 81.50% of energy in the fuel is lost to the surrounding, so there is significant opportunity to improve the thermal efficiency of this type of cook stove. The use of refractory lining in the furnace of cook stove reduce the loss of heat to the surrounding. With this outlook, two design scenario are generated for the thermal analysis of traditional clay and concrete cook stove . The first design scenario simulated the temperature distribution with and without inner lining of ceramic in furnace of cook stove and second design analysis simulated the heat flux distribution with and without inner lining of ceramic in furnace of cook stove.

Effect on total heat flux (W/m2) by changing thickness of Ceramic material				
Case Studies	Without Ceramic Material	5 mm thickness of Ceramic	10mm thickness of Ceramic	15 mm thickness of Ceramic
	Max	Max	Max	Max
Traditional cook stove (Clay Stove)	29384	15431	16860	22186
Bhagyalaxmi cookstoce (Cement stove)	90136	21102	15698	15293

Table No. 01 Effect on heat flux by ceramic thickness



Graph No01. Heat flux Vs Ceramic thickness

It can be inferred from graph 6.1 that maximum loss of heat flux in cook stove when no ceramic lining in cook stove. When we used inner lining of ceramic thickness of 5mm, heat flux in traditional clay stove decrease from 29384 w/m2 to 15431 w/m2.For Concrete cook stove with 5mm ceramic lining heat flux decreases from 90136 W/m2 to 21102W/m2.In traditional clay stove, by using refractory lining of ceramic of 5mm, 10mm, 15mm heat flux loss increases by 47.48%,42.62% and 24 % respectfully.In concrete stove, by using refractory lining of ceramic material of 5mm,10mm/and 15 mm, heat flux loss decreases by 76.58%, 82.58% and 83.03 respectfully

4. CONCLUSIONS

First of all, we have realised that an understanding of local physical infrastructure, economic and social cultural condition is imperative before making any technological choices. The challenge is coming up with an accessible, affordable and sustainable solution for local needs to evaluate best technological solution at given moment of time.

Thermal Analysis by Ansys tool adds important information, such as temperature distribution profile and heat flux distribution profile. Qualitative information may be quickly and efficiently evaluated and analysing the cook stove temperature profile can provide the guidance for characteristic of cook stove.

In this work, thermal analysis of cook stove showed that, the loss of heat due to conduction is much larger in concrete cook stove than traditional clay stove. Loss of heat form furnace area has been targeted as an improvement for this cookstove.

The existing model of clay stove and concrete stove have been modified by providing different thickness of refractory lining in furnace of cook stove. These modified cook stove have been analysed with different thickness of refractory lining of ceramic material and differences in temperature distribution and heat flux distribution will be used to access the effectiveness of those changes. It was also conclude that:

- Ceramic refractory lining would offer suitable thermal insulation of cook stove.
- With increase in the thickness of ceramic material ,heat flux first decreases, attain minimum value and then increase gradually.
- The purpose of ceramic refractory is to reduce unwanted radient heat dissipation
- Providing greater thickness of insulation is not economical viable .

Further modifications focused at redesigning the pot seat vis-à-vis the flue gas exit port in such a way that will minimize heat loss by radiation and convection, and ensure maximum heat transfer to the base of the pot can be pursued in future

5. ACKNOWLEDGEMENT

It is matter of great delight by getting the occasion of highlighting of a fraction of knowledge, we acquired during our technical education through this report. This would not have been possible without the guidance & help of many people. This is only page where we have the opportunity of expressing our emotions & gratitude from the core of our heart to them.

This project report would not have been success without enlightened ideas, timely suggestion & keen interest of our most respected Project guide Prof. Dr. Suhas Kongre, professor, Department of Mechanical Engineering without his best assistance & supervision this would have been a difficult task to complete.

Being one of the same lines we express our deep sense of gratitude to our honorable Project Incharge Prof.P.K. Channe, Head of Mechanical Engineering Department Prof.K.A Pakhare & Honorable Principal Dr. Rajeshkumar Tugnayat for their most valuable technical guidance and administrative assistance.

Last but not the least; we would like to express our thankfulness to teaching & non- teaching staff, my friends & all my well wishers who helped us directly or indirectly.

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