Improvement of Traditional Biomass Cook-Stove for its Performance and Pollution Reduction A Review

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Abstract - The paper present improved biomass cookstove is the improvement with respect to traditional cookstove in order to optimize the process parameter such as thermal efficiency, specific fuel consumption. The study of performance of an improved cookstove is undertaken in this work . The design improvement of the stove focused on the following area: provision of insulation around the combustion chamber to reduce conduction heat loss across the wall, provision of secondary air by providing great at the inlet of combustion chamber and also by providing air holes on the walls of combustion chamber . Performance based on various fuels (wood) used to check for thermal efficiency test was studied . The performance is also better when compared to the three stone fired cookstove in terms of thermal efficiency and specific fuel consumption and hence pollution percentage reduce.

Key Words: **Biomass cookstove, thermal efficiency, insulation, pollution reduction**

1.INTRODUCTION

Indoor air pollution causes significant health problems for the 2 billion people worldwide who rely on biomass fuels for their cooking and heating needs. Over the last 30 years awareness of the environmental and social costs of using traditional fuels and stoves has grown. At the same time, studies of the problem have resulted in proven strategies to reduce both fuel use and harmful emissions. Unfortunately, the local stoves currently available do not always represent the best designs that modern engineering can offer. This booklet is an attempt to address the problem by summarizing some of the advances in stove theory and design. Understanding these concepts would be useful to administrators of stove projects, policy makers, field workers, and cooks alike.

Although open fires are often used wastefully, carefully operated open fires can be fuel efficient and clean burning when tested in the lab. In many situations, cooks are not overly concerned with fuel use, and studies have shown that when fuel is plentiful three-stone fires can use an excessive amount of wood to cook a small amount of food. But in other places where fuel is scarce, open fires can be carefully controlled so that fuel efficiency rivals many first generation improved cook stoves.[1]

How an operator controls the open fire makes the difference, as in the use of other tools. In the seventies and early eighties, open fires were generally characterized as being basically inefficient. But it was by analyzing the open fire that researchers were able to develop truly improved stoves. Dr. Grant Ballard-Tremeer and Dr. Kirk Smith were foremost among those who found that the three stone fire could be both more fuel efficient and cleaner burning than some “improved” cook stoves.

Respecting that indigenous technologies are evolved from countless years of experimentation and have great worth changes the perspective of scientists who are trying to address the causes of human suffering. Watching how experts operated the open fire has taught engineers how to design even better stoves. Modern cook stoves are designed to clean up combustion first. Then the hot gases can be forced to contact the pot increasing efficiency without increasing harmful emissions. [1]

Fires can be clean burning when expert cooks push the sticks of wood into the fire as they burn, metering the fuel. The open fire can be a hot fire useful when food or drink needs to be prepared quickly. The energy goes into the pot, not into the cold body of a stove. The open fire can burn wood without making a lot of smoke; hot fires burn smoke as it is released from the wood. Unfortunately however, many fires used for cooking are built emphasizing simplicity of use and are wasteful and polluting. Modern stoves score higher when tested than even the most carefully operated fire in the laboratory. Good stoves can offer many advantages. Stoves do much more than save wood and reduce smoke. How the stove cooks food is usually most important to the users!

Improved stoves can make cooking with fire easier, safer, faster, and can add to the beauty of the kitchen. A good stove is quicker to start, needs little tending, and can meet the specific needs of a cook. The successful design is appreciated as an addition to the quality of life and usually these concerns far outweigh scores on a test. [1]

2. LITRRATURE REVIEW

In rural areas of most developing countries like India, wood is the most readily available energy source for domestic cooking applications. This means that more than 166 million people depend largely on various forms of biomass to meet their energy needs mainly for cooking. However, the frequent use of these woods leads to deforestation that affects our climatic conditions. Therefore, this woods needs to be properly managed. Therefore, the use of unsafe, inconvenient and inefficient wood stove will not help to solve our problems. A more efficient and saving cooking wood stove would indeed go a long way to saving resources and promoting good environmental conditions for most rural communities. The rate of deforestation in the past ten years has increased considerably due to the increase in wood fuel consumption, the expansion of agricultural land, desert encroachment and construction of new buildings. At present, there are few alternative to wood fuel for cooking particularly that are bio-waste briquettes but these are not easily available in rural India due to lack of proper supply chain management. Exposure to smoke has emerged as one of the major concerns in the rural areas of the developing countries (WHO, 1992). The increase in population will continue to increase the demand for firewood consumption whose supply is limited. Therefore, in order to balance the demand and supply of fuel wood for cooking, a more efficient use of this fuel is desirable by making use of more efficient and save cooking stoves. In India about 69% of the country's population depends on fuel wood for their daily cooking and often on the traditional three-stone cook-stove or inefficient cooking stoves.

The use of open fires and traditional stoves leads to incomplete combustion of fossil fuel, causing high Black Carbon (BC) emissions. Furthermore, open fires and traditional stoves have low combustion efficiency, leading to higher cooking times and inefficient use of fuel wood. Black carbon (BC) exists as particles in the atmosphere and is a major component of soot. Black carbon results from the incomplete combustion of fossil fuels, wood and other biomass. Complete combustion would turn all carbon in the fuel into carbon dioxide (CO2). In practice, combustion is never complete and CO2, carbon monoxide (CO), volatile organic compounds (VOCs), organic carbon (OC) particles and BC particles are all formed. On a global basis, approximately 20% of black carbon is emitted from burning bio fuels, 40% from fossil fuels, and 40% from open biomass burning. The largest sources of black carbon are Asia, Latin America, and Africa. Some estimates put that China and India together account for 25-35% of global black carbon emissions.

3. EXPERIMENTAL SET UP

Experimental setup is based on Dr. Larry Winiarski's design principles which are as follows:

1. Whenever possible, insulate around the fire using lightweight, heat-resistant materials.
2. Place an insulated short chimney right above the fire.
3. Heat and burn the tips of the sticks as they enter the fire.
4. High and low heat are created by how many sticks are pushed into the fire.
5. Maintain a good fast draft through the burning fuel.
6. Too little draft being pulled into the fire will result in smoke and excess charcoal.
7. Use a grate under the fire.
8. Insulate the heat flow path.
9. Maximize heat transfer to the pot with properly sized gaps.
10. The opening into the fire, the size of the spaces within the stove through which hot air flows, and the chimney should all be about the same size. This is called maintaining constant cross sectional area, also as a general rule, a door into the fire with a square opening of twelve centi-meters per side and equally sized chimney and tunnels in the stove will result in a fire suited to family cooking.[3]

Fig-1: Water Boiling Test

3.1 TESTING PROCEDURE FOR THERMAL EFFICIENCY TEST

1.Prepare required amount of fuel as per specification[2]

2. Take the required size and shape of cooking pot for water boiling test [2]

3. For every 5°C increase in temperature measure time by stopwatch and also measure temperature of water.

4. Do the procedure for 30 minute.

5. Interpret the results in observation table.

Fig-2: TESTING PROCEDURE FOR THERMAL EFFICIENCY TEST

3.2 SPECIFICATION

1. Height of combustion chamber(elbow)= 420 mm.
2. Cross section of elbow at inlet= 120mm*120mm.
3. Diameter of outer casing= 250 mm.
4. Thickness of material used= 1.2 mm.
5. Material for setup = mild steel
6. Insulation material = Ecolite
7. Cross section of wood fuel= 120mm*30mm*30mm
8. Weight of setup = 6.618 kg

4. CONCLUSIONS

In this paper, an improved cook-stove was designed, fabricated, and evaluated, along with a traditional metal stove. Thermal efficiency test used to evaluate the improved stove fabricated. A thermal efficiency value increases by 2-4%was obtained for the improved stove than for the traditional metal stove, also specific fuel consumption reduces significantly. The improved cooking stove fabricated proved to be more efficient and effective than traditional stove.

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