Review On Smokeless Biomass Stove

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Abstract— In rural areas, people still use the old mud stove for cooking purpose. The fuel source is mainly biomass. These stoves are not efficient and are unhealthy. The fuel doesn't support complete burning and this leads to generation of smoke. This smoke adversely affects the health of human being (serious health issues such s respiratory diseases, asthma, eye irritation, etc.). Every year 1.6 million people die due to indoor air pollution. Various smokeless stoves have been designed in India to decrease smoke emissions and increase fuel efficiency. It is a present requirement to improve or optimize these designs to fulfill the future needs to prevent the degradation of environment.

Keywords— smokeless stove, biomass, unburnt hydrocarbons, complete burning.

Introduction

In India most of all rural population uses traditional Chula's. The major fuel for the Chula is the biomass. Biomass is the renewable, widely available, carbon neutral and more economical than other renewable sources. Biomass is mostly in the form of wood, it is the oldest form of energy that is used by the humans. Biomass contributes 7-14% of world energy requirement. Burning of biomass give rise to combustion process which provides basic energy requirement for cooking in various countries. More than half of the world population uses open fire for indoor cooking which is highly energy inefficient and unhealthy. In these stoves unburnt gases lead to formation of smoke due to incomplete combustion and thus releases particulate matter and CO [1]. This smoke effects on health of the woman as well as whole family. The serious issues have been seen such as respiratory diseases, asthma, eye irritation, etc. It was observed that just a day's exposure to smoke can lead to accumulation of a carcinogenic compound like Benzopyrene, which is almost equivalent to 14 days of cigarette smoking! And from research is has been found that around 5 lac deaths in every year in India due to this smoke which is produce from biomass. The use of wood or local biomass not only increase the health problems because of pollutants like suspended particles, unburnt hydrocarbons, carbon monoxide etc. but also influence to increase the rate of global warming due to the products which are comes from incomplete combustion [2]. The incomplete combustion occurs when a combustion reaction occurs without a sufficient supply of oxygen or improper supply of oxygen. Now days the developed and improved design stoves are needed to the most of the rural areas. This will help the most of the families to save their life from risk. Therefore, the smokeless stove. In order to have easy access of these Chula's to rural areas the design must be prepared taking into account the factors such as economics and efficiency [3].

Improved stoves in India

Over a period of time research work has led to development of new and innovative technologies. Various organizations have developed new improved stoves which showed reduction of smoke, high energy efficiency and economic feasibility.

Some of them are as follows:

Stove by Mr. V. Jayaprakash:Chula maker from Kerala who improvise portable stove by including a secondary combustion chamber for burning unburnt biomass and hydrocarbons. He got in touch with ANERT (Agency for non-conventional energy and rural technology). It has a versatile MOC such as Bricks, cement, clay, cast iron. The base of bottom chamber in this stove is made up of iron grate on which fuel is kept. Below the grate supplementary air inlet is provided. When fuel burns mixed with unburnt hydrocarbon reaches the upper chamber, which has been provided with air holes and thus complete combustion takes place. Lower cost and portability are the important significant features of this stove with the efficiency of 37.67% and 29.48% when coconut shell is used. The cost of this stove ranging INR 4000 onwards [6]. Stove by Mr. Jayaprakash

ASTRA Ole Stove:This stove is developed by the Indian scientist of Indian institute of science(IISc) in 1980s.the design is three-pan mud stove which is fuel efficient and smokeless in nature built with precise specifications. The fuel which is used for this ASTRA-Ole stove is mainly agriculture waste hence the stove become ecofriendly. It is found that it had efficiency of around 40-50% in their laboratory with three pan stove. If pans decrease's the efficiency of the stove also decrease's. In single pan stove without using chimney the efficiency was around 25% and it not exceeding more than it but its greater than the traditional mud stove which has the efficiency of 12-15%. ASTRA-Ole has another stove which is called 'Ojas Chula' in which the fuel pellets are used as a feed. In this stove the small fan is used for supplementary air and also provides a knob to adjust flame of the stove. The cost of this stove is around INR 3000 [7].

Phillips low smoke The working of Chula is in traditional way but it reduces the indoor air pollution and thus causes to death with significant thermal efficiency. The Chula create a safer environment for indoor cooking in several days. It traps smoke and heat inside a locally cost housing in such way as to heat two pot-holes with high efficiency to consume less fuel. Chimney chamber is provided for the provision of smoke. The stove can reduce consumption by 50% bringing down the time by 30% the cost of this stove is INR 700. Phillips low smoke stove

Greenway smart stoveThis stove is developed by the Greenway Grameen Infra. It is the high efficiency portable cookstove. That comes with the excellent air regulation technology that's leads to better combustion. The material of construction consists of aluminum. The stove is suitable for family member of 4 to 6. It doesn't have any movable parts so special training is not required. For operating this stove, hence it is highly flexible. It gives 65% fuel saving and provide 70% smoke reduction. Cost of greenway smart stove is INR 1300. It has been tested and certified by ministry of new and renewable energy, govt. of India [3].

TERI SPT_0610This stove is developed by the energy and resources institute (TERI). This organization working parameter of stove such as energy efficiency. After analyzing the efficiency of mud-stove they use fan for supplementary air supply (forced convection). Steel is used to fabricate the stove body. Various type of fuel can be fed such as wood, agricultural waste, residue, and cattle dung. The lithium batteries are used to power the fan. It is beneficial as it reduces indoor pollution. The stove reduces 54% of fuel consumption with reduction of 70% smoke. The efficiency of the stove is around 37% and the cost is INR 2000 [3].

ARTI BharatlakshmiIt is developed by NGO-Appropriate Rural Technology Institute (Pune).

Because of this simplicity in the design it is popular in the state of Maharashtra. Wood is the major feedstock for this cookstove, which gives 50% reduction in the fuel consumption and also reduces the cooking time by 30% the cost of this stove is INR 700 the institute conduct their own thermal efficiency testing [3].

Oorja StoveA Pune-based startup called First Energy worked with IISc, Bangalore and created Oorja biomass stove which is much more efficient & has efficiency almost as high as an LPG stove. The fuel used is agricultural waste like bagasse, groundnut husk, crop waste, etc. These materials are formed into fuel pellets. The cost of fuel pellets is 12-14 Rs/Kg. In India, the sale of these stoves is about 4,00,000. The efficiency of this stove is 33%. It is recognized as a gasification-type advanced biomass stove, costing around INR 1500. A fully charged stove provides ten cooking cycles, each of 3 hours. It can be suitable to handle a load up to 150 kg [3].

Design Components Various components which are required in a typical biomass stove are:

Combustion chamber:This is the most important and essential part of any stove. The burning of fuel takes place here. The shape of combustion chamber is preferably cylindrical in shape. A square or rectangular chamber is not used as it can lead to formation of hot spots near the edges. Also, the gases can accumulate in these edges, which is not desirable.

Supplementary air inlet: The air inlet is usually a pipe made of the same material as the stove body. It is mostly used in case of forced draft air circulation.

Grate: The grate is placed in the combustion chamber. The fuel is placed on this grate, which has holes having a diameter such that the fuel pieces don’t fall out of it.4. Air distributor/Sparger: This is generally required in case of forced draft circulation of air. It ensures proper circulation of air throughout the fuel in order to obtain proper mixing of the gases. 5. Perforated plate: Some stoves employ a plate with small holes known as perforations. It is fitted just below the place where the vessel is kept. It helps trap the smoke to ensure the complete combustion of gases [1][2].

TESTING OF DEVELOPED COOK STOVES

Testing of developed cookstove carried out by water boiling test (WBT) for different type of biomass which is done in three phases viz. cold-start phase, hot start phase, and simmer phase. A known amount of fuel is taken and the amount of water evaporated after complete burning of fuel was determined to calculate the efficiency of cookstove. The testing of stove involves design parameters, dimensions and efficiency. Proximate analysis to determine moisture content, volatile matter and fixed carbon is done. Ultimate analysis is carried out to find out the proportion of Carbon, Hydrogen, Oxygen and Nitrogen in the fuel. The calorific value of fuel is also determined using Bomb Calorimeter, since it is required to calculate efficiency of the stove.The parameters needed to calculate are as follows: -a) Cross sectional area of combustion chamber: Ac = ? × rc2Where, Ac = Cross-sectional area of combustion chamber ? = 3.14 rc = Radius of combustion chamberb) Volume of combustion chamber:Vc = capacity of stove/Bulk density of CNS chamberThen the Diameter of the chamber is calculated Vc = ? × rc2 × Hc Where, Vc = Volume of combustion chamber Hc = Height of combustion chamberc)

The Efficiency

For testing of efficiency, standard Water Boiling Test (WBT). The quantity of water evaporated after complete burning of fuel is determined and thus, the efficiency is calculated as,? (%) = × 100Where, Mwi = Mass of water taken in cooking vessel i.e. two third volume of vessel, kg;Cpw = Specific heat of water, kcal/kg;mevap = Mass of water evaporated, kg;F = Mass of fuel burned, kg;Te = Temperature of boiling water, K;Ti = Initial temperature of water in pot, K;H1 = Latent heat of vaporization of water at 373 K, kcal/kgCV = Net calorific value of fuel, kcal/kg;The cooking test can also be done by taking known amount of fuel and measuring the time required to cook known amount of food. The quantity of food, time required, specific consumption of fuel is calculated. The emissions coming out from the stoves are calculated by using various methods and equipment's. Exhaust gas analyzer is commonly used [1][4]. The figure shows a graph of CO2 concentration in ppm v/s time for a traditional three-stone stove and a smokeless stove. It basically compares the variation in concentration of CO2 with time for both stoves. For three-stone stove, the concentration of carbon dioxide increases considerably as time passes, whereas, for smokeless stove, the concentration remains almost constant throughout, indicating that the improved smokeless stove has caused a reduction of Carbon dioxide emissions, thus, making it highly efficient and environment friendly.Graph of CO2 v/s time for Three-stone and Smokeless stove.

Suggestions•

The strength can be increase to improve the stove design. While choosing material of construction, the 1st priority should be given to insulating material.•Standardization of the construction of cook stove and durable material should be taken into account. For supplementary air supply in the case of forced draft (fan/blower) air distributor can be used for the equivalent mixing of oxygen with fuel.•Usage of perforated plate at the top stove surface can provide heat transfer by conduction and convection.•Provision for prevention of smoke escape is the subject to study that should be taken into account. Technique for recirculation of unburnt gases so that they can be burnt again for maximum efficiency is the key of smokeless design.•In the case of natural draft Small holes (mesh 3-8mm) at the combustion chamber can be provided for the air inlet.

Conclusion

Improved biomass stoves have tremendous potential for addressing cooking energy needs in rural areas. It has been found that, the tests conducted for determining the efficiency of these cook stoves are under controlled environment but, in actual practice, various parameters such as temperature, wind direction, rainfall, composition and moisture content of feedstock, humidity must be considered. The major role has been played by the test centers not only in performance testing but also in discovering the areas for research for the improvement in cookstove design

So, it is the present need to consider these parameters for the improvisation of cook stove with significant reduction in CO2 and one will not compromise with its harmful effect on human being.Acknowledgment The authors are thankful to Dr. N.S. Kolhe for his valuable guidance throughout and also to Dr. Aarti Barik for her constant help. We also would like to express our gratitude to the organizers of NEWAGE-2018 for providing us the opportunity to publish this

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