

ABSTRACT

Cooking is one of the essential and energy intensive activities performed using cook stove. Cook stove uses thermal energy of fuel combustion for cooking operation and has long history of evolution. Solid fueled cook stoves are predominant and expected to remain as popular device for large chunk of population in near future despite of certain limitations. There have been efforts to improve the solid fueled cook stove through research and development, policies and programs evidenced from available literature. However, lower level of efficiency and limited functionality of the existing biomass fueled cook stoves are important issues for the biomass stove users. This has motivated to carry out the present research work aiming to develop a multifunctional improved biomass fueled cook stove. The specific objectives of this research are (i) to identify biomass cook stove parameters for improvement of performance using heat transfer analysis, (ii) to develop a multifunctional biomass cook stove with waste heat recovery capability, and (iii) to investigate prospect of technological transfer of the multifunctional biomass cook stove comparing its performance with existing commercial stoves.

The precise knowledge of thermal energy balance in terms of delineated network of heat transfer within the stove has been used to identify the factors for improvement of thermal efficiency the stove. The detailed heat transfer analysis of a typical biomass cook stove have been done which resulted 22 thermal energy components in terms of design and operational parameters of seven systems (surrounding, pot, stove, fuel, fuel bed, flame and load) where igniting fuel bed, flame and hot flue gas act as sources of heat. Integration of these heat transfer components is also used to predict performance parameters (*viz.*, ignition front velocity, burn rate, power delivery, efficiency and time to boil) of a commercial cook stove (Harsha stove) and also to confirm the predictability. Acceptable predictions of *time to boil* and *thermal efficiency* are observed while comparing the reported experimental results of the Harsha stove operated under identical conditions.

The above heat transfer analysis enable to identify two aspects *viz.*, (i) uncontrolled air supply and lack of provision of air pre-heating resulting imperfect combustion and

subsequent thermal energy loss and (ii) excessive loss of recoverable thermal energy for consideration of improvement of the stove. A multifunctional biomass fuelled stove is conceptualized based on the knowledge of heat transfer analysis and aspects related to user's preference such as portability, durability, multi-functionality and stability. Finally, the design parameters of a typical 4.5 kW biomass cook stoves have been worked out based on heat transfer analysis corresponding to operating conditions. The distinguishing features of the new design are (i) waste heat recovery using heat exchanger assembly, (ii) regulated air supply using auxiliary power source and (iii) provision of additional power outlets for cooking, baking, drying and space heating as per users need. The incorporation of new design features enabled to improve the thermal performance of stove substantially. The flexible design also enables to use the stove for two cooking options i.e. single pot and multiple pots cooking. The stove is fabricated and tested using standard test protocols. The performance results accessed computationally are compared with the experimental results for both the options i.e. single pot options (BIS) and multiple pot options (WBT). The stove was found better performance with multiple pots (44.77%) compared to single pot (38.63%). Recovery of about 25.31 % of output power from waste heat for useful purpose has been possible.

The popularity of wood burning stove to cater cooking needs of large sections of rural population along with some semi-urban population is visualized. Therefore, the current research is further extended to analyze the prospect of technology transfer of the multifunctional stove for typical Indian rural and semi-urban situations. Economic analysis aimed to judge the acceptance, sustainability and profitability of the multifunctional biomass fuelled stove as a commercialized product. Comparison of the cost of using this stove with competing technologies has been one part of this procedure. The prospect of entrepreneurship development based on potential production of this new technology is also assessed based on prevailing economic parameters and realistic assumptions. Fuel price and annual use are two important variable parameters deciding the cost of use of multifunctional biomass fuelled stove. Provision of cooking, baking, drying and space heating are features to attract customers for this newly developed 4.5 kW Multifunctional Biomass Fueled Stove. From the analysis it is revealed that a small scale standard

manufacturing facility would be adequate for mass production as a profitable economic venture.

The outcomes of the present research has been the development of multifunctional biomass fuelled cook stove which is expected to bridge the technological gap (improving thermal efficiency and improved user-convenience) as well as to create new business avenues. The research could not cover the details of emission tests and field testing also remains limited, and therefore, these two aspects are suggested as future works.