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"A REVIEW ON DESIGN AND THERMAL ANALYSIS OF IMPROVED WOOD STOVE"

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ABSTRACT

The development of wood-burning stove is not a recent development, several improvement works have been done on the stove design. Apart from the economic and environmental considerations, the other main issue which motivates the various developmental efforts of the wood stove is the health factor.

The design, construction and testing of an improved wood stove is undertaken in this work. The design improvement of the stove focused on the following areas: provision of insulation around the combustion chamber to reduce conduction heat loss across the walls of the chamber, incorporation of smoke rings at the top of the stove, provision of sizable and adjustable air inlet to ensure the availability of sufficient air for the complete combustion of the fuel wood, and the incorporation of chimney to convey flue gases away from the place of use.

Keywords: Wood stove, air inlets, combustion chamber, smoke rings, insulation, thermal efficiency, chimney, smokiness, fuel consumption.

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1. INTRODUCTION

Several sources indicate that wood is the most widely used domestic fuel. Hall et al. (1982) reported that about half of the world's population cooks with biomass fuel for all or some of their meals. The dependence on fuel wood by the rural dwellers of most developing countries including Nigeria is estimated at about 100%, while the annual consumption of fuel wood in Nigerian is estimated at about 70 million cubic meters. FAO has estimated that about two million people around the world use wood stove for their domestic cooking and for keeping their surroundings warm. The large preference for wood as fuel is predicated upon the fact that apart from wood and coal the other primary non-renewable sources of energy such as petroleum, natural gas and liquefied natural gas are no longer easy to come-by in terms of cost and availability. The lifetime for these other alternatives is estimated to range from 15 years for natural gas to nearly 300 years for coal (Yawas 2003). The demand for fuel wood will, therefore, continue to increase in response to the cost and availability factors stated above. This will in turn also continue to elicit innovations and improvements in the design of wood-burning stoves.

2. LITERATURE SURVEY

Calculation Methods for the Heat Release Rate of Materials of Unknown Composition by Hubert Biteau, Thomas Steinaus.This paper focuses on the heat release rate (HRR) of materials. The Heat Release Rate (HRR) is a critical parameter to characterise a fire. Different methods have been developed to estimate it. The most widespread techniques are based on mass balance. If the heat of combustion of the fuel is known, the measure of the mass loss allows its evaluation. If the burning material cannot be identified, calorimetric principles can be used. They rely on

oxygen consumption (OC) or carbon dioxide and carbon monoxide generation (CDG) measurements. Their asset comes from the observation that the amount of energy release per unit mass of O2 consumed or per unit mass of CO2 produced is relatively constant for a large number of materials. Thus, an accurate HRR can be obtained without knowing the composition of the burning fuel. The aim of this work is to assess this last statement and define how essential the knowledge of the chemistry to calculate HRR for complex materials such as polymers including fire retardants and/or nanocomposites, energetic materials or pine needles is. This assessment ends in an OC and CDG calorimetry comparison of several materials in order to investigate the propensity to determine whether converging or diverging HRR results when average energy constants are used.

Performance enhancement of cook stove" by NandishGayad, P. G. Tewari. This paper focuses on the various parameters related to the performance enhancement of cook stove. Use of improved, smokeless and energy-efficient cooking stoves still remains a distant dream. One of the oldest and technologically most simple cooking methods ever developed by civilization continues with its perennially archaic status for billions of its users, mostly poor. Consequently, health and social impacts from cook stoves continue to adversely affect the underprivileged. Women and children are the most suffered section of the society due to their time lost in collecting the fuel as well as due to local and indoor pollution. The changing world scenario that includes rising population and drastic degradation of the ecosystems has renewed the demand for much needed transformation of technology of cooking stoves. The design, construction and testing of an improved wood stove is undertaken according to BIS testing of Chulha. The design improvement of the stove focused on the following areas: the design of the combustion chamber, provision of insulation around the combustion chamber to reduce conduction heat loss across the walls of the chamber, incorporation of ash box to remove the ash, provision of sizable and adjustable air inlet to ensure the availability of sufficient air for the complete combustion of the fuel wood. Results showed that the thermal efficiency of the stove is found to be 37.65% with fuel wood consumption of 1.73kg/hr which is more efficient than the existing models.

Comparative Study on Emissions from Traditional and Improved Biomass Cookstoves Used in India by HarshikaKumari, Avinash Chandra, S.C. Kaushik.Cooking is central to our lives. In developing countries, about 90% of rural households depend on the solid biomass fuels for cooking. Unprocessed solid biomass fuels are used by the poor urban and rural folk for cooking and heating. Approximately 67% of households in India (equivalent to 166 million households) remain wedded to solid fuels as their primary source of cooking fuel. The traditional cookstoves used for cooking are not energy efficient and the fuels are not burnt completely, thus resulting in release of complex mixture of health damaging indoor air pollutants like carbon monoxide and nitrogen oxide. This paper estimates and compares the extent to which the pollutants like carbon monoxide and nitrogen oxides are generated when biomass fuels is burnt in traditional cookstove (U-shaped) as compared to improved cookstove (Priyagini) which is commonly used in northern India. The thermal efficiency of the cookstoves and characteristics of biomass fuels were also established.

Development of Energy Efficient Cooking Systems for Rural Masses by Arvindkumar, Er. K.P. Mishra.This paper presents the design principles to develop energy efficient cook stove model for rural masses and to improve the stove efficiency up to 40%. The application of design principles of Dr. Larry Winiarki, the efficiency test results indicates that the modified cook stove performed better in combustion of wood and heat output. The rate of fuel saving from the modified cook stove was quite significant in comparison with the Priyagni and Harsha Stove of NPIC on average saved 30% of fuel wood per day. This was with the improvement in the combustion efficiency and the expenditure can be reduced by about 34 %.This is possible because of the application of design principles. This research paper brings out the minimization of thermal energy losses to get cooking efficiency of cook stoves up to 30-35% and flame temperature measurement under various combustion conditions. Reduction of heat losses by allowing the gases remain in contact with cooking vessel for more time in the insulated chamber of the combustion chamber.

Smokeless Cook stove an Advancement of the Combustion Technology and Innovative Approach towards Eco-Efficiency and Low Emissions in Rural Areas by Manoj Kumar Sharma, R.N. Shrivastava, Nikita Sharma. In rural India many women spending several hours a day cooking over an indoor open stove is a normal practice. What these women fail to realize is that there is an invisible killer in their kitchen of burning biomass fuels causes almost 500,000 deaths every year in India alone. A design initiative can use its design expertise to help these women continue with their traditional culture, while empowering them to select a way of cooking that does not endanger their lives. It describes the brief and the open-innovation process used in creating the 'Chulha' (Stove) – a low-

smoke stove that prevents sickness and death from indoor air pollution due to cooking activities with biomass fuels in rural low-income communities. Evaluation included a certification of stove's thermal performance, fuel consumption and carbon monoxide emissions. Stoves under testing used bio-organic waste. The firewood used as fuel was free from any potential pollutants. The design brief challenged team has to come up with a low-smoke solution for healthy and safe cooking able to fit the local socio-cultural and infrastructural conditions of rural and semi-urban areas. More specifically, objectives were to design, develop and test a solution, which able to reduce indoor pollution and therefore health-related diseases with respect to local culinary habits and cooking behaviors. With the advancement of the combustion technology and innovative approach towards applying the known principle of cook stove designing. The cook stove technology has gain the boost and now fourfold improvement in the overall thermal efficiency as compare to the traditional tri-stone cook stove. Apart from the type and quality of the fuel used, design of the cook stove chamber is the deciding factor for the associated emission causing by the fuel combustion. . TIDE has put up an effort to train more entrepreneurs. But finding the right candidate for training is a limiting factor to overcome.

Review on Development and Performance Evaluation of Rice Husk Cook-Stoveby Ganesh L. Karemore, S.P. Chincholkar.In many rural contexts of the developing world, agriculture residues and the organic fraction of waste are often burned in open-air to clear or just to dispose them. This is a common practice which generates uncontrolled emissions, while wasting a potential energy resource. In such context household energy supply is a further critical issue. Modern liquid fuel use is limited and traditional solid fuels (mainly wood) are used for daily cooking in rudimentary devices like 3-stone fires, resulting in low efficiency fuel use, huge health impacts, increasing exploitation stress for the local natural resources. Rice husk may be an alternative fuel to wood for household energy supply. In order to recover such a biomass. In an attempt to provide solution to the environmental pollution resulting from in discriminate dumping of by-product of rice mill. The machine can be employed to reduce environmental pollution by enhancing the process of burning of rice husk.

Development of Energy Efficient Cooking Systems For Rural Masses by Arvindkumar, Er. K.P. Mishra In this experimental research study three different designed improved cooking stoves, Priyagni, Harsha and proposed modification of Modified multifuel cook stove developed on the basis of application of DrWiniarski design principles and tested in fuel laboratory and compared in terms of efficiency and emission. The main focus was on the new modified stove design, which is so far a prototype. This stove, which can be locally produced with local materials, consists of an insulated combustion chamber with the comparative energetic analysis based on the experimental observation using different biomass(cow dung, babul wood and mango wood) available at the time of experiment, The merits and demerits of each cook stove model have evaluated experimentally and it is found that each model has expected the efficiency and other parameters of the modified multi-fuel cook stove is in the range of 30-35 % better than from the Priyagni and Harsha cook stove models and the thermal efficiency has been increased by the convective heat transfer co- efficient by forcing the flue gases to flew through the enclosure skirt between pot bottom and pot surrounding and heat transfer increased through preheating the secondary air. The India National Programme on Improved Chulas (NPIC) was only concerned about government design specification and did not respond to need for rural people. There is no option but to look for efficient improved cook stoves on the basis of application of Dr Larry Winiarski design principles during design and development of cook stoves. This paper presents the design principles to develop energy efficient cook stove model for rural masses and to improve the stove efficiency up to 40%. The application of design principles of Dr. Larry Winiarki, the efficiency test results indicates that the modified cook stove performed better in combustion of wood and heat output. The rate of fuel saving from the modified cook stove was quite significant in comparison with the Priyagni and Harsha Stove of NPIC on average saved 30% of fuel wood per day. This was with the improvement in the combustion efficiency and the expenditure can be reduced by about 34 %.This is possible because of the application of design principles. This research paper brings out the minimization of thermal energy losses to get cooking efficiency of cook stoves up to 30-35% and flame temperature measurement under various combustion conditions. Reduction of heat losses by allowing the gases remain in contact with cooking vessel for more time in the insulated chamber of the combustion chamber.

Performance Evaluation and Heat transfer studies on Biomass Gasifier cook-stove" by Kalyani A. Motghare ,Ajit P. Rathod, S. S. Waghmare, K.L.Wasewar. Emissions from solid fuel combustion to indoor, regional and global air emission inventory largely depend on fuel types, combustion devices and other factors. The use of biomass cook stove is widespread in the domestic sector of developing countries, but these stoves are not efficient and generate high amount of air emissions. Approximately half of the world population and up to 90% of

rural households in developing countries still rely on biomass fuels and use conventional three stone chulha to prepare their meals. Due to improper design of combustion zone and low thermal efficiency, it emits gaseous pollutants like CO, particulate matter, etc. In the present work, detailed experimental heat transfer studies have been conducted on commercial gasifier cook-stove and different designs of conventional stoves (chulha). Modifications in the existing designs of combustion chamber of commercial gasifier stove were also proposed to enhance the stove indicator parameters. From performance test results, it was found that gasifier cook-stove shows higher heat transfer efficiency and effective power delivery. This indicates a better performance when compared to the average thermal efficiency value of traditional stove. A complete energy balance for both the cook stoves has been worked out to assess the causes of heat losses and the reasons for the observed reduced thermal efficiencies. Heat transfer experimental results reveal that energy losses due to flue gasses, losses due to thermal inertia and heat losses due to radiation was fond to be lower for gasifier cook stoves when compared with conventional stove . We found that by optimizing thermal inertia of the stove and opening width of the combustion chamber (updraft type), which reduces radiation losses through fuel opening in case of gasifier cook stove, results in improvement of thermal efficiency by around 6-8 %. From emission test results, we inferred that average in-house PM and CO emissions were lower than that of conventional cook stove. It is therefore, necessary to design and develop techno-economically feasible biomass gasifier cook-stove and improving the energy efficiency of biomass clean burning cook stoves, which potentially offers a highly cost-effective alternative for easing the burden of buying fuel by urban poor as well as rural population.

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