Iomass Gasification Technique in Cooking:A Review

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Abstract— **Biomass is the biggest source of energy in rural areas in India. The utilization of biomass in the domestic level has low efficiency level of about 10-15% and resulting in wastage of bio resources and significant indoor air pollution which is injurious to health. Traditional cook stoves, predominantly used in the households for domestic cooking, have been a major contributor to greenhouse gas emission. Certain programs have been implemented in the developing world attempt to address these problems by improving the cook stove using gasification technique. Biomass gasification appears to have a significant potential in India for domestic cooking applications. A good number of gasification based cook stoves have been developed and demonstrated which are more effective, efficient and smoke free than traditional stoves. These systems are based on two broad approaches, i.e., gasifier-stoves and central gas production with producer gas supply network. The current paper is aiming to summarize the recent work done in the area of gasification technique used in cooking.**

Keywords-Biomass, Gasification Technique, Cooking

I. INTRODUCTION

India is developing country and heavily depends on biomass to meet households' energy demand like cooking. Fuelwood accounts for a major fraction of total biomass used as fuel in cooking application. Fuelwood is generally used as a fuel because of its higher energy density and convenience in use as well as in transportation. Ample amount of biomass residues are available in India. These include rice husk, wheat straw, rice straw, coconut shell and husk, and many other agricultural wastes. The residues are normally difficult to use particularly for household applications due to their uneven characteristics. Biomass is a renewable source of energy, its inefficient use in household cooking tends in wastage, air pollution and health problems. Excessive use of fuelwood only leads to pressure of regional forest cover. Although large quantities of biomass residues are available in India, because of certain difficulties experience in using them in the existing cooking stoves, their use has been restricted. The unavailability of suitable cost-effective and efficient technologies for utilization of biomass residues for household cooking has resulted in underutilization and neglect of biomass as a surplus energy source.

The development in the field of cooking using the gasification technology is required for proper utilization of biomass residues. In past few decades many research and development has been done to improve the quality and efficiency of biomass cooking stoves but still it is not enough to utilize by a common person living in rural region.

II. BIOMASS AS AN ENERGY SOURCE FOR COOKING IN INDIA

Domestic cooking accounts for the major share of the total biomass use for energy in India. More than two-third of the entire population of India lives in rural areas with one-fourth of the same lying below the poverty line. 84.5% of India's 160.9 million rural households and 23.8% of 57.8 million urban households use solid biofuel as primary fuel in traditional mud stoves to meet their cooking needs [1]. Availability of the quality basic services for the rural population is yet to reach the desired level. Rural India still relies on inefficient, smoke-emitting chulhas (stoves) causing negative health impacts and drudgery among women and children. In spite of economic development, traditional solid biofuel such as wood, agricultural waste, and dried animal dung cake has traditionally been used in rural areas as cooking fuel, particularly by the poor. Biomass is still widely used for meeting cooking and space conditioning needs though per capita usage of cooking bio-fuels has declined [2].

TABLE I. PAST AND EXPECTED FUTURE ENERGY CONSUMPTION IN HOUSEHOLDS.[3]

Source	**Consumption 2003-2004 MTOE %**	**Projections 2031-2032 MTOE (%)**
Fuelwood	92.57 (57.82)	106.39 (37.44)
Agro Waste	17.12 (10.69)	-
Dung cake	22.62 (14.13)	40.17 (14.24)
Biogas	0.71 (0.44)	-
Kerosene	10.69 (6.88)	15.12 (5.32)
Electricity	7.72 (4.82)	69.72 (24.53)
LPG	8.68 (5.42)	52.49 (18.47)
Total	160.11	284.19

A. *Biomass Gasification technique*

Gasification is the process of converting solid fuels, such as agricultural waste, wood and coal, into a combustible gas. A biomass gasifier has a reactor or chamber into which biomass is fed and a limited (less than stoichiometric) air is supplied. Heat for gasification is produced through partial combustion of the feed material. This results in chemical degradation of fuel material into producer gas. The heating value of this gas is in the range of 4-6 MJ/m^3 at normal temperature and pressure or about 10-15 % of the heating value of natural gas. Producer gas consists of combustible gases like hydrogen (H_2) carbon monoxide (CO), and methane

(CH_4) and the incombustible gases carbon dioxide (CO_2) and nitrogen (N_2). In small size gasifiers, solid biomass is gasified in a fixed bed which can be of three types namely updraft, downdraft, and cross-draft reactor.

Downdraft gasifier operating vehicles and trucks were widely used in the Second World War. During operation, air is drawn down through the fuel bed; In this case, gas contains relatively less tar compared to other types of gasifiers. In Updraft gasifier, the air passes from below up through the stack of fuel. Because of increasing cost of fossil fuel and gas the biomass gasifier are attracting renewed interest. The possibilities of biomass gasification technology for cooking applications are leading to a number of initiatives have been taken to demonstrate the potential benefits of introducing them in developing countries. Cooking stoves can save on fuel costs in developing countries, the widespread use of the gasifier, and more self-sufficient rural communities to improve the reliability of the fuel supply and improve indoor air quality. Gasifier based cooking have some very attractive features like high-efficiency, clean combustion, smoke-free, uniform and stable flame, ease of flame control, and focus-free operation is possible over an extended period. In the kitchen, making them an attractive alternative to the developing world, there is a limit to their broad adoption, which are cost and technology constraints.

III. Biomass Gasifiers For Cooking Application

Gasification system for cooking application can be classified in to two basic types:

1) Gasifier stoves and,

2) Central gas production system with network of delivery pipe for cooking.

The compact gasifier gas burners devices i.e. gasifier stove have been tried since last two decades for cooking application. A number of biomass gasifier based cook stoves are already in oeration in developing countries such as India and China. In many countries, the government support in the form of subsidies on expenditure is also provided [4].

The biomass gasification based cook stoves are fuel efficient and apart from that they are also emission efficient as compare to traditional cook stoves. The traditional cook stove emits more than 10% of their carbon as products of incomplete combustion and having significant amount of tar due to its low efficiency. About 100-180 g of carbon monoxide and 7.7 g of particulate matter are also emitted per kg of wood. In addition, the gases like methane, N_2O are also emitted and these emissions are even higher for loose biomass or cow dung.

Some of the cook stoves based on combustion of gas produced from biomass developed are tabulated in Table 2. The capacity of these stoves ranges from 3kW to 20kW, making them suitable for domestic as well as community cooking applications [5].

Table II. Natural Draft Gasifier Stove Developed World Wide For Cooking Application [5]

Sl. No.	Name of Stove	Developed by
1	Wood -Gas Cook Stove	Thomas Reed and Ron Larson
2	Charcoal Making wood Gas Cooking Stove	Elsen Karstan
3	San San rice husk Gasifier stove	U Tin Win
4	Briquette gasifying stove	Richard Stanley and Kobus Venter
5	IISc Gasifier Stove	Indian Institue of Science
6	Natural draft cross flow stove models IGS2, DGS2 and CS3 San San rice husk Gasifier stove	Asian Institute of Technology, Thailand

Reed and Larson wood-gas cook stove use small wood chips and sticks for the operation, and produce very low CO emissions, and is therefore suitable for indoor cooking. Gasifier gas production rate can be controlled by controlling the primary air supply. Gasifier produces charcoal as a by-product [6]. Furthermore they have modified their natural draft based gasifier into a forced draft stove [7].

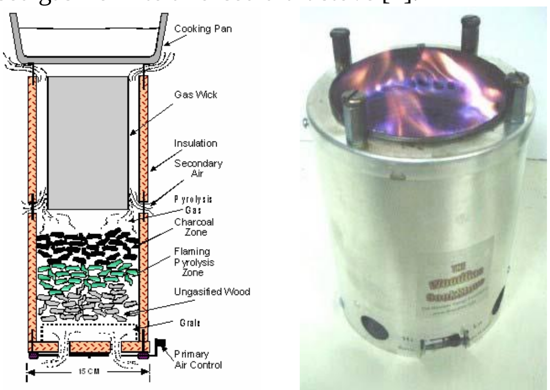

Figure 1. Reed and Larson's Wood-Gas Cook Stove.

Figure 2 shows the Elsen Karstad's Charcoal Making Wood Gas Cooking Stove. It is a simple stove developed for the East African households [8].

Stanley and Venter developed the Holey Briquette Gasifier Stove which operates using a single biomass briquette with a central hole placed in the middle of gasification chamber. The stove gives about 35% efficiency at 1.1kW power. Figure 3 illustrated the schematic of the Stanley and Venter's gasifier stove [9].

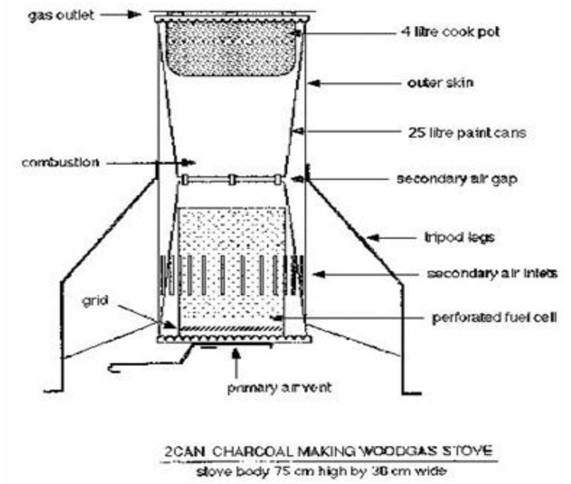

Figure 2. Elsen Karstad's Charcoal Making Wood-Gas Cook Stove

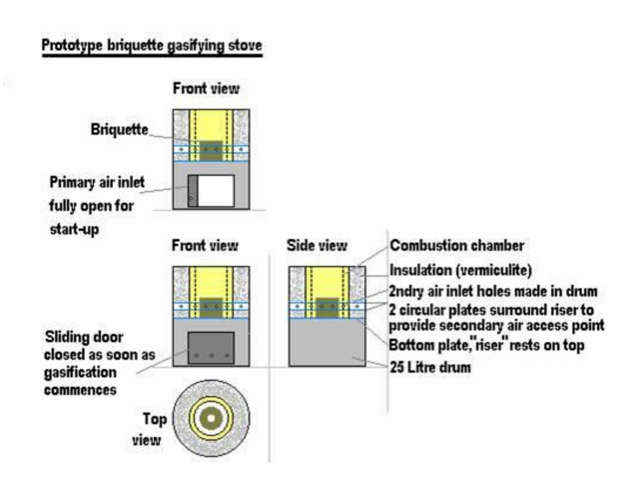

Figure 3. Holey Briquette Gasifier Stove developed by Stanley and Venter

A number of portable wood and biomass stoves have been designed constructed in the last decade at Indian Institute of Science. Fuel in the form of fuelwood, small sticks, saw dust and other well and pulverisable agro residues have been used. The purpose of such program to design cook stove of capacity ranging from 3-50kW.

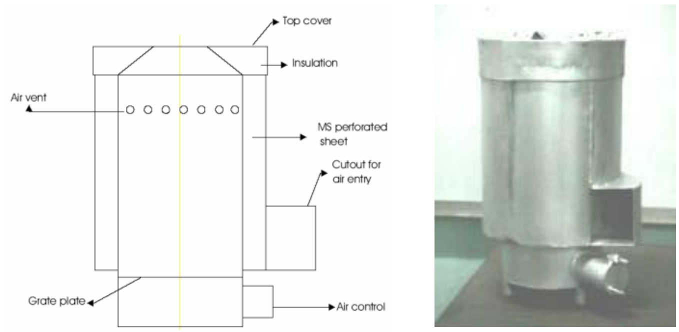

Figure 4. Gasifier Stove manufactured at IISc.

The IISc Gasifier Stove provides efficiency of 25-35%, the stove can operate continuously for about 2 hours for a single fuel loading. Emission from the stove has been found to be low [10].

The San San Rice husk Gasifier Stove developed in Myanmar offers smokeless combustion of the biomass fuel. It uses rice husk as a fuel, in an efficient manner. kitchen wastes such as potato peels, green leaves and fresh biomass, chopped into half inch pieces can be with the rice husk to improve the gasification process[11].

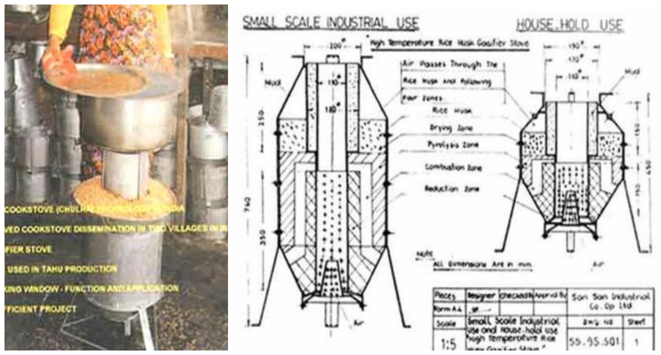

Figure 5. San San rice husk gasifier stove developed in Myanmar

The three models of gasifier stoves developed at AIT which are Institutional Gasifier Stove (IGS2), Domestic Gasifier Stove (DGS20 and Commercial Gasifier Stove (CGS3) using wood chips, wood twigs, coconut shells, rice husk and sawdust briquettes as fuel and they operate on cross draft gasification system. Efficiency of these stoves is in the range of 22-31%, depending on the type of stove and fuel used. Combustion of fuel is clean and steady [12, 13].

Figure 6. Gasifier Stove developed at AIT, IGS2 (left) and CGS3 (right)

Gasification based cooking stove have been developed by Miguel M. Uamusse, Kenneth M. Persson and Alberto J. Tsamba in Mozambique. Cashew Nut Shell has been used as a fuel for stove. The combustion was clean and smokeless. It has a a thermal efficiency of 35.5% and an energy output of 2.19 kW [14].

The centrally operated gasifier which supplies cooking gas to a community through supply lines has also been tasted. Figure 7 shows the schematic of such a system. More than 400 systems are in operation in china [15].

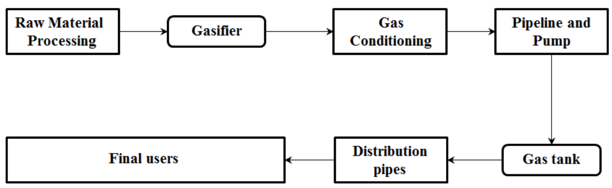

Figure 7. Schematic of a centrally operated gasifier

In Henan Province of china such gasifier system have been installed which provides cooking gas for more than 100 homes with satisfactory operation [16]. The fluidized bed technology base gasifier has been built by ISU Institute for physical

Figure 7. The Fluidized Bed Gasifier generating producer gas, developed in China

Research and technology, peanut shell has been used to produce producer gas. An up draft type gasifier developed in China which uses agricultural residues as a fuel and produces 1400 MJ/h, the system is able to provide 800 m3 of gas fuel to ninety families by a gas delivery system [17].

IV. CONCLUDING REMARKS

Biomass is a major source of energy for cooking applications in India. Large quantities of biomass residues are available in India. A development in gasifier technology for cooking applications in recent years gives an opportunity by utilizing this surplus biomass efficiently and with less emission. Lots of biomass gasifier based cook stoves have been developed both for household cooking and community cooking and been successfully demonstrated.

For better utilization of gasification in cooking, the technology requires some more efforts since there are some technical and social aspects which are still to be taken care. The cost is another aspect such as raw material processing, distribution systems, gas conditioning. Involvement of the private sector can play a vital role in adoption of such systems. It can be expected that the convenience, efficiency and safety advantages offered by gasifier stoves will help their rapid adoption in rural households across India in near future.

REFERENCES

[1] National Sample Survey (NSS), 2008. NSS 63rd Round Household Consumer Expenditure in India, 2006-07. Report No. 527 (63/1.0/1); Ministry of Statistics and Programme Implementation, Government of India, New Delhi.

[2] N.H. Ravindranath, P. Balachandra, “Sustainable bioenergy for India: Technical, economic and policy analysis”, Energy 34 (2009) 1003–1013.

[3] Bioenergy in India. Prepared for International Institute for Environment and Development (IIED) by The Energy and Resources Institute (TERI) Darbari Seth Block, IHC Complex, Lodhi Road New Delhi - 110 003, India October, 2010.

[4] IEA, 2003. IEA Bioenergy Agreement. Task 33: Thermal Gasification of Biomass; Technology Brief: Fixed Bed Gasification.

[5] S. C. Bhattacharya and M. Augustus Leon, “Prospects for biomass gasifiers for cooking applications in asia”, Energy Field of Study, Asian Institute of Technology.

[6] Reed. T.B., and Larson, Ronal, 1996. A Wood-Gas Stove for Developing Countries. The Biomass Energy Foundation, Golden, CO., USA. Conference on "Developments in Thermochemical Biomass Conversion", Banff, Canada, 20-24 May 1996.

[7] Reed. T.B., Anselmo. E., and Kircher. K., 2000. Testing and Modelling the Wood-Gas Turbo Stove. Presented at the Progresss in Thermochemical Biomass Conversion Conference, Sept. 17- 22, 2000, Tyrol, Austria.

[8] Karstad, Elsen., 1997. Elsen Karstad's Charcoal Making Wood Gas Cooking Stove (Sept 97). http://stoves.bioenergylists.org/stovesdoc/Karstad/ELK.htm.

[9] Stanley, Richard., and Venter, Kobus., 2003. Holey Briquette Gasifier Stove Development. Aug. 2003.

[10] IPOBIS.,. “Portable Wood/Biomass Stoves”. Combustion, Gasification and Propulsion Laboratory, Indian Institute of Science, Bangalore. Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS), 3 (3): 513-516, 2004.

[11] SSIC, 2005. SAN SAN INDUSTRIAL Cooperative., Ltd., Myanmar. http://www.benergyssic.com/sansanrice.htm.

[12] Bhattacharya. S.C., and Augustus Leon, M., 2001. “A Biomass-fired Gasifier Stove (IGS-2) for Institutional Cooking”, GLOW, A monthly journal published by the Asia Regional Cookstove Program (ARECOP), Yogyakarta, Indonesia, May 2001.

[13] Bhattacharya, S.C., Augustus Leon, M., and Aung Mit Khaing. “Design and Performance of a Natural Draft Gasifier Stove for Institutional and Industrial Applications.” International Seminar on Appropriate Technology for Fuel Production from Biomass, Yogyakarta, Indonesia,1-3 Oct 2003.

[14] Miguel M. Uamusse, Kenneth M. Persson, Alberto J. Tsamba,” Gasification of cashew nut shell using gasifier stovein Mozambique” Journal of Power and Energy Engineering, 2, 11-18, 2014.

[15] Yong-zhi, Ren., “Biomass Gasification for Gas Supplying System”. Liaoning Institute of Energy Resources, China.,2005.

[16] Young, Bing Lin., and Brown, Robert., 2001. Application of Biomass Thermal Gasification Technology in Henan, China —Collaboration between Iowa State University and Henan Province. ECO-INFORMA: Environmental Risks & the Global Community: Strategies for Meeting the Challenges. Argonne National Laboratory, Illinois, USA. 14-18 May 2001.

[17] Zhenhong, Y., Wu, C.Z., Huang, H., Lin, G.F., 2001. Research and Development on Biomass Energy in China. Int. J. Energy Technology and Policy. Vol. 1, Nos. 1, 2; 2002.