

Smart Methods for Cooking -A Step Towards Smart City

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Abstract— Since nearly three billion people in the world use traditional stoves to cook their meals. Cooking gadgets based on renewable aims to save cooking time (increasing efficiency), as well as, to create a smokeless environment in the kitchen and/or reduce the volume of smoke emission. A brief about solar cooker, biogas plant, portable type improved cook stove and heat pipe based hybrid cooking system is introduced in this paper to create awareness regarding renewable energy based cooking.

Key words: Smart Methods for Cooking, Box Type Solar Cookers, Improved Cook Stoves

I. INTRODUCTION

Nearly 50% of the world's Population cooks on open fires, and the task of gathering fuel wood falls almost entirely on women and children. Assuming that one family needs at least 3 kg fuel wood a day, it is not uncommon for those who live in regions with particularly sparse vegetation to spend more than 90 hours a month collecting fuel wood buying it can cost 40% of the family income; Sometimes, it costs as much as the food to be cooked [1, 5]. Even in the 21st century, nearly 50% of the worlds, population cooks on open fire, and the actual fuel consumption is seldom reflected in statistics because the source of that energy is fuel wood, other biomass, or cow dung.

Burning of firewood or cow dung cakes through direct combustion creates smoke which consisting particulate matter (PM), carbon monoxide, nitrogen oxide, sulfur oxide, polyaromatic and other hydrocarbons and various organic substances [6]. These pollutants are contributing to serious health problems as shown in Table.1, particularly cancer and respiratory infections. Approximately half a million premature deaths and nearly 500 million cases of illness are estimated to occur annually as a result of exposure to smoke emissions from biomass use by households in India, making indoor pollution the third leading health risk factor [7]. So it is imperative that traditional and inefficient chulhas are replaced by more fuel efficient device with a view to conserve fuel wood, to improve health and hygienic conditions, reduce drudgery for women and children and to improve overall quality of life [8].

Pressure cooking by high temperatures and high pressure steam can complete cooking in a quarter of the time compare to ordinary boiling. In addition, because of a much higher heat capacity, steam and liquids transfer heat more rapidly than dry air. Increasing the deployment of Renewable Energy systems requires their integration into the existing systems. Hybrid technology can contribute to significant reduction of fossil fuel consumption and reduce carbon emission [11]. Fabian Korn [4] said that the Heat pipes are one of the most effective procedures to transport thermal energy from one point to another. It is based on a combination of conduction and convective heat transfer, what makes it to a complex heat transfer problem.

This article is objected to deliver those super-efficient renewable cooking mechanism that ultimately reduces burden on nature.

II. SOLAR COOKER

As solar cooker is a thermal device converts solar radiation into thermal energy. This is achieved using a black metallic surface (absorber) enclosed in an air tight box and covered by insulating materials from sides other than that exposed to sunlight. This side can be covered with glazing surfaces. Some of these devices are discussed here.

A. Box Type Solar Cookers

Box type solar cookers are capable of cooking different types of food including rice, vegetables, chicken, fish, and for steaming, roasting, boiling etc. It works as an airtight box with double glass covers. A reflector is placed over it for boosting the solar radiation and thus its temperature increases. Because of its simplicity and ease of handling, the box type solar cooker has found wider acceptance especially in rural areas.

Pollutants	Associated health effects
Carbon monoxide (CO)	Binds to hemoglobin thereby interfering with transportation of oxygen Causes headache, Nausea and Dizziness Leads to low weight at birth Results in increase in perinatal deaths
Particulate matter	Causes irritation and oxidative stress producing lung and airway inflammation, hyper-responsiveness, and in the long run, exposures to airway remodeling and emphysema.

	Causes reduced mucociliary clearance and macrophage response Is carcinogenic
Nitrogen oxide (NO ₂)	Causes irritation, affecting the mucosa of eyes, nose, throat, and respiratory tract Increases susceptibility to infections because of increased bronchial reactivity, longer-term exposure
Sulphur dioxide (SO ₂)	Causes irritation, affecting the mucosa of eyes, nose, throat, and respiratory tract
Lower molecular weight PAHs (1,3 butadiene, benzene, styrene, and formaldehyde)	Is carcinogenic

Table 1: Health effects of pollutants produced by incomplete combustion of solid fuels

B. Dish Type Solar Cookers

Dish solar cooker is a concentration type parabolic dish cooker with aperture diameter of 1.4 m and focal length 0.28 m. The reflecting material used for fabrication of this cooker is anodized aluminium sheet which has a reflectivity of over 75 per cent. The tracking of the cooker is manual and thus has to be adjusted in 15 to 20 minutes during cooking time. It has a delivering power of about 0.6 kW which can boil 2 to 3 L of water in half an hour.

C. Root benefits of Solar Cooker

Solar cooker helps to improve livelihood of the rural poor and simultaneously conserve the natural environment (e.g. forests) and reduce emission of carbon dioxide. If 3% of Indians cook with solar energy, they would save 3.2 million tons of wood and reduce carbon dioxide - emission by 6.7 million tons. Thus solar cooking can contribute immensely not only to stopping deforestation but also to improving the lives of people and protecting the environment.



(a) Box type solar cooker



(b) Dish type solar cooker

D. Biogas Technology

Biogas is produced by decomposition of organic matter i.e. cattle dung, agriculture waste, kitchen waste etc. in the absence of air. Biogas mainly consisting 55-65 percent methane (CH₄), 35- 40 percent carbon dioxide (CO₂). It is almost 20 percent lighter than air. Biogas cannot be converted into liquid like liquefied petroleum gas (LPG) under normal temperature and pressure. The liquid slurry coming from digester is rich in nitrogen which is an essential nutrient for plant growth.

The anaerobic digestion (decomposition of organic matter in the absence of oxygen) process is a low carbon generating technology for efficient management of waste and sanitation. Biogas is, thus, a clean gaseous fuel for cooking, heating, generating electricity and also for motive power & operating vehicles. Biogas is an easy and healthy cooking fuel since methane emissions from untreated cattle dung and biomass wastes can also be avoided. Since there is no pollution from biogas plants, these are one of the most potent tools for mitigating climatic change and being earth saviours. There are two designs of biogas plant popular in India:

E. Floating Drum Type Design

In this design the digester is an underground tank constructed in brick masonry, stone masonry, RCC or ferrocement. An inverted metallic drum is placed over the tank which acts as gas holder. The gas is liberated at a constant pressure from gas holder that depends on the weight of gas holder. The merits of this design are:

F. Fixed Dome Type Design

This is dome shaped underground construction design. The masonry gas holder is an integral part of the digester called dome. The gas produced in the digester is collected in dome at variable pressure by displacement of slurry to inlet and outlet.

G. Root benefits of Biogas Plant

Upto December, 2015 with the cumulative total installation of about 48.7 lakh family type biogas plants about 39.58 % of the estimated potential has been harnessed. During the 12th Plan period, about 3.22 lakh plants have been set up. The average estimated biogas generation capacity of these biogas plants is about 6.46 lakh cubic meters per day. These biogas plants are giving an estimated annual savings of about 70.90 lakh numbers of LPG cylinders equivalent and simultaneously producing about 88.4 lakh tonnes of organic enriched bio-manure per year, which is equivalent to about 31,100 tonnes of Urea per annum.



Deenbandhu Biogas Plant



Biogas application for cooking

III. IMPROVED COOK STOVES

Biomass cook stove is basically a combustion device which burns biomass fuel more efficiently with reduced emissions and offers cleaner cooking energy solutions. Biomass Cook stoves are of two types; fixed type and portable type. The portable cook stoves are also of two types; natural draft and forced draft. Advanced cook stoves utilizing fans are more efficient cook stoves compared to natural draft ones. Each type of cook stove can be used for domestic as well as community cooking applications. The improved cook-stoves may be made with metal, ceramic and terracotta/pottery (durable type) and combination thereof. With this, the stoves will be categorized as metallic (MS, SS, cast iron and combination thereof), metal clad ceramic/ pottery and ceramic types.

Improved chulhas have a high thermal efficiency in the range of 20–35 per cent as compared to 8–12 per cent of traditional chulhas. Improved chulhas consume lesser fuel and emit less smoke, apart from reducing the drudgery of women and save cooking time. Besides, portable metallic cook stoves with thermal efficiency of 30–35 per cent were also developed. High-altitude multi-purpose chulhas which could be simultaneously used for cooking, water and space heating in hilly areas were promoted.

A. Root benefits of Improved Cookstoves

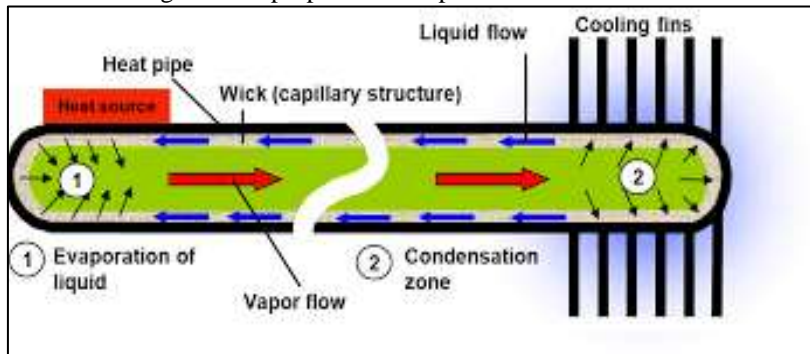
Thus a traditional cook stove consumes 2000-2500 kg of wood per annum for an average family while an improved cook stove consumes 800-1000 kg. This means half the consumption compared to a traditional stove. If a lower average figure of 1000 kg of wood (valued at Rs. 2000) is taken as saving per annum, the average cost of Rs. 1500 for an improved cook stove could be recovered in just one and half year.



Operational view of improved cook stove

B. Hybrid cooking system :

Hybrid system can be used which combines the benefits of ETC based solar water heater, solar heat pipe manifold, solar photovoltaic system to harness the solar energy and a biogas as a auxiliary system, to fulfil the demand of high pressure steam/hot water requirement for cooking or other purposes in the process industries.



Heat pipe diffuse solar radiation efficiently in the minimum possible time as a result Hybrid system gives more thermal energy in minimum possible time as compare to simple system. Integrated system will be used for the following purposes.

- High temperature & Pressure Steam requirement for cooking purpose.
- High temperature & pressure Steam requirement for the process work in the industries.
- In the integrated system use of Heat pipes manifolds system will minimize carbon emissions to the environment.

IV. CONCLUSION

According to the 2011 India census, 62.5 per cent of rural households use firewood as the primary fuel for cooking, 12.3 per cent use crop residue as the primary cooking fuel, and 10.9 per cent use cattle dung. On the whole, about 66 per cent of India’s total population used traditional biomass for cooking purposes IN 2011 (IEA). Box type solar cooker is the most cost effective device. Dish type solar cooker is customized device, it can provide as per demand of customers. Farmers having 5-6 cattle can easily operate a biogas plant. Initial cost for installing biogas plant is quite high comparing to solar cooker and improved cook stove. A comparison between four technologies is concluded.

Parameters	Box type Solar Cooker	1 cum Biogas Plant	Portable natural draft Improved Cook Stove	Hybrid with heat pipe (community cooking)
Input	Solar radiation	Cattle dung	Firewood	Solar radiation
By product	NIL	Digested Slurry	Ash	NIL
Cost (Rs.)	3500	9500*	2500	2 lacs
Life (years)	5	20	5	25
Pay back period	13-14 months	13 -14 months	17-18 months	20-24 month
Reduction in CO ₂ emission per annum	38.4 million tons	9.7 tons	161 kg	Undergoing experiment
Limitations	Can't work in cloudy days Chapaties couldn't be prepared as it requires manipulation.	Daily feeding of cattle dung is needed. Production rate decreases in high winters.	Small pieces of firewood are required. There is no provision to stop fire instantly in improved portable cook stove	Circulation pump is required in heat pipe system. To maintain required temperature

Table 2: Comparison between Renewable based cooking technology

*Cost after deducting subsidy as provided by Govt. of India for family size biogas plant.

Also Hybrid heat pipe based system emerged as the most significant and cost-effective technology owing to their excellent heat transfer capabilities, high efficiency and structure simplicity.

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