© 2017 IJSRSET | Volume 3 | Issue 1 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

A Review on Energy Efficient Solar Cooker with Phase Change Materials

Anju B*[1], Sankaran Nampoothiri K[2]
[*1] UG Student, Department of EEE, Sree Buddha College of Engineering, Pathanamthiita, Kerala, India
[2] Assistant Professor & HOD, Department of EEE, Sree Buddha College of Engineering, Pathanamthitta, Kerala, India

ABSTRACT

This paper examines the effectiveness of solar cookers in day to day life. Energy is the basic requirement of mankind all across the world. In developing countries like India, energy requirement for cooking is 36% of the primary energy consumption. The fuel used by the population of India in rural or urban area is leading to deforestation and continuously polluting the environment. The fumes emitted by the burning of these fuels causes health problems such as burns, eye disorders and lung disorders. So there is a need of an alternative method for cooking is very urgent for the developing country like India. Solar energy is the most promising energy source among all the clean energy technologies, which is available to us, in abundant and at free of cost. It is possible to use the solar energy heat for cooking process. So the need for thermal storage in solar cookers is important.

Keywords- Solar cooker, LPG, Thermal Energy, PCM, Autogas, biomass, Reneable Energy

I. INTRODUCTION

In many regions of the world, the primary source of energy is derived from biomass. This biomass can take the form of wood (either foraged or directly harvested), animal wastes, crop residue, or other similarly burnable materials. In India, 70% of population is living in rural areas and more than 80% of this population is dependent on firewood, dung-cake and agricultural waste for fulfilling energy requirements. While in urban area, people are dependent on firewood, LPG, Kerosene oil and electricity. In rural areas, the dung-cake, firewood, agricultural waste are available at free of cost but it requires a lot of effort in gathering these fuels and in urban areas the fuel is available at high cost.

The energy content of these fuels varies but they all share in common their relatively low caloric content, necessitating large usage volumes for a relatively small amount of delivered energy. Also in common, each represents a significant threat to environment and human health if overused. So, need of an alternative method is required which overcomes the problem of pollution and is also economical. Assume that there are 1.5 million operating solar cookers, globally, and that each one cooks an average of 1 meal per day for 3 people. This results in an emissions reduction of approximately 690 million kilograms (equivalent) of CO_2 per year.

II. METHODS AND MATERIAL

Literature Review

Cooking is an activity that must be carried out almost on a daily basis for the life. Cooking is divided into four major categories based on the heat required for each stage. They are backing (85- 90^0C), boiling (100- 130^0 C), frying (200-250^0 C) and roasting (<300^0 C).The use of solar energy to cook food presents a viable alternative to the use of fire wood, kerosene, and LPG traditionally used in developing countries for the purpose of preparing food .LPG is quite commonly used in urban areas of developing countries and is becoming increasingly common in rural areas.

A. LPG Usage as a Cooking Fuel

Liquefied petroleum gas or liquid petroleum gas (LPG or LP gas), also referred to as simply propane or butane, are flammable mixtures of hydrocarbon gases used as fuel in heating appliances, cooking equipment, and vehicles. It is increasingly used as an aerosol propellant and a refrigerant, replacing chlorofluorocarbons in an effort to reduce damage

to the ozone layer. When specifically used as a vehicle fuel it is often referred to as autogas.

In India alone since 1985 the petroleum industry reports that over 100 million households have switched from other cooking sources to LPG. Today even close to 40% of rural household are using LPG mostly for quick heating such as water boiling, and this amounts to about 30 million households. Not only is LPG subsidized in India, but it has become more widely available over the years. India has had an aggressive LPG promotion campaign for years and just recently announced that there will be a program to provide free stoves to households below the poverty line. The subsidies no doubt are expensive for the government and as the program continues to expand one can question whether such subsidies are justifiable given the ready acceptance of LPG by the mostly high and middle income consumers. Commercially available LPG is currently derived mainly from fossil fuels. Burning LPG releases carbon dioxide, a greenhouse gas. The reaction also produces some carbon monoxide. It emits 81% of the CO_2 per kWh produced by oil, 70% of that of coal, and less than 50% of that emitted by coal-generated electricity distributed via the grid.[citation needed] Being a mix of propane and butane, LPG emits less carbon per joule than butane but more carbon per joule than propane.

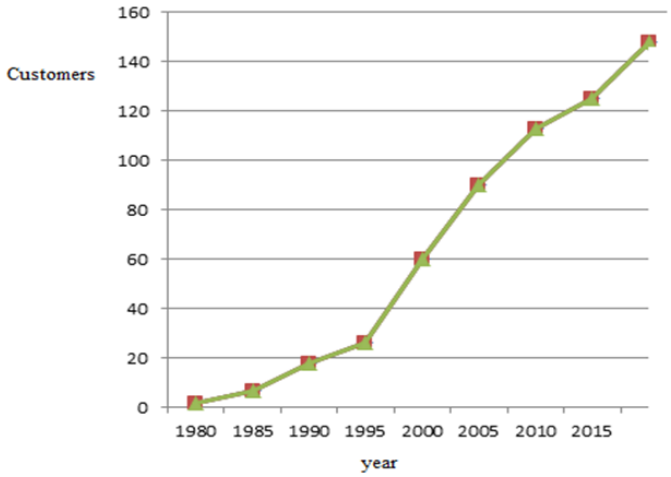

Figure 1. LPG usage in India

In a refinery or gas plant, LPG must be stored in pressure vessels. These containers are either cylindrical and horizontal or spherical. Typically, these vessels are designed and manufactured according to some code. In the United States, this code is governed by the American Society of Mechanical Engineers (ASME).LPG containers have pressure relief valves, such that when subjected to exterior heating sources, they will vent LPGs to the atmosphere or a flare stack. If a tank is subjected to a fire of sufficient duration and intensity, it can undergo a boiling liquid expanding vapor explosion (BLEVE). This is typically a concern for large refineries and petrochemical plants that maintain very large containers. In general, tanks are designed that the product will vent faster than pressure can build to dangerous levels. While the problem is more serious for birds it exists for people, too.

A study commissioned by the Air Resources Board of California showed that gas ovens generate unhealthy levels of combustion byproducts like carbon monoxide and nitrogen dioxide. (It also showed that the self-cleaning mode generated a lot of indoor air pollution, whether it was a gas or an electric oven.) If we do use gas, the Children's Health Environmental Coalition has a list of ways to reduce gas pollution in our home.

B. Electricity as Cooking Fuel

Here electricity is introduced for cooking purposes. But the cost of energy is high. And most of the cooking usages are at the peak hours. This will be causes large electricity bill and energy reduction. Safety is an important consideration when cooking especially with children around, it need more care.

Now days the stoves available with more safety features such as the burner will automatically switch off when pan take from it, and in most cases you can touch the burner seconds afterwards without burning yourself. This safety feature is also great when you are cooking. With traditional electric or gas hobs it's impossible to avoid food being baked on to the surface. Not only can that cleaning be easier.

C. Off Sun Shine Solar Cooking

The solar cooking is the simplest, safest, clean, environment friendly, and most convenient way to cook food without consuming fuels or heating up the kitchen. A major concern of today is the rapidly depleting natural resources. So it is the urgent need of time to reduce the dependency on non-renewable sources, judiciously using the remaining sources and at the same time switching to new and better alternatives and renewable source of energy.

In most parts of India, solar energy is available almost throughout the year and can be used as alternate input to meet out energy needs. Solar energy is the cheapest, inexhaustible and can be used for various domestic and agricultural requirements including cooking, drying, dehydration, heating, cooling and solar power generation. Solar cookers are helpful in cooking at day time when sun is shining. Off-Sunshine/Evening or night cooking is not possible with them. This is the main limitation of solar cookers. So it can be reduced by the usage of storage materials in cookers.

Energy storage materials are mainly of two types depending on the way it stores energy. These are:

a) Sensible/Specific heat storage materials

b) Latent heat storage materials/phase change materials (PCMs).

Table 1. Cost of electricity in various electric cookers

	Temperature (degrees F)	Time	Energy Used	Cost
Electric oven	350°	1 hr.	2.0 kWh	24¢
Gas oven, electric ignition	350°	1 hr.	0.112 therm +0.35 kWh	18¢
Electric oven, convection	325°	45 min.	1.39 kWh	17¢
Gas oven, pilot (but costs more over a year, since the pilot is always on)	350°	1 hr.	0.112 therm	14¢
Crockpot	200°	7 hours	0.70 kWh	8¢
Toaster oven	350°	1 hr.	0.33 kWh	4¢
Microwave oven	High	15 min.	0.36 kWh	4¢

Materials which stores energy in the form of specific heat are called specific heat storage materials. Initially researchers used these materials for storage of solar energy. The most probable specific heat storage materials used are sand, used engine oil, mineral oil, water, pebbles etc. This technique of storing solar energy in the form of thermal energy by specific heat storage material is not popular because the amount of energy stored by these materials is dependent on specific heat, temperature change and mass of the storage material. Large mass of material is required for storing solar energy if material has low specific heat; which makes the system bulkier. In addition, energy storage by these materials is also not able to cook the food efficiently and requires large time for cooking. So this technique is dropped and another alternate will be investigated.

PC materials have advantage over the specific heat storage materials because they require small mass for storing large amount of energy. So these materials are helpful in making energy storage system compact. PCMs can be defined as the material, which change their phase by absorbing energy and regaining its initial state by releasing energy. The phase transition can be from solid-liquid, liquid-gas, solid-gas and vice-versa depending upon the application. But for cooking purpose generally solid-liquid phase transition is preferred because in liquid-gas, solid-gas transition the difficulty of handling large volume and leakage comes in picture. These materials are becoming popular for storing energy because of their efficient action. There are different types of PCMs available for storing energy and researchers have used many of them. The important PCMs which were used by researchers to store energy are: Erythritol, acetanilide, commercial grade stearic acid, commercial grade acetamide, pentaerythritol etc.The most commonly used PCMs are salt hydrates, fatty acids and esters, and various paraffins (such as octadecane). Recently also ionic liquids were investigated as novel PCMs.

As most of the organic solutions are water-free, they can be exposed to air, but all salt based PCM solutions must be encapsulated to prevent water evaporation or uptake. Both types offer certain advantages and disadvantages and if they are correctly applied some of the disadvantages become an advantage for certain applications. They have been used since the late 19th century as a medium for the thermal storage applications. They have been used in such diverse applications as refrigerated transportation for rail and road applications and their physical properties are, therefore, well known.

Unlike the ice storage system, however, the PCM systems can be used with any conventional water chiller both for a new or alternatively retrofit application. The positive temperature phase change allows centrifugal and absorption chillers as well as the conventional reciprocating and screw chiller systems or even lower ambient conditions utilizing a cooling tower or dry cooler for charging the TES system. The temperature range offered by the PCM technology provides a new horizon for the building services and refrigeration engineers regarding medium and high temperature energy storage applications. The scope of this thermal energy application is wide ranging of solar heating, hot water, heating rejection, i.e. cooling tower and dry cooler circuitry thermal energy storage applications. Since PCMs transform between solid–liquid in thermal cycling, encapsulation naturally become the obvious storage choice.

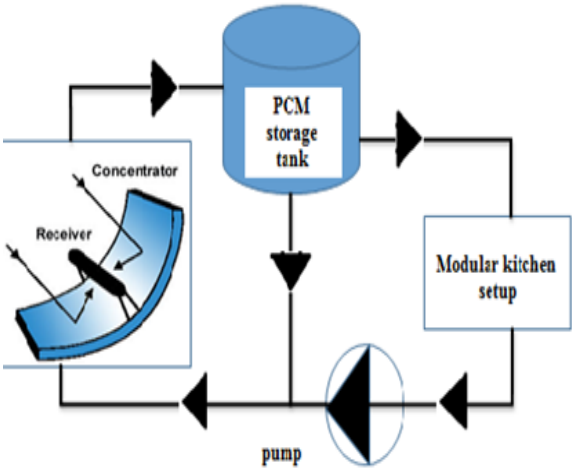

Figure 2. Schematic representation of solar cooking

The entire arrangement works by utilizing heat from the solar irradiation. The parabolic collector is reflects sun rays and converge it into a point. Where the vacuum tube packed with PCM is positioned. CU tubes are mounted inside the PCM. The water as a working substance is circulated inside the cu. It absorbs the heat extracted by the vacuum tube. Hot water is transferred to the cooker by insulated pipes. The small tank is sited next to the cooker for the condensation. A pump is used to drive the system fluid. A valve is used to adjust mass flow rate of water. It controls the cooking temperature.

Renewable energy resources will play an important role in the world's future. According to the global renewable energy scenario, proportion of the solar thermal applications will be about 480 million tons oil equivalent by 2040.

Average cost of solar cookers decreases day by day on the contrary their power output and efficiency considerably increases. In the upcoming future, widespread use of this technology is expected hopefully not only in developing countries but also throughout the world. In addition, the most challenging point of solar cookers, unavailable to use when sun goes away, is overcome with thermal energy storage techniques.

III. RESULTS AND DISCUSSION

- **Advantages**

  - Cooking is done at the night time also.
  - High-performance parabolic solar cookers can attain temperatures above 290 °C (550 °F).
  - They can be used to grill meats, stir-fry vegetables, make soup, bake bread, and boil water in minutes.
  - Solar cookers use no fuel. This saves cost as well as reducing environmental damage caused by fuel.

- **Disadvantages**

  - Cool the food due to convective losses.
  - And disturb the reflector. It may be necessary to anchor the reflector, such as with string and weighted objects like bricks.
  - Initial cost is high.
  - Large size.

IV. CONCLUSION

Thus the cooking process by using solar energy provides the cooking at evening time with enhanced heat supply. It reduce the fuel cost also environmental pollution and related health problems. And make the earth green. Briefly, it is anticipated that solar cooking technology will be demanded by a huge group of people in the near future because of its outstanding features. Lot of work has to be performed on solar cookers from research point of view for meeting demands of society. Some important work have to be done in future are listed below Research should be carried out for reducing the cost and increasing the efficiency of solar cooker. Work should be performed in designing more compact and efficient thermal storage unit Work should be carried out to minimize thermal losses in order to make solar cookers more efficient.

Solar cooker should be designed for low temperature hilly and isolated areas. High energy density PCMs should be developed for storage unit. Research should be carried out in developing highly efficient hybrid solar cooking unit so that it could cook food uninterruptedly during the complete diffusion of energy from the storage unit. These are the probable areas of interest on which work can be carried out in future for making the system more efficient, easy to handle, available at low cost and commercially viable for each and every household. In brief, the upcoming era is of renewable energy resources and solar energy is one of them.

V. REFERENCES

[1]. Chaudhary, A., Kumar, A. and Yadav, A. "Experimental investigation of a solar cooker based on parabolic dish collector with phase change thermal storage unit in Indian climatic conditions". J. Renew. Sustain. Energy.,2013.

[2]. Chen, C.R., Sharma, A., Tyagi, S.K. and Buddhi, D. "Numerical heat transfer studies of PCMs used in a box type solar cooker". Renew. Energy, 2008.

[3]. Domanski, R., El-Sebaii, A.A. and Jaworski, M. "Cooking during off-sunshine hours using PCM as storage media". Energy, 1995.

[4]. El-Sebaii, A.A., Al-Amir, S., Al-Marzouki, F.M., Faidah Adel, S., Al-Ghamdi, A.A. and Al-Heniti, S. "Fast thermal cycling of acetanilide and magnesium chloride hexa-hydrate for indoor solar cooking". Energy Convers. Managmnt,2009.

[5]. Foong, C.W., Nydal, O.J. and Lovesh, J. "Investigation of a small scale double-reflector solar concentrating system with high temperature heat storage". Appl. Thermal Energy. 31,2011.

[6]. Krishnan et al. "Residential Solar Cooker". International Journal of Scientific & Research Publication, 2012.