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Experimental Investigation of Solar Powered Cooking Stove

C.V. Papade

[1]Department of Mechanical Engineering. N. K. Orchid. College of Engg. & Tech. Solapur, Solapur University, Maharashtra (India)

ABSTRACT

Design and development of solar powered cooking stove" is about using solar energy for cooking purpose aiming commercialization of the product. As per the increase in the use of solar energy, these types of innovation may support enhancement of small scale businesses. The solar energy is available free of cost and lead us to save our non-renewable sources of energy which are getting vanished due to high demand. This problem is also seen in the cooking application, the currently used source of energy is LPG instead of that solar energy converted into electrical energy achieves the purpose. This research utilizes solar energy for conversion into electrical energy with the help of solar P-V panels. It is then stored into 72 Volts 42 Amh battery packs. This DC power is supplied to the metal coil, which gets heated and later forcefully convicted to the utensil by a blower. Temperature of the coil is varied with the help of regulator. The overall system consists of a solar panel, storage unit, temperature controller and heating coil with blower which is put into structure like a mini canteen. This energy used for a cooking place to make different snacks, hot drinks, etc. The results are such that, batteries get fully charged up to 72 Volts in 5 hours and it runs continuously for 3 hours. The maximum temperature range achieved is 160^0c -180^0c in less than 10 minutes, which is sufficient for all cooking types such as boiling, baking and frying. The coil gets cooled in short time making it safer to use. It completely replaces present stoves as it is convenient and efficient for commercial as well as home applications. It takes less time for cooking and it has low maintenance cost. This research cuts the cost required for such fuel consumption and uses solar energy which is available for free of cost. So the research gives varies cooking examples like bhaji, papad, eggs, curry and time required for various operation is less than induction by 40 %.

Keywords: Solar Energy, DC Coil, Polycrystalline Panel, Battery

1. INTRODUCTION

In today's period, energy is the crucial and most universal evaluate of all kinds of work by human beings and nature. Everything what happens in the world is the expression of flood of energy in one of its form. Energy is required as an input to all machines and that energy is extracted from conventional fuels and electric power. Cooking is an integral part of each and every human being as food is one of the basic necessities for living. An enormous amount of energy is thus expended regularly on cooking. Commonly used sources of energy for cooking are firewood, crop residue, cow dung, kerosene, electricity, liquefied petroleum gas (LPG), biogas etc[3]. Half of the world's population is exposed to indoor air pollution, mainly the result of burning solid fuels for cooking and heating. Wood cut for cooking purpose contributes to the 16 million hectares (above 4% of total area of India) of forest destroyed annually. The world health organization (WHO) reports that in 23 countries 10% of deaths are due to just two environmental risk factors: unsafe water, including poor sanitation and hygiene; and indoor air pollution due to solid fuel usage for cooking. In under-developed countries, women have to walk 2kms on average and spend significant amount of time for collecting the firewood for cooking. The cooking energy demand in rural areas of developing countries is largely met with bio-fuels such as fuel wood, charcoal, agricultural residues and dung cakes, whereas LPG or electricity is predominantly used in urban areas. Normally for cooking purpose LPG fuel is being used which costly and vanishing due to high demand day by day. With increasing fuel costs as well as their decreasing availability and also increase in the population rate in India makes use of solar energy necessary[11]. This research cuts the cost required for such fuel consumption and uses solar energy which is available for free of cost. If we consider one time investment, then this research has a lot of scope. The proposed system can open up the possibilities of saving significant proportion of fuel used for cooking for reducing of shortage of energy that we are facing in the current scenario in India. Also, mini canteen which works on solar energy is a best option for places where shortage of fuel is a problem like, hilly area, rural area, villages etc[5]. The currently used fuel for cooking is LPG (Liquified Petroleum Gas) which is getting high demand day by day. Also many of the people face on time cylinder delivery problems. Safety, which is a prime concern in any working system, is not fully achieved by LPG driven cooking stove. This research solves all of the above issues with use of solar energy which

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is abundantly available in India [6]. Also this cooking stove is designed along with a mini canteen structure which aims commercialization. The concept of "Design a-nd development of solar powered cooking stove" is about using solar energy for cooking purpose as per the increase in the use of solar energy, these types of research support enhancement of small scale businesses[2].

2. METHODOLOGY

Traditional covered pan method is considered for calculation of the amount of heat required to cooking for 4 people. In covered pan method 300gm of rice, 200gm dal, 400gm wheat and 200gm for curry is to be taken and then pour it in a covered pan containing approximately 1 liter of water. The system includes a covered pan which contains water and above ingredients. Constant heat is provided to the system to raise its temperature from 25^{O}C to 100^{O}C. When all ingredients are poured in water, it absorbs some amount of water and its weight is doubled at the end of the process. In the system around 30% by weight of left water evaporates at 100^{O}C [10].

I. Amount of rice, dal, wheat for chapatti and currey consumed by 4 people is 300gm, 200gm, 400gm, 200gm respectively and it requires nearly 1-1.5litre of water for cooking.

II. Time taken to reach 100^{O}C from 25^{O}C is 5 min and then it is boiled for 15 min at 100^{O}C.

III. The pan is provided heat at constant rate.

IV. Heat lost due to convection and radiation when the temperature of system is increasing from 25^{O}C to 100^{O}C is negligible.

V. Pan is considered to be a cylinder for calculation of area and volume.

VI. Height of Pan (h) = 19cm and Radius of Pan (r) = 12.5 cm.

3. SETUP OF SOLAR POWERED COOKING STOVE

The below block diagram shows line diagram of experiment setup . Various connections are also shown below. Batteries are charged with the help of solar panels. DC coil runs on the batteries. The block diagram is self-explanatory.

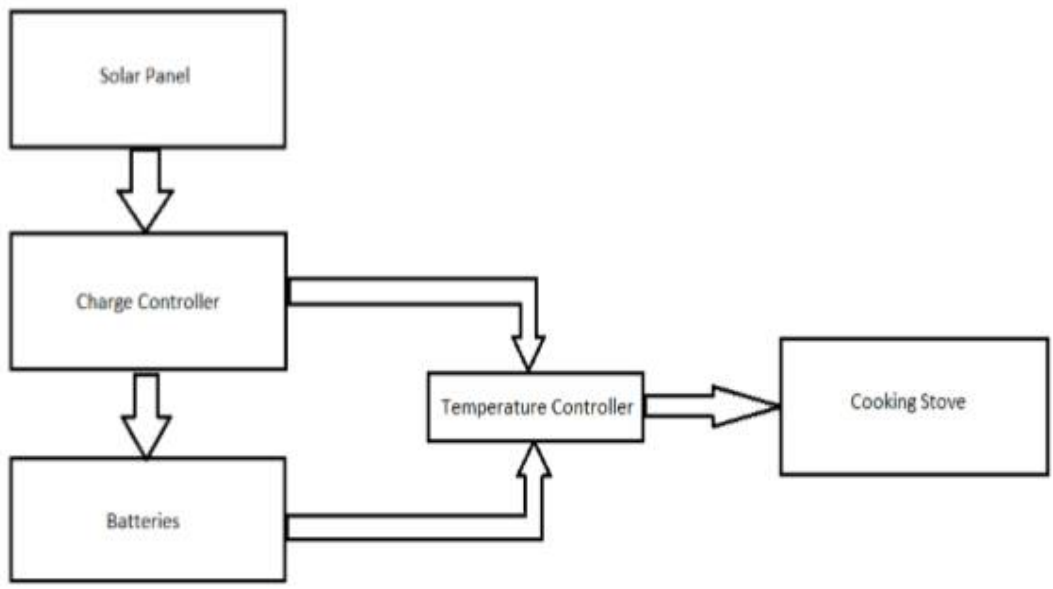

Figure 1. Block diagram of solar powered cooking stove

3.1 Structure

Structure is main part of our system. The entire components are mounted on the Structure. For selection of Structure material considered all load coming on system on different area by considering weight of human, battery, stove, solar panel. Hence according the calculation we selected 1-inch square M.S Pipe for structure.. On the top of structure solar panel is mounted and batteries are kept below. The thickness of MS pipe is 2mm.

In this experimental setup 2000 W DC coil is used for the cooking purpose. A DC coil is runs by solar energy as well as on battery power. Solar energy is natural resource available free of cost and in adequate quantity. A small stove type structure is made for the mounting of DC coil, on which cooking utensils are mounted. All parts like batteries, panels, charge controller are mounted on structure. Batteries are used for store energy in form of electrical and this energy used

for cooking the food. In this system, temperature controller is provided for the variation of temperature according to cooking operations. Solar panel also mounted on system.

3.2 Solar panel mounting

On structure we mounted 250 watt solar panel. For proper mounting we provide 8mm nut and bolt between panel and structure. To charge batteries in minimum time we created solar station at outside, which has capacity of 600 watt. Solar panel mounted at an angle of 18^0 to get more solar radiations according to latitude of our region[6].

3.3 Charge controller

A solar charge controller is fundamentally a voltage or current controller to charge the battery and keep electric cell from overcharging. It directs the voltage and current hailing from the solar panels setting off to the electric cell. Generally 12 V boards /panels put out in the ballpark of 16 to 20V, so if there is no regulation the electric cell will damage from overheating. Generally, electric storage device required around 14 to 14.5 V get completely charge. The ranger of charge controller are from 4.5A and up to 60 to 80 A. Generally solar power system utilizes 12V of batteries. Solar panels can convey much more voltage than is obliged to charge the battery. The charge voltage could be kept at a best level while the time needed to completely charge the electric storage devices is lessened. The charge controller can distinguish when no power is originating from solar panel and panels and open the circuit separating the solar panels. The solar charge controller can also control the reverse power flow[4,8]

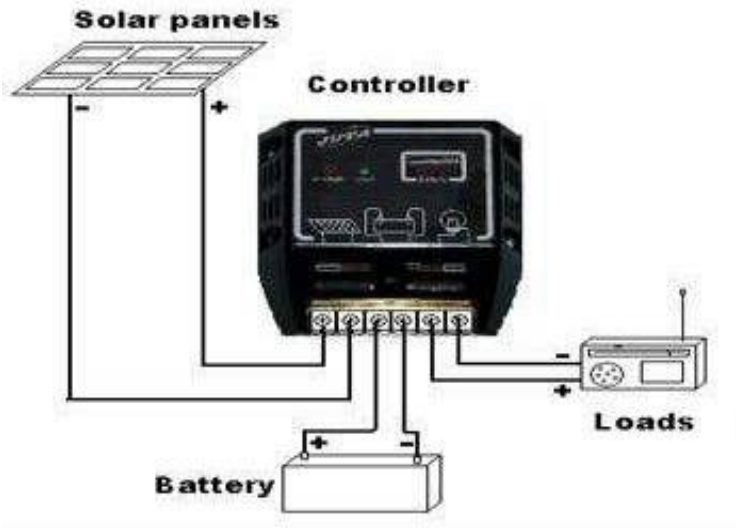

Figure 2. Charge controller

3.4 Solar charge station

In solar charge station we have provide solar panel for charge batteries. Because mounting all panels on vehicle is not possible. So we calculated solar panel wattage. According to calculation 433 W powers is required to charge batteries in 6 hrs. So we provide 130W, 20 V, four panels. These four panels are connected in series. We get total power 520 W and total voltage as 80V from panel. All panels are placed on ground at an angel having approximately 18o from ground for getting better solar radiation.

4. RESULT AND DISCUSSION

Setup is tested in different environmental conditions and compared observations. All the readings are taken during clear sunny day for getting good performance analysis. It is necessary for the purpose of evaluation of system parameters that the time mentioned isin hours and minutes.

4.1 Plain readings of solar charging

In this section only maximum charging achieved by the panels and the time for which charging of batteries is achieved. The Charging is varied due to the solar radiations.

TABLE 1 OBSERVATION OF CHARGING TIME

Sr. No.	Time	Final Voltage	Intensity (LUX * 100)
1	9:00	88V	-
2	9:30	88.5V	971
3	10:00	89.6V	1006
4	10:30	90.2V	1011
5	11:00	90.8V	1013
6	11:30	91.3V	1017
7	12:00	91.9V	1020
8	12:30	92.7V	1025
9	1:00	93.5V	1030
10	1:30	94.2V	1032
11	2:00	94.8V	1033
12	2:30	95.4V	1035
13	3:00	95.9V	1035
14	3:30	96.3V	1036

The initial temperature at 9:00am was 88Volts and solar intensity was 971 LUX*100. The maximum battery voltage of the day was 96.3Volts at 3:30pm. And the solar intensity was 1035 LUX*100. The charging was started in solar radiations at 9:00am and at that time, the voltage of batteries was 88V (Discharge Voltage). It increased gradually because of high intensity of solar radiations and it reached up to 96.3 at 3:30pm. The battery was charged at full voltage that is 96.3Volts further that we removed supply of solar panel from batteries and cooked food until 7 pm

4.2 Iteration on system with and without insulation

The DC coil which is 2000Watt, .To check its heat transfer with the help of practical demonstration and selection to insulate the system because the heat losses are more. There is following observations. The initial temperature at 10:00am was 320C and battery voltage is 96.1Volts . The maximum temperature achieved was 2250C and water temperature is 720C within 15min. without insulation and the achieved 300 0C and water temperature is 86 0C which is boiling temperature of water at Sholapur.

Table 2 Observations with coil temperature

Sr. No.	Time	Coil Temp.(^{0}c)	Voltage	Water Temp(^{0}C)
Without Insulation				
1	10:00	32	96.1V	30
2	10:05	80	96V	52
3	10:10	170	95.8V	63
4	10:15	225	95.7V	72
With Insulation				
Sr. No	**Time**	**Coil Temperature (^{0}c)**		**Water Temp(^{0}C)**
5	10:00	32		30
6	10:05	100		60
7	10:10	300		86

4.3 Cooking results with DC Coil

In this section cooking results of different food products are recorded. For this purpose three food products are selected i.e. rice, Eggs, potato, Papad, Pakoda (250 gm each). Temperature of oil is raised by using DC coil. Table 3 shows the

cooking results obtained by using DC coil without insulation. As per the observations recorded Eggs, rice, Pakoda, Papad and potato requires 20, 32 , 15 , 10 and 30 minutes respectively for cooking. Above table 4 shows the cooking results obtained by using DC coil with insulation. As per the observations recorded Eggs, rice ,Pakoda, Papad and potato requires 12, 16 , 10 , 2 and 17 minutes respectively for cooking.

Table 3 Cooking results with dc coil (without insulation)

Type of Food (250 Grams Each)	Initial Time	Final Time	Initial Temp. (Oil)	Final Temp. (Oil)	Total Time
Eggs	1:00	1:20	71	70	20
Potatoes	1:20	1:50	71	68	30
Pakoda	1:50	2:05	100	92	15
Papad	2:05	2:10	100	95	10
Rice	2:10	2:42	71	66	32

Table 4 Cooking results with insulation

Type of Food (500 Grams Each)	Initial Time	Final Time	Initial Temp. (Oil)	Final Temp. (Oil)	Total Time
Eggs	11:00	11:12	86	84	12
Potatoes	11:12	11:28	86	82	16
Pakoda	11:28	11:38	150	141	10
Papad	11:38	11:40	150	146	10
Rice	11:40	11:57	87	82	17

4.4 Complete cooking result

In this section, avg. cooking time for Induction cooking and DC powered coil is combined together. For this purpose Five food products are selected i.e. Eggs, Rice ,Pakoda, Papad and potato (250gm each). Table 5 shows the difference between the induction stove and without Insulation and with Insulation DC coil. The time required for the all are little bit different but the DC coil with insulation are having less time then all of above so insulated the system with pastor of paris(POP).

Table 5 combined cooking result

Type of Food	Without Insulation Cooking Time (Min.)	With Insulation Cooking Time (Min.)	Induction Stove Cooking Time (Min.)
Pakoda	15	10	20
Rice	32	17	30
Potato	30	16	30
Eggs	20	12	20
Papad	10	2	9

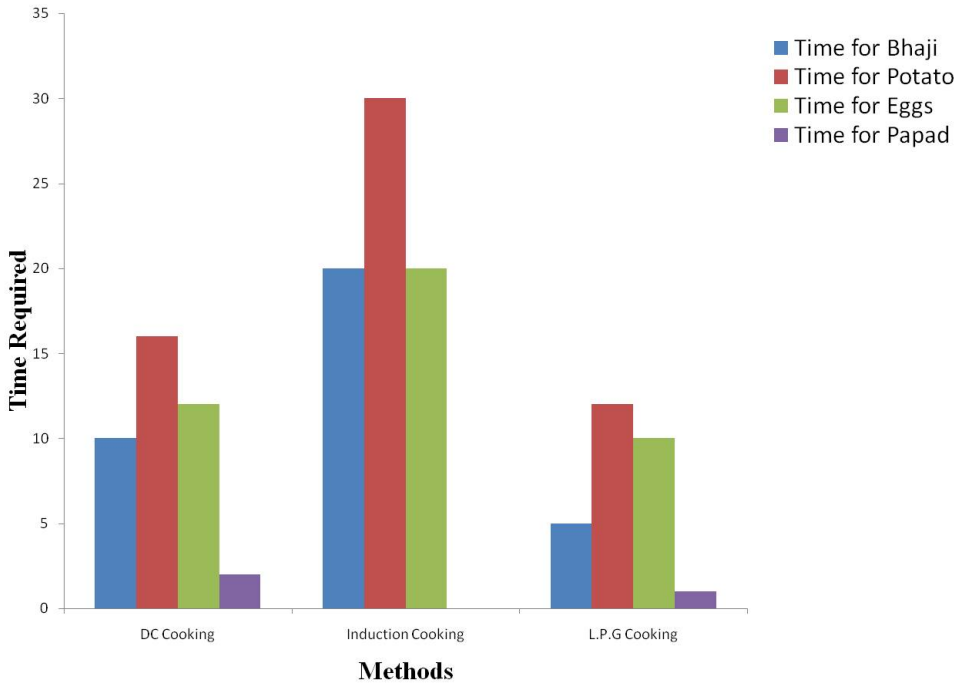

Figure 3. Cooking methods Vs Cooking Time

Above figure 3 shows results of cooking methods with cooking time .After analyzing all the observations conclusion is made that, this system successfully used for cooking during day time as well as in the evening. Performance of the system is directly based on intensity of the solar radiations available and efficiency of batteries. The concept of DC coil with insulation is efficient than the other induction stove available in market. Time required 40 % is less than induction cooking and 10 % more than LPG cooking

5. CONCLUTIONS

In this research, the design and fabrication of mini canteen is done. The attempt to change the existing design of food stall is successfully completed. This innovation is implemented with an idea to find an effective solution to current cooking problem. The main objective is to achieve the cost reduction and minimize the fuel consumption by using renewable energy sources for cooking. Charging time required for fully charging of batteries is about 6 hours on solar panels and the cook stove run for 3 hours continuously. Various types of cooking like boiling, frying, roasting etc. is done easily. The use of this cooking stove is same as conventional cooking stove that it do not have various buttons like the current induction cook tops are having. Use of solar energy as a power source which is freely avaible. The concept of DC coil with insulation is efficient than the other induction stove available in market. Time required 40 % is less than induction cooking and 10 % more than LPG cooking. The research involves cooking bhajji, papad , potato, eggs and time required for cooking the food is less then induction stove by 40 %.

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