International Journal of Innovations in Engineering and Technology (IJIET)
http://dx.doi.org/10.21172/ijiet.263.01

Minimum Time Cooking and Drying of Foods or Grains using Solar Energy

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ABSTRACT - In this work, the cooking or the drying processes are carried out on an induction stove, and microwave oven respectively. Here, it is discussed that for given amount of input energy - these two processes using these appliances - require the minimum time.
This paper also discusses efficient way of generation of electrical power from the Sun's rays.

KEYWORDS: Induction heating, Microwave heating of molecules having dipole moment, Solar energy cooking, Solar energy drying

I. INTRODUCTION

1a. DEFORESTATION

Deforestation can cause climate change which includes soil erosion, crop damage, flooding, and other greenhouse effects such as buildup of carbon dioxide in the atmosphere. The reason for deforestation is due to the need for greater agricultural land and raising of cattle.

1b. EFFECTS OF DEFORESTATION ON ENVIRONMENT

In addition to the loss of habitat, the lack of trees also allows a greater amount of greenhouse gases to be released into the atmosphere. Healthy forests absorb carbon dioxide from the atmosphere, acting as valuable carbon sinks. Deforested areas lose that ability and release more carbon.

In the absence of trees, the land heats up- sucks too much heat and higher temperature results due to the lack of shade. This directly affects the moisture content and the depletion of oxygen, or the water content in the atmosphere. This affects the pattern of rain. If the rain pattern is disturbed, then it directly affects the crop production. The failure of crops results in rising inflation.

The result of all this is that we frequently see cloud burst, forest fires, excessive flooding, and drought. We have witnessed all this in recent times [1-7].

Increased use of fossil fuel has resulted in excessive smog and carbon dioxide buildup in the atmosphere which is very unhealthy. If the buildup of carbon dioxide remains unchecked, then it will affect the countries which are on the tropics in a big way. This will cause increase in sea level and as a result – a lot of coastal areas and islands will submerge under the ocean.

This changing weather pattern has resulted in increased heat in the northern hemisphere such as European countries and North American countries. This also results in increased frequency and magnitude of thunderstorms.

One needs to shift away from the petroleum-based fuels to power our industries - to the use of renewable energy such as solar energy. The combustion of fossil fuel pollutes the atmosphere and causes various types of lung diseases and thereby it shortens the lifespan of people living in cities manly.

II. COOKING AND DRYING PROCESSES

This society has been using firewood, kerosene, and other cooking gases such as natural gas, propane, and liquified petroleum gas. The combustion of all these fuel's result in production of carbon dioxide and other harmful gases.

To replace these gases, one can also use electricity where electricity is generated by photovoltaic solar panels.

One has to remember that for a given solar panel of certain rated capacity the Sun's rays should fall from a perpendicular direction to the solar panel to generate maximum amount of electricity. If such a condition is not met, then only a fraction of the rated capacity of the input energy will be converted.

Figure 1 shows a solar cooker which is mounted on wheels and capable of rotations about horizontal and vertical axes. One can rotate the cooker about the vertical axis using the wheels. Thus, by rotating about two orthogonal axes, horizontal and vertical - one can orient the glass surface of the cooker such that the Sun's rays are incident on the glass surface from the perpendicular direction. This perpendicularity enables one to utilize the maximum amount of Sun's rays to heat the content of the cooking material. This is the most efficient way of heating the food to be cooked inside the cooker.

In current times, the population in large number of countries has moved from the rural areas to the urban areas. This has resulted into the inability of the society to use the solar energy since most of the people cannot utilize the Sun's energy because the buildings are closely spaced, and they don't have areas where they can place the cooker to receive the Sun's rays. This is the reason they are using fossil fuel instead of the solar energy.

Secondly, the intensity of the Sun's rays is not sufficient to carry out the cooking process as fast as that is possible using fossil fuels. In other words, the rate of input energy for cooking is quite high which is not possible to obtain from the Sun's rays. The cooking process due to low rate of heat supply by the Sun's rays - will be slow and will take long time for cooking. The storage of Suns thermal energy poses a difficult problem. In order to supply heat at a faster rate - one can use electricity either from the grid or stored in the battery whereby the energy can be supplied at a very high rate which is the requirement of a cooking process.

Figures 2A and 2B show a dryer. One can place wet grain such as wheat or rice inside the dryer and allow it to dry up during the day. This process, just like the cooking using solar cookers- is extremely slow. References 8 and 9 discuss the use of electricity in form of electromagnetic energy for cooking and drying. References [10 -12] discuss about drying of food using the solar thermal energy.

However, if one uses electricity then it is possible to carry out either cooking or drying processes quite rapidly. Figure 3 shows an induction stove. In the induction process the current is induced in the pot or the container thereby heating the container very efficiently and rapidly without many losses to the atmosphere. Instead of using induction stove, one can also use a resistor-based stove [8,9]. In this kind of stove - a significant amount of the energy is lost from the sides to the atmosphere or the surrounding. Thus, the induction stove can be used to cook food in minimum time due to its high transfer of input energy directly to the container or the pot.

The advantage of using the Sun's energy in electrical form is that one can heat the cooking pot at a high rate which is not possible as easily in case of directly using the Sun's rays.

Figures 7 and 8 show other types of arrangements of using the Sun's rays for cooking. In Figure 7, the sunrays are incident on the paraboloidal mirror and are reflected on to a pressure cooker. The paraboloid concentrates Sun's rays thereby heating is more rapid than what is possible in Figure1. One can improve the situation, if one uses solar oven shown in Figure 8. If the pressure cooker is placed inside this over whose one side is made of glass to receive the concentrated rays reflected from the paraboloidal mirror. This arrangement is thermally more efficient than the pressure cooker being placed in open atmosphere where the pressure cooker loses part of its heat from the surface to the atmosphere. Figure 9 shows a stove having resistor elements.

Figure 3 shows a pot containing lentil being cooked on an induction stove. This figure also shows various knobs to control the amount of heat. Figure 4 shows the cooked lentil which is called Toor or Arhar in India.

Just like the lentil, one can cook rice, and vegetable also. In the experiment, the rice cooked was of Basmati variety, and the vegetable was a combination of potato and cauliflower.

Figure 5 shows a photovoltaic panel mounted on a tracking mechanism. In this mechanism, the panel is rotated at a spin rate of 15° per hour from the starting position at the sunrise to sunset. The orientation is adjusted such that the

Sun's rays are always incident on the photovoltaic panel from the perpendicular direction. This way the conversion efficiency is 100% which means whatever amount of energy that is incident on the photo voltaic panel is converted 100% into electricity depending on the efficiency of the material of the solar panel which is normally about 16%. To clarify this matter, if the incident energy is 1000 Watts per square meter, then this photovoltaic panel of 1m square will convert 160 Watts provided the Sun's rays are incident from the perpendicular direction on this panel. On the other hand, if this panel remains fixed to the earth, then under this condition the conversion will be 61% of the 160 Watts which is equal to 97.6 Watts.

Figure 6 shows large number of solar panels which are held stationary with respect to the ground. In such cases only 61% of the rated capacity of these panels will result in electrical conversion.

Reference 14 describes the 61 percent conversion limit for similar panels due to their stationarity condition.

Reference 15 describes the details of mounting solar panels on a solar tracking system whereby the conversion efficiency meets the maximum condition i.e. In this paper this solar panel is held such that the Sun's rays are perpendicular on the panel all the time with minimum energy requirement for rotation by the motor.

Reference 16 describes how to control the motion described in reference 15 using wireless technology. In this paper the photovoltaic panels mounted on many tracking systems can be controlled from one central location. As an example, all the solar panels shown in Figure 6 can be mounted on number of solar tracking systems and all these tracking systems can be controlled for motion from a centralized location using wireless technology.

This shows that it is very easy to generate maximum possible electrical energy using solar panels in countries such as India which has large amount of solar energy available, and it is cheaper than generating electricity by conversion of coal. It should be noted that the coal mines in India are located mostly in the eastern part and this coal is transported to various electrical power generating stations on trains or trucks all over India.

On the other hand, one can generate solar energy generated electricity to a grid whereby electricity is available throughout India without having to transport coal on trains or trucks. Electrical power generation using coal for countries like India is very uneconomical as compared to the electrical power generation using photovoltaic panels.

Rajan and Lamba [13] emphasize greater efficiency of processes or increase productivity in their book. If India has to compete in this modern era of free trade, then it has to generate electricity in most efficient manner otherwise it would be very hard for the Indian products to compete in the international market. Lack of efficiency in carrying out the processes result into high cost and thereby high unemployment which is being witnessed in the present-day India. It is highly important that the Indian production be as efficient as possible to compete in the international market.

III. EXPERIMENTATION- COOKING AND DRYING

Table 1 describes the details of the cooking process. The vegetable consisted of potato and cauliflower whose masses are given in row 2. It was cooked on high as well as low heat shown in rows 2 and 3. The two settings of the heating rate were controlled through the knobs of the induction stove. Various times taken in their respective processes are shown in in column 4 which was in seconds. The energy consumed is expressed in Kilowatt-Hr. The cost of this energy of one Kilowatt-Hr is equal to rupees 8 in India. Hence, the total cost is shown in the last column.

The details of the cooking of rice and the lentil are shown in the next two rows. These two could be cooked at the high heating rate. The last row shows the total cost which is Rs 15.77.

The cooking process on the induction stove is extremely efficient because the input energy is directly transferred to the container or the pot without any loss to the surroundings.

if any other method of cooking is used such as heating using gas or resistance heating, then only a fraction of the input energy is transferred to the container or the pot. This will result in slower cooking.

Table 2 shows the details of the drying process in the microwave oven. Here, the rice was placed on the plate first. At first, the plate was weighed, and then the rice was put on the plate to determine the weight of the two together.

The weights were measured in the same sequence as shown in Table 1. Then the rice was washed with water and placed on the plate and then mass was measured.

Afterwards, this plate containing the wet rice was put in the microwave oven and the time was set for four minutes to start with. The mass was measured every 30 seconds, or every half a minute and the readings were noted. The process was stopped when the complete water was dried out. The total drying time found was equal to 6.5 minutes or 390 seconds.

The reason for very fast drying Is that the water molecules have electrical di-pole moment in their structure. This di-pole moment responds to the electromagnetic field of the microwave oven and generates internal heat. Therefore, the electromagnetic field selectively generates heat within the water molecule and causes the water to change its state from liquid to vapor very rapidly.

In a nutshell, these two above processes require least amount of time for a given amount of input energy among all alternate processes used in cooking or drying.

IV. CONCLUSIONS

In this work, various processes for cooking or drying were discussed. These two processes are possible using different types of energy sources such as natural gas, propane, coal or firewood.

In the discussions above the harmful effects of combustion of these other sources on the environment was also discussed. These discussions brought out many harmful effects such as drought, cloudburst, flooding, rise of sea level, erosion of soil, buildup of carbon dioxide in the atmosphere thereby producing global warming etc.

Next, different methods of drying and cooking using the conventional approach was discussed through various experimental models shown in various figures.

The disadvantage in these cases was that either cooking or drying - took too much time if the sunlight was available to the people - hence not practical.

Considering these difficulties - the two processes selected in this research work using microwave oven for drying and induction stove for cooking were the best ways to achieve the objectives of drying or cooking.
The results obtained in the cooking was that this method is very economical and can be performed in a short time.

Similarly, the drying process using the microwave oven showed extremely good results.

V. ACKNOWLEDGEMENTS

The author is thankful to Veena Sharan and Rajat Sharan for their assistance in carrying out of this research.

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TABLE 1: COOKING DETAILS ON INDUCTION STOVE

Item	Mass (g)	Wattage Setting (Watt)	Time (Seconds)	Total K-Watts	Energy (KWHr)	Energy Cost Per KW-Hr Rs	Total Cost Rs
Potato-Cauliflower (Potato 237 g + Cauliflower 264g)	502	1,800	420	756.	0.2100	8	1.68
		467	951	444.117	0.1234	8	0.99
Total Potato-Cauliflower				1200.117	0.3334	8	2.67
Rice	500	1,800	1,208	2,174,400	0.6040	8	4.83
Lentil (Toor or Arhar Daal)	500	1,800	2,067	3,720,600	1.0335	8	8.27
Total							15.77

TABLE 2: DRYING TIMES OF THE WET RICE IN A MICROWAVE OVEN OF 700 WATTS RATING

Number	ITEM	MASS (GRAMS)	TIME (MINUTES)	
1	PLATE	385		
2	PLATE AND RICE	650		
3	PLATE+RICE+WATER	691	0	
4	PLATE+RICE+WATER	660	4	
5	PLATE+RICE+WATER	657	4.5	
6	PLATE+RICE+WATER	655	5	
7	PLATE+RICE+WATER	653	5.5	
8	PLATE+RICE+WATER	651	6	
9	PLATE+RICE+WATER	650	6.5	
TOTAL ENERGY CONSUMED =	0.076 KW-HR			

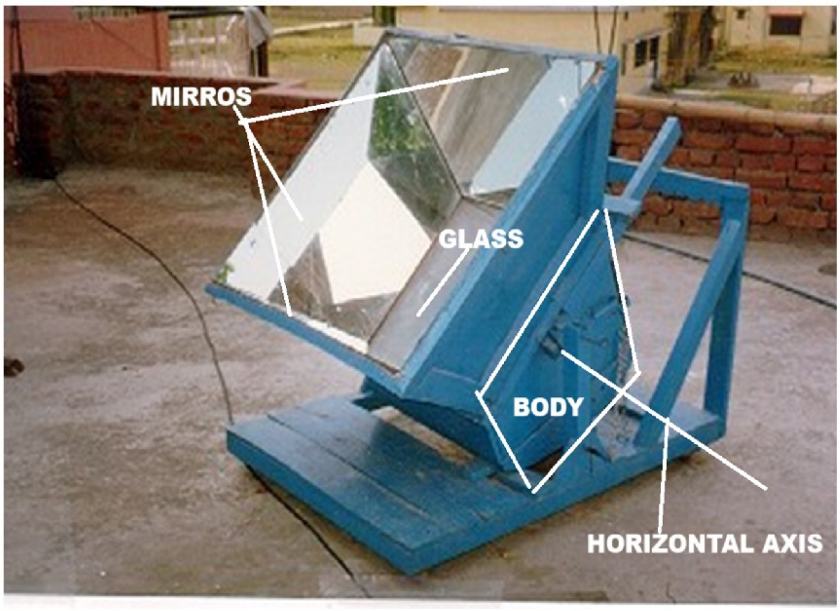

FIG 1 SOLAR COOKER DETAILS

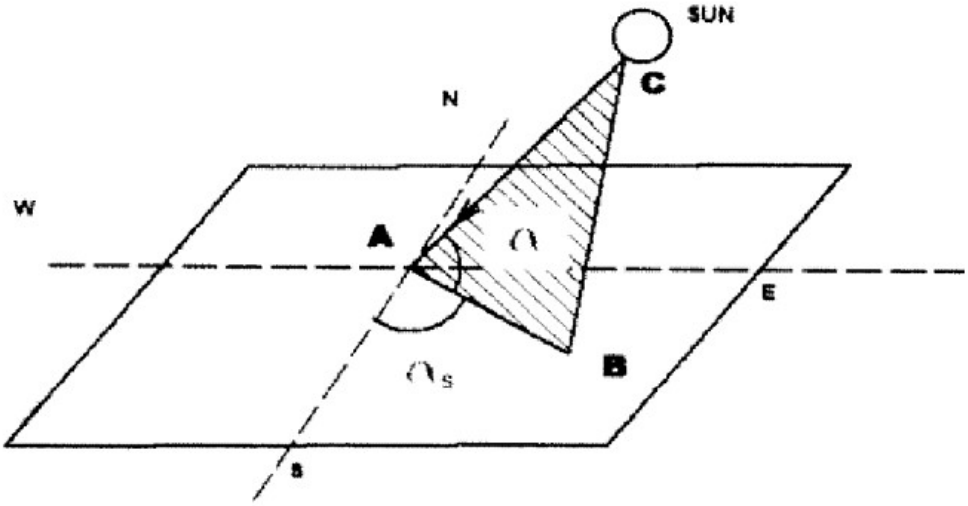

FIG 1B TWO ANGLES NEEDED TO DEFINE THE INCOMING DIRECTION OF SUN'S RAY

FIG 2A DRYER STRUCTURE

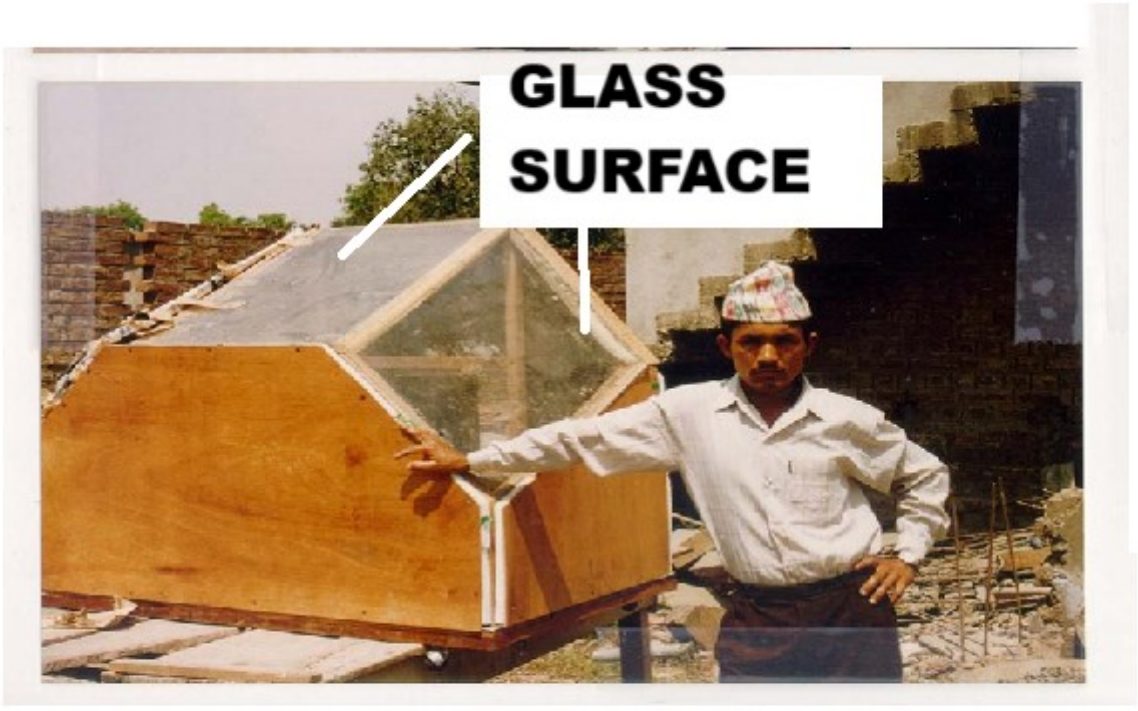

FIG 2B SOLAR DRYER

FIG 3 INDUCTION STOVE WITH KNOBS TO CONTROL HEAT

FIG 4 LENTIL BEING COOKED ON INDUCTION STOVE

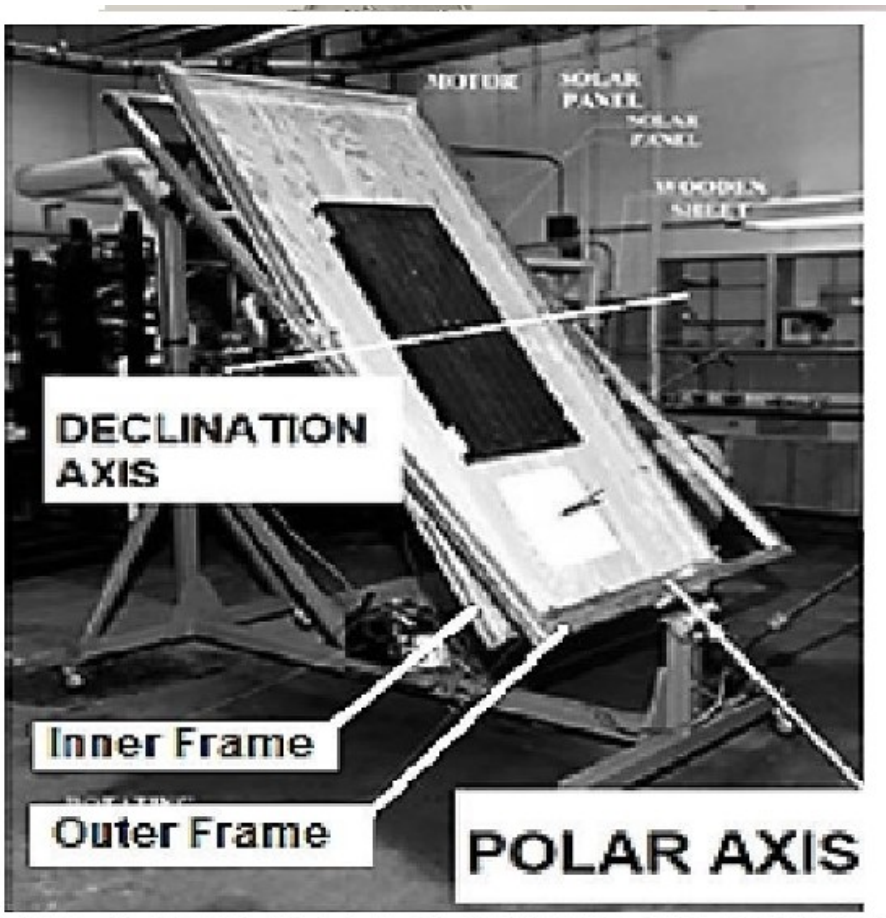

FIG 5 SOLAR TRACKING MECHANISM FOR PHOTOVOLTAIC ELECTRICAL POWER GENERATION

FIG 6 CENTRALIZED SOLAR ELECTRICAL POWER GENERATION

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FIG 7 HEATING OF COOKER BY SOLAR RAYS CONCENTRAT

FIG 8 SOLAR OVEN HAVING A GLASS SIDE

FIG 9 COOKING STOVE WITH RESISTOR HEATING ELEMENT