

Reverse Absorber Solar Air Heater with Evacuated Tubes

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Abstract: Solar energy is the natural resource of energy. Solar energy is rapidly advancing as an important means of renewable energy resource. The Sun is the source of all energy. The energy obtained from the sun is the most promising renewable energy sources since it is clean, safe and free. Solar power is the technology of obtaining usable energy from the light of the sun. Applications of solar energy are commercially available and are used by millions of people in various parts of the world. One of the promising areas of the applications of solar energy is solar air heater. Solar air heaters are used for drying and space heating.

Cultivation is one of the important occupations for the livelihood of the people in villages. Peas, Cardamom, Lemabeans, Groundnut and Coffee are mainly cultivated in Theni District in Tamilnadu, India. Drying the products in a hygienic manner is one of the important processes in agriculture. We have decided to design a **solar air heater with evacuated tubes** and study its **thermal efficiency**.

This type of air heaters can be used to dry the agricultural products which require hot air at low temperature ranges from 40⁰C – 100⁰C. This type of air heater can be utilized for various applications such as dehydration and drying. This would be beneficial not only in conserving the fossil fuels, but also in protecting the environment by the emissions of harmful pollutants and green house gases.

Keywords: Solar energy, dehydration, thermal efficiency

I. Introduction:

Energy is nothing but the ability to do work and has many different forms. Energy can be classified into two groups.

Non-Renewable Energy:

Non-Renewable Energy Sources come out of ground as liquids, gases and solids. The energy sources are considered non renewable because they cannot be replenished in a short period of time. Oil, Coal, Natural gas and Nuclear are the forms of Non-Renewable Energy.

Renewable Energy:

Renewable energy sources can be replenished in a short period of time. The five Renewable Energy sources used most often include hydropower, Solar, Wind, geothermal and Biomass. Renewable energy has the advantages that it is available at free of cost. It does not cause pollution. It is clean and pure. This is one of the most promising resources which could replace the non-renewable resources.

Solar Energy:

The Sun is the source of all energy. The energy obtained from the sun is the most promising renewable energy sources since it is clean, safe and free. Applications of solar energy are commercially available and are used by millions of people in various parts of the world. One of the promising areas of the applications of solar energy is solar air heater. Solar air heaters are used for drying and space heating.

The use of drying has been demonstrated as an application of air heaters. A hot air from a solar air collector is circulated through the crop to reduce its moisture content.

Solar Energy Applications:

Many Technologies have been developed to make use of the solar radiation. Some of these technologies make direct use of the solar energy (e.g. to provide light, heat etc) while other technologies produce electricity. **Solar air heating** is a solar thermal technology in which the energy from the sun, solar radiation, is captured by an absorbing medium and used to heat air.^[1] Solar air heating is a renewable energy heating technology used to heat water or air for buildings. One of the traditional use of solar energy has been for drying of agricultural products. The drying process removes moisture and helps in the preservation of the product. Conventional air heater can provide hot air at temperature which is 15-30⁰C above the ambient temperature. The rise in temperature can be achieved by reducing the convective and radiative heat losses from the absorber to ambient through the top glass cover. This is possible in a new type of solar air collector known as **Reverse Flat Plate Collector (RFP)**. It can collect solar heat at high temperatures.

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II. Design and fabrication of solar air heater:

Solar air heater fabricated consists of

1. Input unit
2. Collector unit
3. Drying unit

Input unit:

Input unit is the unit through which air can be passed. Battery operated fan is used to pass the air. It operates at 12v d.c supply. The fan is located at one end of the collector. Digital sensor is used to display the inlet temperature.



Fig1. Input unit

Collector unit:

The collector unit consists of the following

1. Parabolic aluminum reflector
2. Evacuated tube

The parabolic aluminum foil is used to focus sunlight on the evacuated tube which is located at the focal point of the parabolic aluminum reflector. The parabolic aluminum reflector is used to attain the multiple reflections if the radiation is from any direction. Hence it increases the efficiency of the air heater. The evacuated tube is located at the focal point of the parabolic aluminum reflector to increase the temperature of the evacuated tube in an efficient way.

To increase the useful energy, we can use the selective surface, which reduces the radiative heat loss, but further reduction in the convective loss is required in order to fully utilize the potential of such surfaces. This can be achieved by removing the air over the absorbing surface, i.e by evacuation. Air is removed completely between the absorber and glass

cover. The only heat loss mechanism remaining is radiation

Drying unit:

The drying unit is made up of wood which is insulated from external radiation and also avoid the thermal loss. There are many perforated trays of different sizes of holes. The crops to be dried are kept in the trays and placed in the drying unit.

The fan provides the input air which is allowed to rotate inside the evacuated tube. The hot air is allowed to pass on the wet crops. When hot air passes through the crop, the moisture in it is evaporated and dried. The difference in weight gives the amount of moisture evaporated.



Fig2. Output unit

III. Construction of Solar Air Heater:



Fig3. Evacuated Tube solar air heater

IV. Efficiency of Air Heater:

The efficiency of the air heater was calculated using the formula

$$\eta = [m C_p (T_o - T_i)] / A_c G$$

Where

- m-mass flow rate (Kg/s)
- C_p-specific heat capacity (j/Kg/k)
- T_i-inlet temperature (°C)
- T_o-outlet temperature (°C)
- A_c-Area of the collector (cm)
- G- Incident solar radiation (W/m²)

V. Results and Discussion:

All experiments were conducted in the sunny days during the period 10.00am to 4.00 pm, which recorded a maximum solar radiation (756w/m²). This shows that the temperature difference is one of the major factors that determine the thermal efficiency of solar air heater. Readings were taken for the various agricultural products such as coffee, cardamom, peas, groundnut, cereals, potato and pappads and its efficiencies were calculated and tabulated. The efficiency graph was drawn for various products. The readings were taken during April 2014. The maximum intensity of radiation recorded was 677 W/m.

Ground Nut

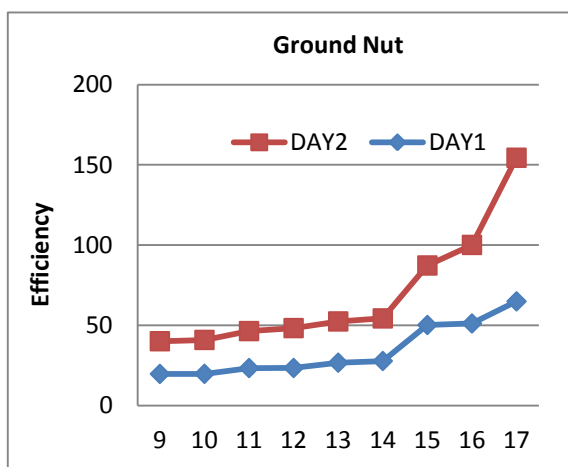


Fig. 4 Efficiency for groundnut

Coffee

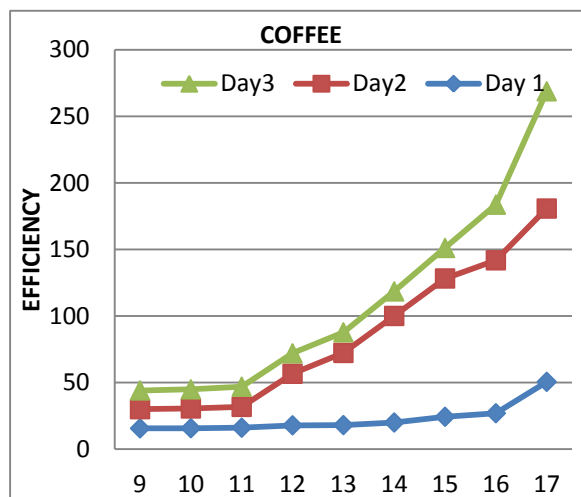
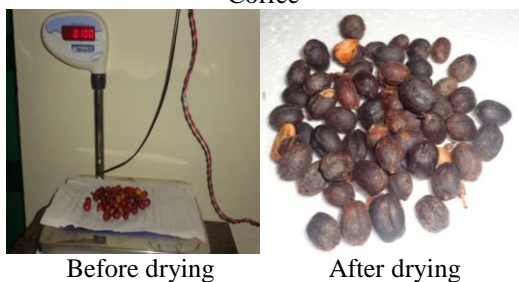


Fig.5. Efficiency for coffee

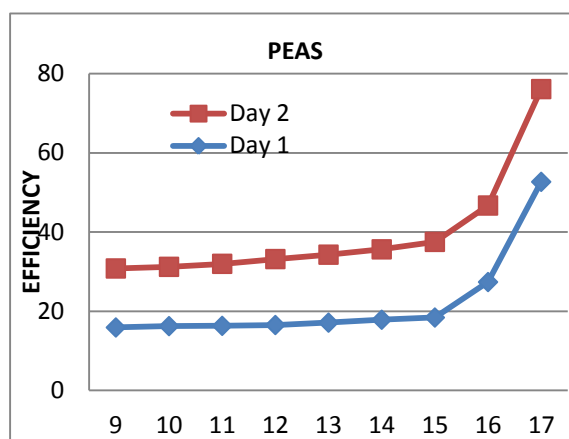


Fig .6. Efficiency for green peas

Cardamom



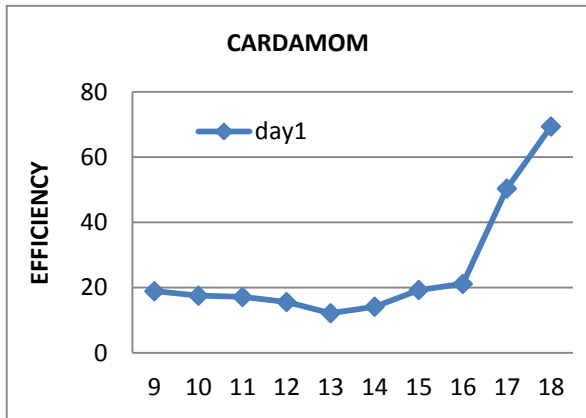


Fig. 7. Efficiency for cardamom

VI. Conclusion:

With these observations, it was found that the efficiency of the air heater is very high after 12.00 p.m. This may be due to the absorption of heat by the evacuated tube till 12.00 p.m and emission of radiation after that. Due to evacuated tubes, the efficiency is increased to a larger extent. With these observations, it is concluded that this type of air heater can be constructed at an affordable price and is much suitable to dry the agricultural products in an efficient way and in a hygienic manner. Mechanised drying is faster than open drying and gives a better quality product.

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