Solar Air Heating Using CPC - (Compound Parabolic Concentrator) Collector for Agro Industries

M.Arasumani[1] M.E.,M.Sc(Engg), M.Thiruppathirajan[2] DEEE, R.Anbarasan B.E.,T.Dineshkumar[4]B.E.,
Universalsunenergy- R&D departments
5th Forest Road Theni – Tamilnadu – India - 625531

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 compound parabolic collector (CPC) and study its thermal efficiency.

This type of air heaters can be used to dry the agricultural products which require hot air at high temperature ranges from 70°C-120°. 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.

Key Words - *CPC collector, CPC Air Heating, compound parabolic concentrators*

I. INTRODUCTION

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

01. Renewable Energy
02. Non- Renewable Energy

A. 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.

B. 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.

C. 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. A hot air from a solar air collector is circulated through axial fan or centrifugal pump.

D. 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. 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 15-30◦C 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 CPC . It can collect solar heat at high temperatures. 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.

E. Disadvantage of Natural sun drying

01. contamination by birds.
02. uncontrolled drying.
03. insect and dust.
04. required more labours.

F. Advantages of Solar drying

01. Makes product more uniform, healthy, and hygienic
02. Preserves color, texture and natural appearance and Retains nutrients like beta carotene
03. Gives long life to products
04. Maintains moisture level at optimum level
05. Can be easily adopted into fossil fuel systems
06. The system Functions consistently and efficiently for 15-20years.

G. Applications

01. This system can be used for processing of grain and other food products like spices, tealeaves, fish, dehydrating fruits& vegetables.
02. This system can also be used in industry for producing paper& board, supplying hot air toboilers, space heating at hill stations, processing leather& hides, etc.
03. Same system can be used for heating the thermal liquid which can be used as heat source.

H. Design and fabrication of solar air heater:

Solar air heater fabricated consists of

Input unit

Collector unit

output unit

I .Input unit

Input unit is the unit through which air can be passed. Battery operated fan (or) D.C axial (or)D.C Radial 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.

J. Collector unit

The collector unit consists of the following

1. Parabolic aluminium reflector

2. CPC collector tube

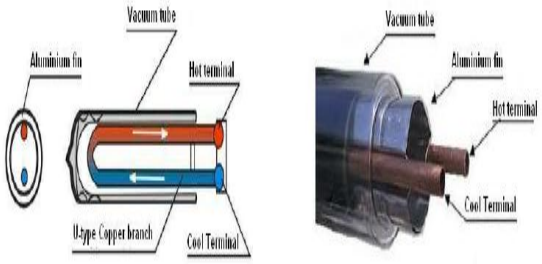


fig:1

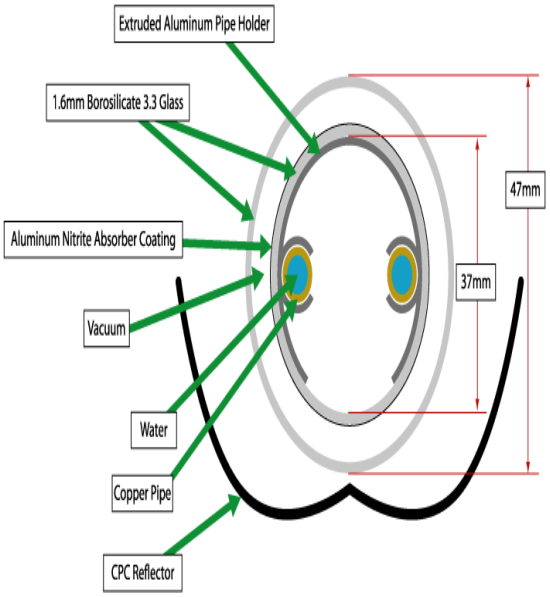


Fig:2

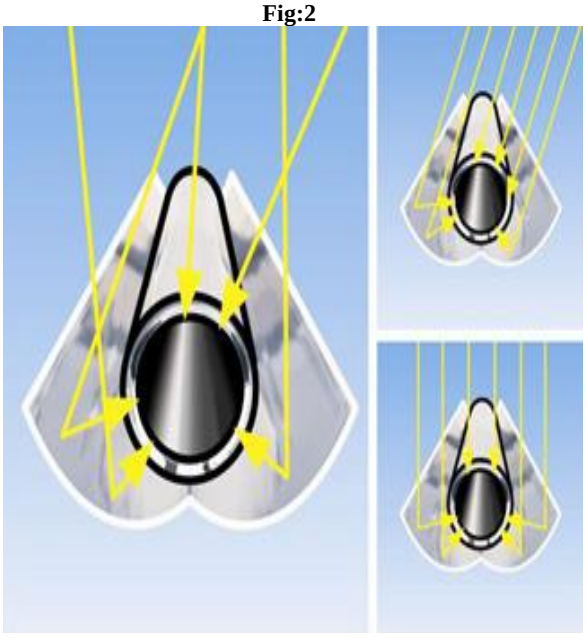


Fig:3

Fig:4

The parabolic aluminium foil is used to focus sunlight on the CPC tube which is located at the focal point of the parabolic aluminium reflector. The parabolic aluminium 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 CPC tube is located at the focal point of the parabolic aluminium 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.

Output Unit

The fan provides the input air which is allowed to rotate inside the CPC tube. The hot air is allowed to pass on the wet products. When hot air passes through the product, the moisture in it is evaporated and dried.

K. Materials And Measuring Instruments

01. solar collectors
02. axial fan (or) blower
03. drying chamber
04. Temperature sensor
05. Radiation meter
06. Pyranometer
07. Anemometer

L. Experimental setup

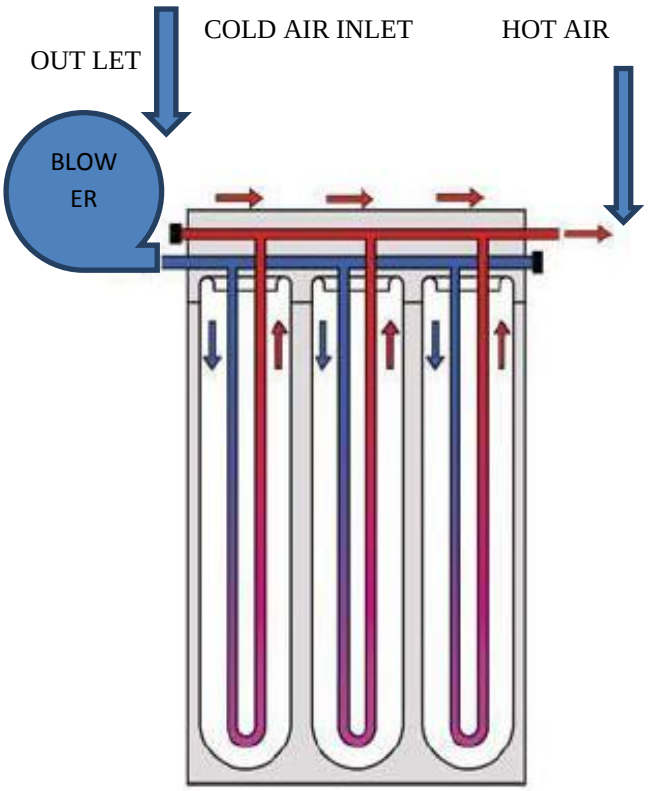


Fig:5

Fig:6

The indirect type forced convection solar air heating is mainly constructed with two essential features namely, the blower, the CPC collector, Fig shows the section of the CPC collector .

It consists of 18 CPC tube collectors with a copper header for transfer of heat cold air enter the inner copper tube and hot air from outer tube. The collector is placed along North – south direction. facing south so as to track maximum solar radiation during the day time. The blower is attached at the inlet of the CPC collector for conducting the experiment of forced convection. Air is blown into the CPC collector with the help of the external device blower. The solar radiation falling on the collector, the collector gets heated up and transfer heat to the air flowing through the collector.

M. Analytical calculation

01. Determine energy of the system.
    $Q=\dot{M}\ C_P\ \Delta T$..... (4)

    $\Delta T=(T_1-T_2)$
    T_1= Inlet Temperature
    T_2= Out let Temperature
    Q=Energy- kcal
    $\dot{M}$=Mass (m^3/h)
    C_P= specific heat(j/Kg/k)
    ΔT= change in Temperature- ^0C

02. Determine the efficiency of the system.
    $Q = \frac{\dot{M}\ C_P\ \Delta T}{I_T\ A\ T}$..... (5)

    $\Delta T=(T_1-T_2)$
    T_1= Inlet Temperature
    T_2= Out let Temperature
    Q=Energy- kcal
    $\dot{M}$=Mass
    C_P= specific heat
    ΔT= change in Temperature- ^0C
    I_T= solar Radiation (w/m^2)
    A = Area of the collectors(m^2)
    T =Time period (seconds)
03. Volume flow of the system
    Volume flow = velocity*area
    Velocity (m3/h)
    Area (m^2)

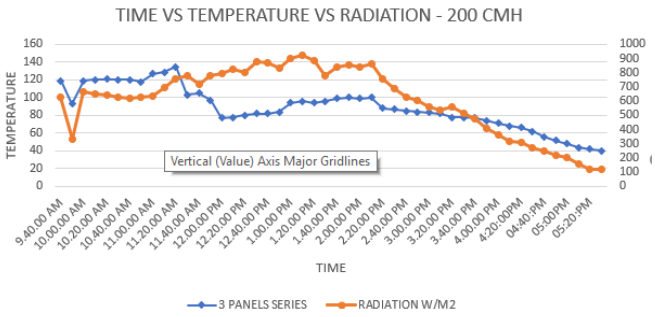
N. TABLE -I

Readings Data for testing reports

Time	Radiation (w/m^2)	Ambient °c	Hot air °c	Δt °C
09.40am	630	30	123	92
10.00am	670	31	136	105
10.30am	630	31	136	105
11.00am	635	31	414	108
11.30am	779	33	128	95
12.00Nn	795	35	130	95
12.30pm	879	36	132	96
01.00pm	898	36	137	101
01.30pm	778	36	138	102
02.00pm	841	36	139	103
02.30pm	689	34	134	100
03.00pm	562	32	124	92
03.30pm	518	32	115	83
04.00pm	462	32	106	74
04.30pm	271	32	90	58
05.00pm	201	32	77	45
05.30pm	185	32	56	24
06.00pm	180	30	42	12

Energy delivery (Q)=$\dot{M}\ C_P\ \Delta T$
C_P= specific Heat of air value = 1 assume

O. Compare Temperature VS Radiation



Data- 1

II. CONCLUSION

In this experimental study, two different modes as natural and forced convection. The indirect type forced convection solar hot air generator using CPC collectors generates air in high temperature. As the solar air heating using CPC collector can perform better even during cloudy days and winter season.

The efficiency of the system high compare to flat plate collectors – 30 to 35 % increase the efficiency of the system. The designed indirect type solar dryer utilized the more solar thermal energy as a result obtained as reducing fuel consumption.

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