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Performance Improvement of Solar Air Collector using Phase Change Material

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Abstract: The main purpose of the report deals with flat plate solar air collector which is used for heating purposes in order to improve the efficiency of flat plate solar air collector. Solar air collector is the major component of solar energy utilization system which absorbs the incoming solar radiation, converts it into thermal energy and transfers the energy to the air flowing through the collector. This experimental setup is used to improve the efficiency of a solar air collector by using an Phase Change Material (PCM) for determining the changes incurred in the collector, which is noted by an set of readings taken with PCM and without PCM and observing improvement of efficiencies by comparing both the stages. The absorber plate of the solar air collector is made of copper sheets with a predetermined area and thickness of (9.5*6) ft of length and breath. The wooden box which covers the entire experimental setup ranges (186*57) in length and breath The results of the collector efficiency in the natural and forced convection were evaluated and their graphs have been plotted based on the results.

Highlights

1) ***Review performance improvement of solar air collector by using the PCM.***
2) ***The PCM is used to store the heat.***
3) ***The collector can be used in night and sunshine hours.***

Key points: *Phase Change Material, IC engine, copper sheets, thermocouples.

I. INTRODUCTION

The sun is the most powerful heat generator with which neither of the heat sources created by mankind can compete. Annually, the solar energy obtained by earth is 15000 as much as the power industry of the whole world can produce. It means that only a tiny part of solar energy is used for the sake of mankind.

Solar air collectors are the key component of active solar-heating systems. They gather the sun's energy, transform its radiation into heat, and then transfer that heat into a fluid (regularly water or air). The solar thermal energy can be used in solar water-heating systems, solar pool heaters, and solar space-heating system.

Flat-plate collectors are the most common solar collectors for use in solar water-heating systems in homes and in solar space heating.

A solar air collector consists basically of an insulated wooden box with a glass or plastic cover (the glazing) and absorber plate. Solar radiation is absorbed by the absorber plate and transferred to the wind that circulates through the collector in tubes.

In an air based collector the circulating medium is air, whereas in a liquid-based collector it is usually water. Solar air collectors heat the circulating medium (air) to a temperature which is best suited to applications where the require temperature is 30-70°C (86- 158°F) and/or for applications that require heat during the chill months. Air-based collectors are typically used for heating buildings and drying crops. Liquid-based may be glazed or unglazed.

This section deals only with low temperature solar air collectors, the plane solar air collectors, which in general are simple devices easy to construct, to install and to function

A. Types of Collector

There are a large number of solar collector designs that have turned out to be functional. These designs are classified in 2 general types of solar air collectors.

1) *Flat-plate Collectors:* The absorbing surface is approximately as large as the overall collector area that intercepts the sun's rays.
2) *Concentrating Collectors:* Large areas of mirror or lenses focus the sunlight onto a small absorber.

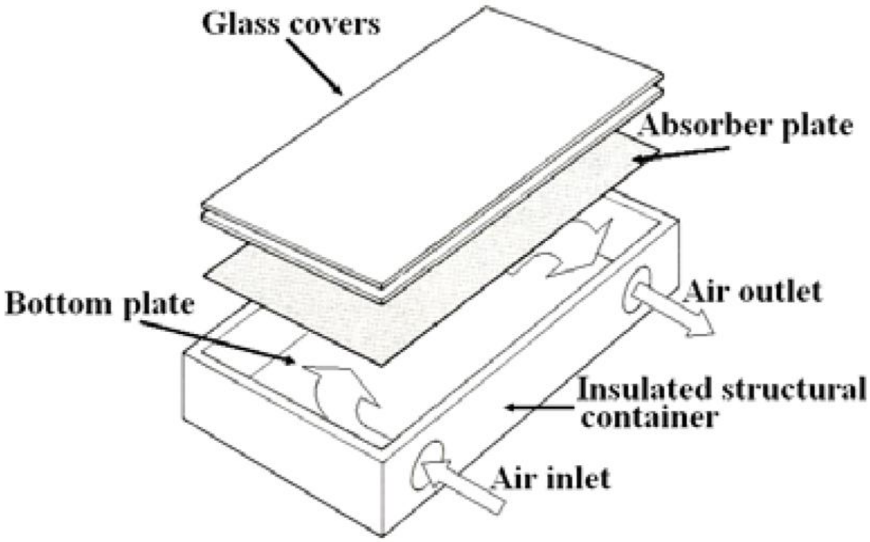

Figure 1.1 Flat plate collector

B. Construction Elements of a Solar Collector

1) *Absorber Plate or Selective Surface:* It is a metal, glass or plastic surface, mostly black in colour. It absorbs and converts radiation into thermal energy and then, by convection and conduction it is transfer to the circulating air.
2) *The Transparent Cover:* It is the upper part of the collector covering the tide absorber plate. It is made from glass or transparent plastic sheet to allow penetration of solar energy.

C. Operational Characteristics of the Collector

1) *Collector Efficiency (η):* It is the ratio of useful gained thermal energy for period of time to the incident solar radiation onto the collector for the similar time period.
2) *Thermal Capacity of the Collector (C):* It is the volume of heat that can be stored per surface collector area and per unit of temperature change.
3) *Pressure Drop (Δp):* It is the difference in pressure between the inlet to the collector and the outlet due to circulation friction.
4) *Incidence Angle Coefficient ($k\theta$):* The proportion of the optical efficiency of a solar collector with a fixed beam angle of incidence to the optical efficiency of the collector is normal.

D. The Characteristic Parameters of the Collector

1) *The cover Reflectance (ρ_c):* As cover reflectance is consider the ratio of reflected solar radiation from the cover to the surroundings to the incidence solar radiation.
2) *Cover Transmittance (τ_c):* It is the ratio of the solar radiation passing through the translucent cover to the incident irradiation.
3) *Cover Absorbance (α_c):* It is the ratio of the absorbed solar radiation in the absorber to the incident radiation.
4) *Coefficient of cover Emissivity (εc):* The coefficient of cover emitters is the ratio of the intensity emitted by the cover, for a fixed temperature, to the intensity of black body irradiance, of precisely the same shape and same temperature.
5) *Selective Coat:* Selective coats are resources that possess high solar radiation absorbance ($\lambda \leq 3\ \mu_m$) and simultaneously low remittance for wave lengths larger than three μ_m ($\lambda \geq 3\ \mu_m$).
6) *Collector Efficiency Factor (F'):* It is the ratio of the real energy output of the collector to the energy output in the case when the total absorber area was at the average air temperature with the same air quantity of flowing wind.
7) *Collector Flow Factor (F"):* It is the ratio of the energy that the collector can distribute at the average temperature of the air to the energy that the collector can supply at the inlet collector temperature. For a certain collector the flow factor is a purpose of the flowing air quantity.

E. Main Components of flat Plate Collector

A collector is a self-governing unit which consists of: the absorber plate, the translucent cover and the insulation material bound together by a case that houses the collector components. They are;

1) The casing of collector - Plywood
2) Solar radiation absorber - Copper sheet
3) Thermal insulation - Black paint
4) The transparent cover - Transparent Glass
5) Thermocouple
6) Pyrometer
7) Rubber hose
8) Anemometer

a) *Plywood:* Plywood is a material manufactured from thin layers or "plies" of wood veneer that are glued together with adjacent layers having their wood grain rotate up to 90 degrees to one another. It is an engineered wood from the folks of manufactured boards which include medium-density fibreboard (MDF) and particle board (chipboard). All plywood bind resin and wood fibre sheets (cellulose cells are long, strong and thin) to form a composite material.

Figure 1.2 Plywood

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b) *Transparent glass or Glazing:* Glass is a non-crystalline, amorphous solid that is often translucent and has widespread practical, technological, and attractive usage in, for example, window panes, tableware, and optoelectronics. The most familiar, and historically the oldest, types of manufactured glass are "silicate glasses" based on the chemical compound silica (silicon dioxide, or quartz), the primary element of sand. The term glass, in popular usage, is often used to refer only to this type of material, which is familiar from use as window glass and in glass bottles. Oxide (Na_2O) from sodium carbonate (Na_2CO_3), calcium oxide (CaO), also called lime, and several minor additives.

c) *The Solar Radiation Absorber:* An absorber is characterized by the type of material, the form of tube fins and the type of absorption coat. The most usual materials of construction are: steel, aluminum, copper, and a mixture of copper tube with aluminum fins. Copper is a chemical element with the symbol **Cu** and atomic number 29. It is soft, malleable, and ductile metal with very high thermal and electrical conductivity. A freshly exposed surface of pure copper has a pinkish- orange colour. Copper is used as a conductor of heat and electricity, Copper is one of the few metals that can occur in environment in a directly usable metallic form (native metals).This lead to very early human use in numerous regions, from 8000 BC. Thousands of years later, it was the first metal to be smelted from sulphide ores, during 5000 BC, the first metal to be cast into a shape in a mould. Copper used in buildings, usually for roofing, oxidizes to form a green verdigris (or patina). Copper is sometimes used in decorative art, both in its elemental metal form and in compounds as pigment.

Figure 1.3 Corrugated Copper sheet

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d) *Thermal Insulation:* Thermal insulation is given by means of using black paint, covering the total surface of the plywood box. Thermal paints provide superior insulation.

i) *Black Paint:* Isolative paints, or insulating paints, claim to use a technology where a broad spectrum thermally reflective coating is applied to a specific type of micro-spheres to block heat radiation in a much larger or broader range of thermal energy (heat) to dissipate heat rapidly. This type of coated thermally reflective material (coated micro-sphere) reduces heat transfer through the coating with 90% of solar infrared radiation and 85% of ultraviolet radiation being radiate back from the coated surface.

Figure 1.4 Black coated insulation

e) *Thermocouple:* A thermocouple is an electrical device consisting of two dissimilar electrical conductors forming electrical junctions at differing temperatures. A thermocouple produces a temperature-dependent voltage as a result of the thermoelectric effect, and this voltage can be interpreted to measure temperature. Thermocouples are a generally used type of temperature sensor

Figure1.5 Thermocouple

f) *Pyrometer:* A pyrometer is a type of remote-sensing thermometer used to measure the temperature of a surface. Different forms of pyrometers have historically existed. In the modern usage, it is a device that from a distance determines the temperature of a surface from the amount of the thermal radiation it emits, a process known as pyrometer also sometimes radiometry.

Figure1.6 Pyrometer

g) *Rubber Hose:* A hose is a flexible hollow tube designed to transfer air from one location to another. Hoses are also sometimes called pipes (the word pipe usually refers to a rigid tube, whereas a hose is usually a flexible one), or more commonly tubing. The shape of a hose is usually cylindrical (having a circular cross section). Hose design is based on a combination of application and performance. General factors are size, pressure rating, weight, length, straight hose or coil hose, and chemical compatibility.

Figure1.7 Rubber hose

h) *Anemometer:* An anemometer is a device used for measuring wind speed and direction. It is also a common weather station instrument. The term is derived from the Greek word anemos, which means wind, and is used to explain any wind speed instrument used in meteorology.

Figure 1.8 Anemometer

i) *Exhaust Gases:* In this case exhaust gases or flue gases which are obtained from the automobiles or generators are used to obtain thermal efficiency of collector which differs from the previous analysis of thermal efficiency calculation of solar air collector which uses atmospheric air and varies the measurement by varying natural and forced convection simultaneously. Exhaust gases consist of carbon di oxide (co2), carbon monoxide (co), Nitrogen oxide (No), dust particles, sulphur particles and so on. Hot exhaust gases which are obtained from collector are filtered and it can be used to keep up dryness of dry fruit and dry food particles.

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Figure1.9 Exhaust gases

F. Fabrication Process

To carry out the experimental analysis, an active collector was used with the size of 9.5*6 ft. The wall of the collector is made from plywood profile insulated by thermal paint (Black paint). The absorber plate is made from Copper sheet which CORRUGATED in shape is used for absorbing solar radiation from sunshine. In order to decrease heat loss through the absorber plate, it was insulated underneath by thermal coating of 5cm thickness. Air flow simultaneously occurs through the channel 1(under the absorber plate) and the channel two (over the absorber plate). Three thermocouples were installed with a specific distance from each other in the inlet, via the center of the glass, to measure the inside temperature and outlet of the solar air collector. The temperature was measured for every half an hour and its average values are calculated. Moreover, a temperature sensor was used to measure the inlet temperature in the way in of the collector. The which the weather was clear were the case study was passed out

1) *Collector with Natural Convection:* In this case, the collector was evaluated without using blower and its average efficiency was recorded at dissimilar hours.
2) *Collector with Forced Convection Using Exhaust Gases:* In this case, a blower with a speed control system was planned and located on a board to stabilize the outlet temperature of the solar air collector at the desired temperature ranges and Exhaust gases from the automobiles are used to determine the temperature and efficiency of flat plate collector. Moreover, a small screen was used to show the collector inlet and outlet temperatures.

G. Exhaust Gas Properties

The exhaust system includes several specialized components, ranging from muffler to emission after treatment devices. The designer of the exhaust system and/or exhaust system components must know a quantity of exhaust gas properties.

Compared to the composition of air used the largest part of most **combustion gas** is nitrogen (N_2), water vapor (H_2O) (except with pure-carbon fuels), and carbon dioxide (CO_2) (except for fuels without carbon); these are not toxic or noxious. The concentrations of both H2O and CO2 can vary from a few percent, up to about 12% in petrol exhaust. These combustion products displace oxygen, the concentration of which can vary from a few percent, up to about 17% (compared to 21% in ambient air). The main component of petrol exhaust, just as is the case with ambient air, is nitrogen (N2). By evaluation, the concentrations of petrol exhaust pollutants are very small—for the purpose of calculating the physical properties of petrol exhaust gas, they can be neglected.

As an approximation, the properties of air can be used for petrol exhaust gas calculations

1) *Engine Exhaust Back Pressure:* Another parameter is the maximum pressure drop through the exhaust system, caused by the hydraulic resistance of exhaust system components. This parameter commonly referred to as the engine back pressure require that the engine perform additional pumping work, and has other impacts on engine function which are discussed in the back pressure paper. Common metric units of exhaust back pressure include kilopascal (k_{Pa})—which we use in this paper and milli bar (mbar), the latter being equal to hectopascal (h_{Pa}). Common customary units include inch of water column (in H20) and inch of mercury column (in Hg). The following connection exists between these units: 1 kPa = 10 hPa = 10 mbar = 4.0147 in H20 = 0.2953 in Hg
2) *Vaccum Effects on Performance:* The effect of vaccum with micro-channel technique on solar air collector performance is investigated experimentally. Vaccum space reduces the loss of heat for the absorption plate by conduction and thus improves the solar air collector performance.

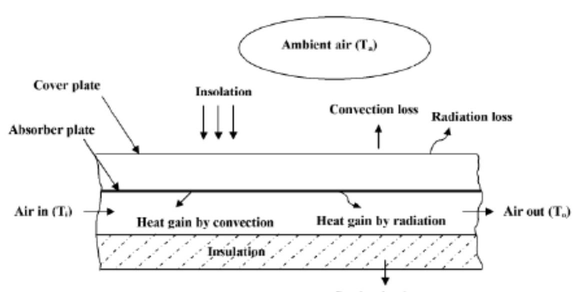


Figure 1.10. Vaccum Pressure effects

II. LITERATURE REVIEW

Dupeyrat et al., 2011: The study of the initial part of this paper is on the development and testing of a flat-plate PVT solar collector. The propose of 2 models PVT collectors are obtainable. (PVTA) with plastic-layered c-Si solar cells For the primary collector (PVT-A), the PVT absorber was group-produced with an improved method for the lamination of solo crystalline silicon solar cells on the top of an optimized flat heat exchanger. The relative temperature coefficient of CdTe thin film is about -0.20 %/K, compared to -0.45 %/K for silicon cells.

WenfengGao, Wensian Lin, Tao Liu, Chaofeng Xia, 2006: In the following study experimental analysis of the corrugate copper plate is studied experimentally and rationally. The corrugated copper plate is the gesture like shaped absorbing plate and also a gesture like bottom plate, which are crosswise situated to form the airflow channels. First the absorber plate was along the flow way and the bottom plate was at a 90 degree angle to the airflow direction. The major plan of using the bottom plate was to generate higher rate of turbulence and enhance the heat convey rate.

Zhang Zhiqiang, ZuoRan,LI Ping and Suwenjia, 2009: The Translucent honeycomb construction with bony-walled glass tube of a small relation as the honeycomb section is designed and applied to a flat-plate solar air collector. Research is performed for solar air collectors with six dissimilar honeycomb dimensions. The highlighting is to study the effects of diameter and aspect relation of the honeycomb section on the transmission and efficiency of the solar air collector. The translucent honeycomb plate is prepared of the bony-walled glass tubes which come from the waste of the vacuum tube solar collector and the dual layer of Fiberglass Reinforce Plastic (FRP) material as sustaining plates. And the consequences were,

1) The atmosphere temperature of the collector is mostly pretentious by the honeycomb aspect relation and the material transmission, but not the actual honeycomb scale.
2) The collector's slightest ratio yields the highest principle temperature, and the collector of dual-layer FRP plate without honeycomb has the slightest typical temperature. The peak temperature disparity is about 12.

A. Hachemi 1999

The thermal hea**t** arrangement of a solar air collector depends strappingly on the thermal heat loss and the effectiveness element. In the study we are absorbed by the estimate of these heat broadcast and thermal heat failure coefficients.
Efficiency factor of the solar air collectors with fin's system and with selected and non-selected Absorber plates.

B. DonatienNjomo, Michel Daugenet, 2003

The Sensitivity analysis is a numerical mechanism, initial developed for optimization techniques, which target to distinguish a system response through the difference of its output parameters following adjustment imposed on the input parameters of the system. The core reason of this study is to display that the heat convey model developed is robust sufficient to be used for thermal plan studies of flat plate solar air heaters, and level of flat plate solar water collectors.

C.TurhanKoyuncu, 2005

Altered sources of heat are used for crop drying. A Flat plate solar air collector is one of them. He constructs and analyzed for their performance.

1) Type-1-Solo artificial Glazing, black layered hardboard absorber and fore pass.
2) Type-2-Solo artificial Glazing, black layered flat plate absorber and fore pass.
3) Type-3-solo artificial Glazing; black layered crisscross absorber and – fore pass. Solo artificial Glazing, black layered flat plate absorber and reverse pass.
4) Type-4-solo artificial Glazing, black layered crisscross absorber and reverse pass.
5) Type-5-dual artificial Glazing, black layered flat plate absorber and reverse pass.

The complete prototype was examined in the similar weather conditions and with the similar air flow. The experiments were done in the north of turkey latitude=41.21 longitude=36.15 with an airflow of 65kg/(hm^2).After the testing was performed it was inspected that the performance of the Type 1, Type 2, Type 3, Type 4 and Type 5 were 42.11, 45.88, 44.23, 39.76 and 39.05 equally. This shows that the performance of the most capable solar air collector is 9%.

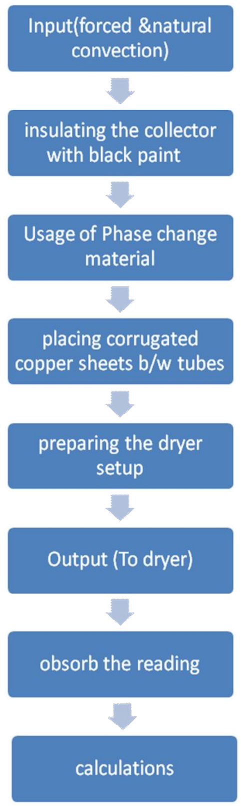
III. METHODOLOGY

The experiment is carried out, to increase the efficiency of solar air collector by using phase change material.

At first we have made the two pass solar air collector and placed the absorber plate between the copper tubes. Then we painted the solar air collector with black paint .which helps to absorb the high rate of solar radiation.

Then experiment is carried with a solar air collector, by natural convection method with a Phase change material and identifying the efficiency changes and observing the changes without Phase change material.

Forced convection method is implies with the use of dry fruits by using the exhaust gas from vehicle and observing the changes occurred in the weight of the fruits while observing with the use of Phase change material and without Phase tabulated for four days and calculation are made according to the change material. Both observed efficiencies are compared and readings are.



A. Heat Transfer Characteristics

1) *Heat Transfer Definition:* Heat transfer is defined as the simply a heat which determines the movement of thermal energy from one place to another place of different temperatures.

There are three different modes of heat transfer medium takes place they are;

1) Conduction
2) Convection
3) Radiation

2) *Modes of Heat Transfer*

a) *Conduction:* An energy transfer across a system boundary due to temperature difference by the mechanism of intermolecular interactions. Conduction needs matter and does not require any mass motion of matter.

Conduction rate equation is described by the Fourier Law:

$q = - kA\, dt/dx$

where:

q = heat flow vector, (W)k = thermal conductivity, a thermodynamic property of the material.(W/m K)

A = Cross sectional area in direction of heat flow. (m^2)

dt = Gradient of temperature (K/m)

Note: Since this is a vector equation, it is often convenient to work with one
For example, in the x direction:
qx = kAxdT/dx
In circular coordinates it may convenient to work in the radial direction:
qr = kArdT/dr

b) Convection: An energy transfer across a system boundary due to a temperature difference by the combined mechanisms of intermolecular interactions and bulk transport. Convection needs fluid matter.

Newton's Law of Cooling:
q = h As DT
Where:
q = heat flow from surface, a scalar, (W)
h = heat transfer coefficient (which is not a thermodynamic assets of the material, but may depends on geometry of surface, flow characteristics, thermodynamic properties of the liquid, etc

c) Radiation: Radiation heat transfer involves the transfer of heat by electromagnetic radiation that arises due to the temperature of the body. Radiation does not need matter.

B. Convection

An energy transfer across a system boundary due to a temperature difference by the combined mechanisms of intermolecular interactions and bulk transport. Convection needs fluid matter.

Types of convection

1) *Natural Convection:* Natural convection is a mechanism, or type of heat transfer, in which the fluid motion is not, generated by any external Play media Rayleigh–Benard cells.source (like a pump, fan, suction device, etc.) but only by density difference in the fluid occurring due to temperature gradients. In natural convection liquid surrounding a heat source receives heat and by thermal development becomes less dense and rises.
2) *Forced Convection:* Forced convection is a mechanism, or type of transfer in which fluid motion is generated by an external source (like a pump, fan, suction device, etc.). It should be considered as one of the main methods of useful heat transfer as significant amounts of heat energy can be transported very efficiently. This mechanism is found very generally in everyday life, including central heating, air conditioning, steam turbines and in many other equipment. Forced convection is often encountered by engineers designing or analyzing heat exchangers, pipe flow, and flow over a plate at a Applications dissimilar temperature than the stream.

C. Experimental Procedure

The experimental analysis is carried out by using an active collector with the size of (9.5*6) ft. The wall of the collector is made from plywood profile insulation coated by thermal paint. The absorber plate is made from copper sheet which CORRUGATED in shape is used with the thickness of 0.5mm. In order to decrease heat loss through the absorber plate, it was insulated underneath by black paint with two to three coats.

Air flow concurrently occurred through the channel 1(under the absorber plate) and the channel 2 (over the absorber plate). Two thermocouples were installed with a specific distance from each other in the inlet & outlet of collector. The temperature was measured for every half an hour and its average values were calculated. Moreover, a temperature sensor was used to measure the inlet temperature in the doorway of the collector.

The collector was located in the 32 ° degrees latitude in north-to south direction in an open area. The tests with the solar collector system were carried out for several days and 8 hours per day (from 9 a.m. to5 p.m. local time). The collector was intentional according to the natural and forced convection.

The experiments on the efficiency were conducted for a week during which the atmospheric conditions were almost uniform and data was collected from the collector using atmospheric air as inlet gas for first two days and Exhaust flue gases as inlet component to collector for another two days and temperature of both air hot flue gases are noted and thermal efficiency of them are calculated.

After the thermal efficiency calculation temperature of them are compared correlated and graphs are plotted based on the variation in thermal efficiency of air and hot flue exhaust gases. And thus the results are summarized and resolute.

During above experimentation following parameters will be checked

1) Temperature and mass flow rate atmospheric air at inlet of collector (T_{in})
2) Temperature and mass flow rate atmospheric air at outlet of collector (T_{out})
3) Temperature of glass due incident radiation
4) Temperature and mass flow rate of exhaust gases at inlet of collector (T_{in})
5) Temperature and mass flow rate of exhaust gases at outlet of collector (T_{out})

To determine these following parameters, temperature gauges such as thermocouple are incorporated at various places. The temperature sensors are incorporated at

a) Collector inlet (T_{in} or T_1)
b) Collector outlet(T_{out} or T_2)

These temperature gauge wires or thermocouple wires are linked to the Digital temperature indicator so that the temperature measured is indicated in its display.

The experiment carried out during different time and dissimilar readings were tabulated based on natural and forced convection.

Figure 3.1 Experimental setup without PCM

Figure 3.2 Experimental setup by bike exhaust as inlet

Figure 3.3 Experimental setup with using PCM

Figure 3.4 Experimental setup of dryer with products

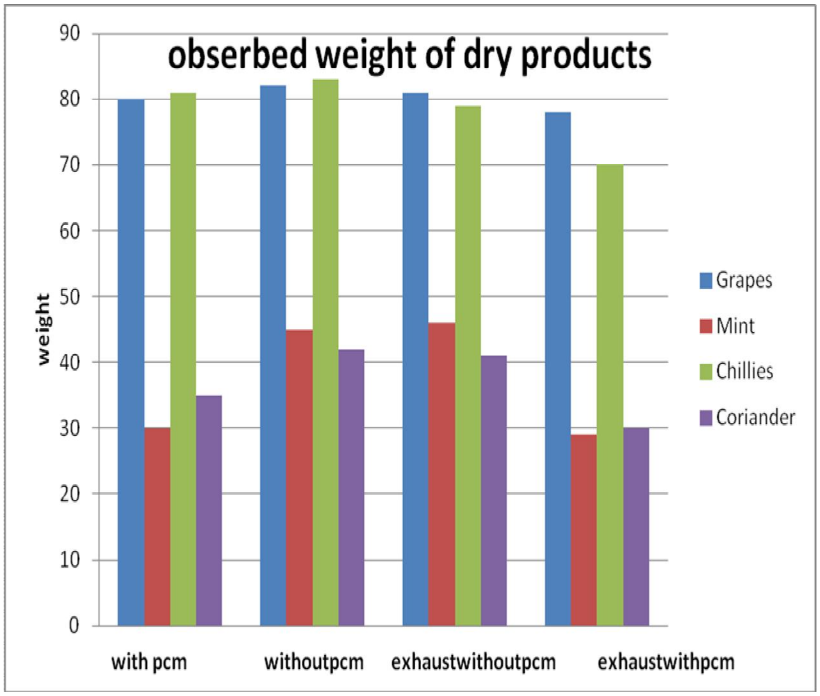
i) Natural method (with PCM)

Materials (vegetables)	Actual Weight (gms)	Observed Weight (gms)
Grapes	100	80
Mint	100	30
Chilies	100	81
Coriander	100	35

Figure 3.5 Observed weight of grapes during natural method

Figure 3.6 Observed weight of chillies during natural method

Graph for observed dry products



ii) Natural method (without PCM)

Materials (vegetables)	Actual Weight (gms)	Observed Weight (gms)
Grapes	100	82
Mint	100	45
Chilies	100	83
Coriander	100	42

iii) Convection method using exhaust gases (without PCM)

Materials (vegetables)	Actual Weight (gms)	Observed Weight (gms)
Grapes	100	81
Mint	100	46
Chilies	100	79
Coriander	100	41
3.3.4 Convection method using exhaust gases (with PCM)		
Materials (vegetables)	Actual Weight (gms)	Observed Weight (gms)
Grapes	100	78
Mint	100	29
Chilies	100	70
Coriander	100	30

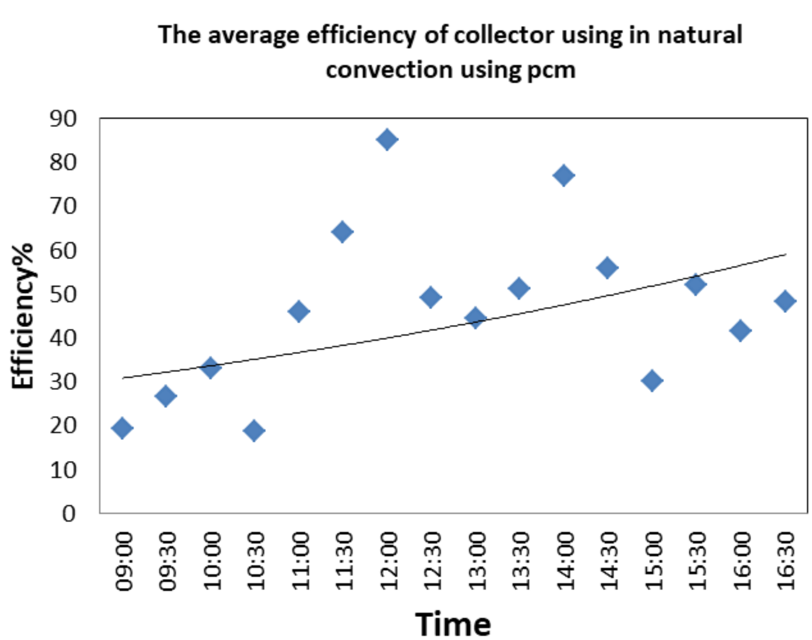
IV. READING WITH ATMOSPHERIC AIR FOR EFFICIENCY AND TIME FOR SOLAR AIR COLLECTOR WITHOUT PCM

1) Reading with atmospheric air by natural convection using Without PCM

M (kg/s)	Cp	ΔT(°K)	I_β (W/m^2)	Quseful (W)	Q (W)	η collector%
0.183	1003	1.24	949.5	227.60076	1177.4	19.33
0.275	1003	5	1033	1379.125	5164.5	26.70
0.367	1003	4	1109	1472.404	4435.6	33.19
0.222	1003	4	1184	890.664	4737.6	18.79
0.55	1003	0.5	1201	275.825	600.4	45.94
0.734	1003	2	1148	1472.404	2295.6	64.14
0.93	1003	1	1097	932.79	1097.2	85.01
0.498	1003	13	1017	6493.422	13225	49.09
0.406	1003	4	918.4	1628.872	3673.6	44.33
0.425	1003	5.5	830.4	2344.5125	4567.2	51.33
0.516	1003	1.6	672.1	828.0768	1075.4	77.03
0.329	1003	5	589.5	1649.935	2947.5	55.97
0.145	1003	1	482.7	145.435	482.7	30.12
0.214	1003	3.2	412.5	686.8544	1320	52.03
0.163	1003	3.2	392.7	523.1648	1256.6	41.63
0.14	1003	3	290.8	421.26	872.4	48.28

NOTE: Readings are taken from 9am to 5pm(1/2hour interval for each readings)

2) Comparison chart for efficiency and time using PCM



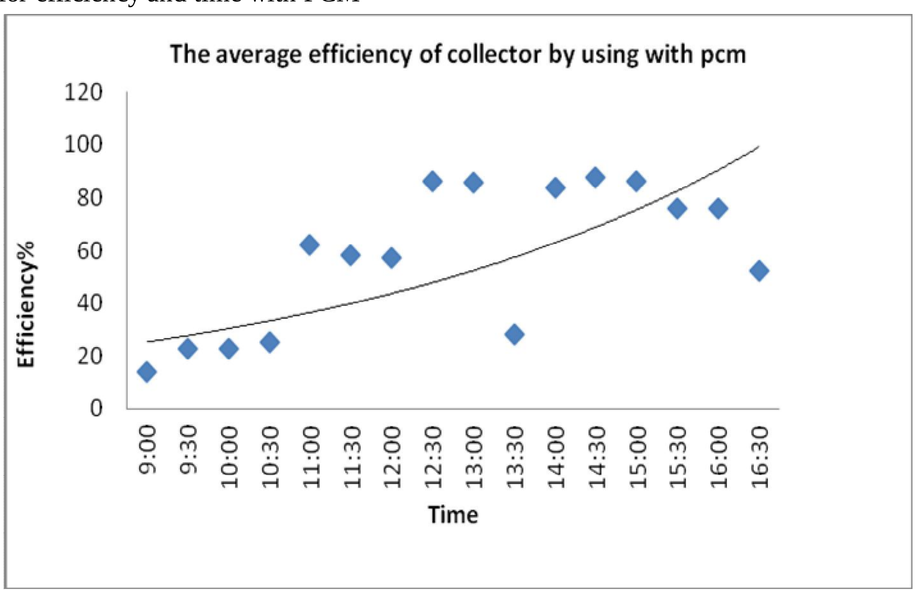
A. Reading With Atmospheric Air For Efficiency And Time For Solar Air Collector With PCM

1) Reading with atmospheric air by natural convection with PCM

m (kg/s)	Cp (KJ/kg.*K)	▲ T (*K)	I_β	Q_{useful} (W)	Q(W)	ὴ collector (%)
0.131	1003	7	949.5	919.751	6647	13.83
0.235	1003	3	1033	707.115	3099	22.81
0.262	1003	4	1144	1051.144	4576	22.97
0.301	1003	4	1184	1207.612	4738	25.48
0.747	1003	5	1201	3746.205	6004	62.39
0.668	1003	3	1148	2010.012	3443	58.37
0.629	1003	3	1097	1892.661	3292	57.49
0.878	1003	4	1017	3522.536	4069	86.56
0.786	1003	1	918.2	788.358	918.2	85.85
0.233	1003	1	830.4	233.699	830.4	28.14
0.564	1003	5	672.4	2828.46	3362	84.13
0.517	1003	4	589.5	2074.204	2358	87.96
0.416	1003	1	482.7	417.248	482.7	86.44
0.313	1003	2	412.5	627.878	825	76.10
0.306	1003	2	403.1	613.836	806.2	76.13
0.205	1003	3	390.9	616.845	1173	52.60

NOTE: Readings are taken from 9am to 5pm(1/2hour interval for each readings)

2) Comparison chart for efficiency and time with PCM



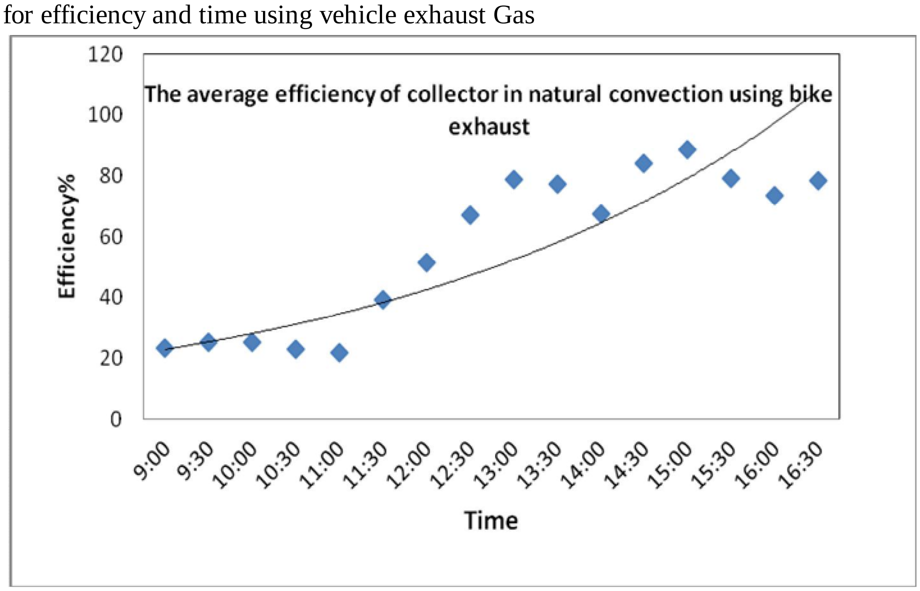
B. Reading With Atmospheric Air For Efficiency And Time For Solar Air Collector Using Vehicle Exhaust GAS

1) Reading With Atmospheric Air By Forced Convection Using Vehicle Exhaust Gas

m (kg/s)	Cp (KJ/kg. *K)	▲ T (K)	I_β	Q_{useful} (W)	Q(W)	ἠ collector (%)
0.22	1003	3	949.5	661.98	2849	23.23
0.26	1003	2	1035.1	521.56	2070	25.19
0.28	1003	1	1110.3	280.84	1110	25.29
0.275	1003	3	1204.2	827.475	3613	22.90
0.249	1003	4	1151.3	998.988	4605	21.69
0.432	1003	3	1099.3	1299.888	3298	39.41
0.524	1003	5	1020.7	2627.86	5103	51.49
0.616	1003	4	921.52	2471.392	3686	67.04
0.655	1003	4	835.21	2627.86	3341	78.65
0.52	1003	2	675.12	1043.12	1350	77.25
0.53	1003	1	589.3	531.59	589.3	67.45
0.408	1003	2	486.1	818.448	972.2	84.18
0.365	1003	3	412.5	1098.285	1238	88.75
0.309	1003	2	392.12	619.854	784.2	79.03
0.213	1003	1	290.87	213.639	290.9	73.44
0.205	1003	1	262.12	205.615	262.1	78.44

NOTE: Readings are taken from 9am to 5pm(1/2hour interval for each readings)

2) Comparison chart for efficiency and time using vehicle exhaust Gas



V. CONCLUSION

In this project, a flat plate solar air collector has been designed and developed. The collector was designed with PCM and without PCM and using atmospheric air and exhaust gases as inlets.

Some of the developments in the flat Plate Solar air collector are discussed. The basic idea of all the research is to increase the efficiency of the Flat-Plate Solar air Collector, reduce the time taken for remove the moister in the dry products and using the solar air collector at night hours.

This is achieved by making improvisations and innovations in the different parts of the air collector. Weather it may be done by the use of selective coatings; by modifying the path of the air flow so the heat transfer is proper, and to increase the heat transfer rate. Use of the corrugated copper sheet instead of the flat plate absorbers and also increased its thermal efficiency using PCM and reduced the losses of heat. According to our project the efficiency of the solar air collector without PCM (TIME:13.00=44.35%) and using PCM in solar air collector gives (TIME:13:00=51.33%).so the efficiency of the collector is increased when the PCM is used.

According to the above-mentioned results, it has been found that the collector provided with the phase change material using atmospheric air gave high efficiency when compared to collector without having phase change material provides less efficiency and the solar air collector can work without the need of the sunlight. However, the heat loss in the forced convection is considerably lower than the natural convection. Furthermore, the results showed that the average air speed in the forced convection was about higher than the natural convection which is important in solar dryers.

And it is noted that the Efficiency and Mass flow rate values of SOLAR AIR COLLECTOR is higher when the phase change material is used and it was achieved due improvisations and innovations in the different parts of the air collector.

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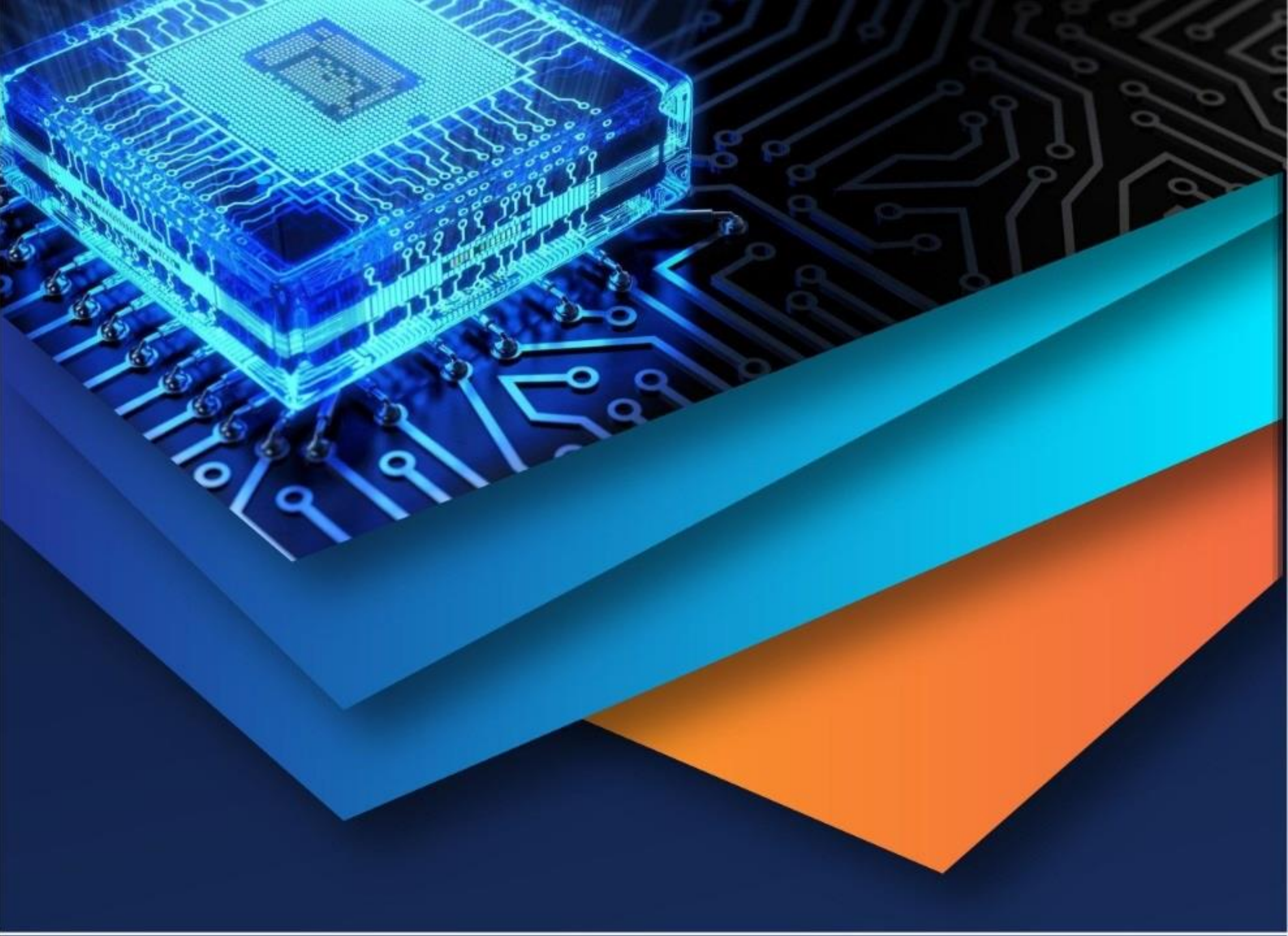

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