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# EXPERIMENTAL ENTROPY AND ENTHALPY ANALYSIS WITH COMPUTATIONAL STATIC THERMAL ANALYSIS OF NOVEL SOLAR AIR HEATER INTEGRATED WITH SENSIBLE HEAT STORAGE

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## ABSTRACT
Most of the solar air heater required direct sunrays to work and their effectiveness decrease due to unavailability of solar rays. This paper present an experimental entropy and enthalpy analysis with computational static thermal analysis of novel solar air heater composing of a concentric double pipe straight tube heat exchanger filled with oil in between them acting as sensible heat storage medium. Experiment were conducted in 75% sky clearance factor with air as working fluid within the range of 5000 to 10000 Reynolds Number. It is found that the novel solar air heater perform best at Re 5000 compare to higher Reynolds number with average air outlet temperature of 42.288 °C ± 1.6614 °C . The whole day average entropy change and enthalpy change for Re 5000 was found to be 0.3846 kJ/kg.K ± 0.0145 kJ/kg.K and 7.76 kJ/kg ± 1.8129 kJ/kg respectively. The energy transfer from heat exchanger to the air was gradually increasing independent of local time solar intensity but mainly dependent on the sensible thermal energy stored in oil. The least fluctuating effectiveness 140.2076 % ± 5.894 % throughout the day was found for Re 5000. It was also found that it can maintain air outlet temperature 7.76 °C ± 1.8129 °C above the ambient temperature .We expect this novel solar heater will be advantageous for the places where harvesting solar energy is limited due to its weather condition.

## INTRODUCTION
Power generation for developing nations is crucial to meets its needs for different sector like industry, telecommunication, defense and health care facilities. Trilemma which India facing today are demand of low cost power, adequate supply and environment conservation [1]. For such need, renewable energy stand out as a unique option for harvesting and generating energy. India is endowed with a very vast solar energy potential. Most parts of the country have about 300 sunny days. Average solar radiation incident over the land is in the range of 4-7 kWh per day. The solar energy can be utilized through solar photovoltaic technology which enables direct conversion of sunlight into energy and solar thermal technologies which utilizes heat content of solar energy into useful applications. Many ministry programs supporting for the deployment of renewable energy systems and devices such as biogas plants, photovoltaic systems, solar cookers and solar thermal systems for rural and semi-rural applications [2]. The "Development of Solar Cities" programs aims at minimum 10% reduction in projected demand of conventional energy at the end of five years which, can be achieved through a combination of energy efficiency measures and enhancing supply from renewable energy sources [3].

**Nomenclature**
$C_p$, Specific heat of air at constant pressure (kJ/Kg.K)
h, enthalpy (kJ/kg)
K, thermal conductivity (W/mK)
L, length of copper pipe (m)
M, mass (kg)
Q, heat transfer rate (W)
q, thermal Energy Stored (J)
R, resistance (K/W)
Re, Reynolds Number
$r_1$, inner diameter of inner copper pipe (mm)
$r_2$, outer diameter of inner copper pipe (mm)
$r_3$, inner diameter of outer copper pipe (mm)
$r_4$, outer diameter of outer copper pipe (mm)
s, entropy (kJ/Kg.K)
T, temperature (°C)
$T_1$, ambient temperature (°C)
$T_2$, air inlet temperature (°C)
$T_3$, air outlet temperature (°C)
$T_4$, lenses focus point temperature (°C)
$T_5$, focus node temperature (°C)
$T_6$, middle node temperature (°C)
$T_7$, average copper pipe surface temperature (°C)
$Z_1,\ldots,Z_n$, uncertainty factor

**Greek symbols**
Δ, differences
ε, effectiveness

**Subscripts**
o, oil
cu, copper pipe
sys, system
out, outlet
in, inlet

Solar power has grown exponentially in India attributed to Jawaharlal Nehru National Solar Mission (JNNSM) introduced in 16 June 2010 which was one of the eight mission launched as a part of the National Action Plan on Climate Change [4]. Solar installations have increased at a rate of 198 per cent from 2007 till March 2015. Installed capacity of solar power by the end of March 2012 was 941 MW and currently installed capacity till March 2015 was 3,383 MW, forecasting a revised target of 1,00,000 MW till 2022 [5]. Most commonly the method used for harvesting solar energy are either converting it in electric energy or thermal energy [6]. Conversion of solar energy to electric energy is done by using photovoltaic cells which use the photon energy present in light to excite the electron in silicon cells. The other method is using the thermal energy of light and storing them into materials like PCM or any sensible heat storage material [7] [8].
Deli et al. [9] used phase change thermal energy storage in solar heating system which result in increase of heating efficiency by 31.7%. Yu et al. [10] integrated solar energy harvesting in traditional heat pump drying and achieved 40.53% of energy consumption in term of thermal storage and heat recovery. Belmonte et al. [11] used solar heat stored in rocks and pebbles. They integrated it with PCM fluidized-bed storage in solar air system for building heating with 50% heat contribution from heated pebbles. Hamidreza et al. [12] developed a thermal network to predict the performance of latent heat thermal energy storage (LHTES) system including cascaded phase change materials and embedded heat paipes. It's found that LHTES with lowest melting temperature PCM yields higher exergy efficiency. Weihuan et al. [13] found using Magnesium chloride as PCM in LHTES with graphite form as additive improve the heat transfer and exergy efficiency of the system. Hassen et al. [14] used Portland cement in form of sprayed powder and adhesive layer as heat storage medium in solar desalination and studied the thermal behavior on the output and heat storage medium amount as resulted spraying 150 g of powder cement/m$^2$ of absorber area leads to improvement of the output by 51.14%. Nahar [15] presented a solar cooker with oil unit which act as sensible heat storage medium resulting in increase of efficiency by 27.5%. G. Kalaiarasi et al. [16] used copper as absorber-cum-storage unit in the analysis of flat plate solar air heater which result in 18.25-37.53% exergy efficiency and 49.4-59.2% maximum energy efficiency. Various material exhibits change in physical and chemical properties when expose to solar radiation. Some goes to phase change process other shows increase in entropy. In this research oil was used as heat storing medium which does not go under phase change process.

## EXPERIMENTAL SETUP

Experiments were conducted for different Re and tested at Parandwadi locality of Pune city of Maharashtra in India during month of January 2015. Its latitude and longitude are 18.6981° N, 73.6580° E, respectively. Table 1 shows the climatological data of Pune city obtain from Maharashtra Energy Development Agency. The monthly mean maximum and minimum temperature were 30.3 °C and 11.7 °C with sky clearance Factor of 75%. The radiation received in east or west and horizontal were 2162 W/m$^2$ and 4841 W/m$^2$ respectively.

**Table 1 Climatological Data of Pune City**

| Sr. No | Item | JAN | MAY | AUG | NOV |
|---|---|---|---|---|---|
| A | Temperature: Normal, Mean & Extremes ($^0$C) | | | | |
| | Normals | | | | |
| | 1. Mean monthly maximum | 30.3 | 37.1 | 27.6 | 30.3 |
| | 2. Mean monthly minimum | 11.7 | 22.4 | 21.4 | 14.7 |
| | 3. Mean highest of the month | 32.8 | 40.9 | 30.3 | 32.7 |
| | 4. Mean lowest of the month | 8.2 | 19.1 | 19.4 | 9.9 |
| | Extremes | | | | |
| | 5. Maximum ever recorded | --- | 43 | --- | --- |
| | 6. Minimum ever recorded | 1.7 | --- | --- | --- |
| B | Humidity and Rainfall | | | | |
| | 1. RH Morning (%) | 69 | 61 | 84 | 76 |
| | 2. RH Evening (%) | 25 | 32 | 74 | 35 |
| | 3. Mean Vapour pressure (m b) | 10.3 | 18.4 | 23.2 | 14.2 |
| | 4. Mean monthly rainfall (mm) | 1.5 | 26.9 | 90.2 | 27.4 |
| | 5. Mean annual rainfall (mm) | --- | --- | 672.8 | --- |
| | 6. Heaviest within 24 hrs. (mm) | --- | --- | 149.1 | --- |
| C | Wind | | | | |
| | 1. Prevailing directions | | | | |
| | Morning | C/S | W/NW | W/SW | C/E |
| | Evening | C/W | W/NW | W/NW | E/C |
| | 2. Mean monthly speed (m/s) | 5.95 | 14.65 | 14.32 | 5.95 |
| | 3. Mean number of days with wind force > 4/8 | | | | |
| | Morning | | 12 | | |
| | Evening | | 43 | | |
| D | Radiation (W/M$^2$) | | | | |
| | 1. Horizontal | 4841 | 7858 | 7702 | 5191 |
| | 2. East or West | 2162 | 3094 | 3094 | 2304 |
| | 3. South East or South West | 3780 | 1851 | 2149 | 3845 |
| | 4. South | 4919 | 104 | 427 | 5074 |
| | 5. North East or North West | 337 | 2511 | 2227 | 273 |
| | 6. North | --- | 1923 | 544 | --- |
| E | Sky Clearance Factor (%) | 75 | 71.3 | 16.3 | 60.7 |
| F | Comfort Zones | T – D | T - D | T – Hu | T - Hu |
| G | Comfort Conditions | 1-4 | 3-5 | 2-4 | 1-4 |

Figure 1 shows the schematic view of the experimental setup. The setup compose of two concentric copper pipe having value of $r_1$, $r_2$, $r_3$ and $r_4$ value as 3.5mm ,4.5mm , 5mm and 6mm respectively and the space between the pipes was filled with oil and the end were gas welded. The length L of each pipe was 500mm.The value of $K_o$ and $K_{cu}$ are 0.141 W/mK and 386 W/mK. Figure 2 represent the cross sectional view of heat exchanger. Oil used in heat exchanger was mineral oil JASO (T903): JASO MA-2 having viscosity SAE 10W-40 // 20 WW-50. 7 set of identical oil heat exchanger pipe were connected in parallel manner and placed in a wooden box of dimension 700x900x500mm. Figure 3 shows the experimental setup. The sun rays was concentrated on the surface of copper pipe with the help of 35 lenses having focal length of 450mm sporting on 35 points on the grid (5 focus point on each pipe) which is clearly shown in Figure 4. The insulating box is free to rotate and base can be move to any direction helpful to trace the sun rays. The air flow was generated using centrifugal blower of 0.5 HP motor rotating at 2800rpm.The air coming out from the blower is adjusted to require Reynolds number before it send to the experimental setup. The air flow was measured by TES-1340 hot wire anemometer having tiny glass bead thermostat structure.

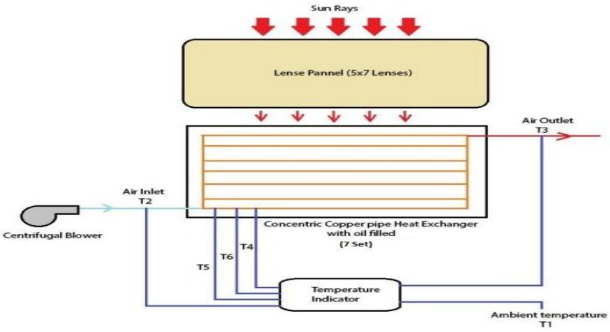


**Figure 1 Schematic view of setup**

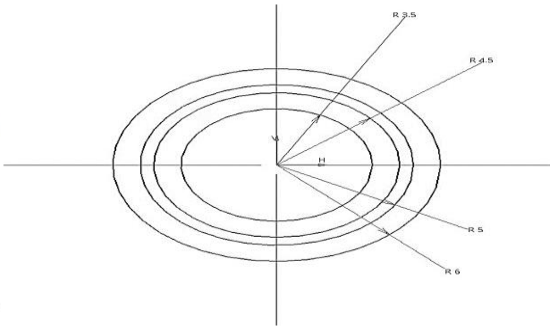

**Figure 2 Cross sectional view of heat exchanger**

The 7 set of oil heat exchanger are identical and place under same condition. Therefore representing the corresponding temperature of selected surface node we have attached sensor to single set of oil heat exchanger at three different position. The dialer can switch on to the corresponding numbered sensor placed at different position and its temperature reading can be seen on digital display.

**Figure 3 Experimental Setup**

**Figure 4 Inside view of setup when expose to sunrays**

The reading from the experiments was measured with the help of suitable instrument and there uncertainty are listed in Table 2. The relative uncertainties in the individual factor $Z_n$, the total uncertainty could be represented as in Eq. (1).

$$W = [(Z_1)^2 + (Z_{21})^2 + \cdots (Z_n)^2]^{\frac{1}{2}} \quad (1)$$

Table 2 Uncertainty in measurements

| Measurement parameters | Error limits |
|---|---|
| Uncertainty in the measurement of temperature | |
| Ambient air temperature | ± 1 °C |
| Copper pipe surface temperature | ± 1 °C |
| Air inlet temperature | ± 1 °C |
| Air outlet temperature | ± 1 °C |
| Lenses focus point temperature | ± 1 °C |
| Uncertainty in time measurement of temperature values | ± 1 min |
| Uncertainty in reading values of table | ± 1-2 % |

The tests were conducted from 11:00 hrs. to 15:30 hrs. during which maximum solar radiation falls on earth surface and atmospheric mean temperature was calculated for same duration hours. Density and dynamic viscosity of air was calculated for corresponding atmospheric mean temperature using online air property calculator provided by Microelectronics Heat Transfer Laboratory. For required Reynolds number, the velocity of air to be circulated into the setup was calculated with the tests day air density and dynamic viscosity value. The sun was manually traced with the help of rolling balls arrangement of insulating box such that the lenses panel should focus the rays concentrated on heat exchanger. For every half an hour the reading of six temperature sensor was taken with digital temperature indicator. Each dialer position give corresponding numbered sensor temperature value.

**Table 3 Sample calculation of various parameters with respect to time for Re 5000**

| Time | Ambient temperature ($T_1$) | Air inlet temperature ($T_2$) | Air outlet temperature ($T_3$) | Lenses focus temperature ($T_4$) | Focus node temperature ($T_5$) | Mid node temperature ($T_6$) | Average copper surface temperature ($T_7$) | Enthalpy change (Δh) | Entropy change (Δs) |
|---|---|---|---|---|---|---|---|---|---|
| Hours | °C | °C | °C | °C | °C | °C | °C | KJ/kg | KJ/kg.K |
| 11:00 | 34.88 | 34.88 | 34.88 | 34.88 | 34.88 | 34.88 | 34.88 | - | - |
| 11:30 | 37.8 | 34.8 | 40.1 | 130.6 | 62.3 | 64.6 | 63.45 | 5.3 | 0.3538 |
| 12:00 | 38.5 | 34.6 | 41 | 125.5 | 68.1 | 69.7 | 68.9 | 6.4 | 0.4041 |
| 12:30 | 38.6 | 34.7 | 41.1 | 130.2 | 68.4 | 67.2 | 67.8 | 6.4 | 0.3906 |
| 13:00 | 38.7 | 34.7 | 42.3 | 121.5 | 70.3 | 69.7 | 70 | 7.6 | 0.4004 |
| 13:30 | 39.3 | 34.9 | 43.1 | 136.6 | 68.2 | 70.4 | 69.3 | 8.2 | 0.3828 |
| 14:00 | 40 | 34.9 | 43.2 | 130.8 | 69.3 | 70.8 | 70.05 | 9.3 | 0.37769 |
| 14:30 | 39.5 | 34.3 | 44.3 | 134.4 | 69.1 | 71.5 | 70.3 | 10 | 0.37925 |
| 15:00 | 39 | 34.3 | 43.2 | 137.4 | 68.6 | 71.2 | 69.9 | 8.9 | 0.3882 |
| 15:30 | 38 | 34.1 | 43.7 | 137.4 | 68.8 | 71.5 | 70.12 | 9.6 | 0.3849 |

## THERMAL ANALYSIS

Thermal analysis is a tool which help us to understand and explain the behavior of material and system undergoing to rate of change of temperature. This paper investigate the performance of system for different Re using thermodynamic property like change of entropy and change of enthalpy.

### A. CHANGE OF ENTROPY ANALYSIS

Entropy is a property used to determine the loss of energy due to irreversibility of the process. This is very important property to consider during analysis of solar air heater because it clarify the addition of heat i.e. heat transferring from heat exchanger to air is increasing or decreasing for local time instant. We could express this as in Eq (2).

$$\Delta S_{sys} = \frac{Q_{out}}{T_{system}} \quad (2)$$

Where

$$Q_{out} = \frac{\Delta T}{R_{Total}} = \frac{T_7 - T_3}{R_{Total}} \quad (3)$$

### B. CHANGE OF ENTHALPY ANALYSIS

Enthalpy is another important thermodynamic property used to analysis the system which represent the total heat contain of the system. Here, the change of enthalpy of working fluid air is consider. This help us to understand the amount of energy air is getting from solar air heater to the air. The equation can be written as Eq (4).

$$\Delta h = mC_p(T_3 - T_2) \quad (4)$$

### C. EFFECTIVENESS

Effectiveness help us to determine the actual performance of air solar heater which was carried out for different Reynolds number with respect to the expected maximum performance it can achieved. This can be shown by Eq (5).

$$\varepsilon = \frac{Q_{actual}}{Q_{max}} \quad (5)$$

Where, $Q_{actual}$ and $Q_{max}$ is calculated from,

$$Q_{actual} = \frac{\Delta T}{R_{Total}} = \frac{T_7 - T_3}{0.2381} \tag{6}$$

$$Q_{max} = \frac{\Delta T}{R_{Total}} = \frac{68.936 - 46.6}{0.2381} = 93.809\ W \tag{7}$$

For $Q_{max}$, the value taken for $T_7$ and $T_3$ are the maximum value achieved during the experimental trials.

**Table 4 Average lenses focus temperature and average heat exchanger outer surface temperature of whole day for different Reynolds Number**

| Sr. No. | Reynolds Number | Average lenses focus temperature ($T_4$) of whole day (°C) | | Average heat exchanger outer surface temperature ($T_7$) of whole day (°C) | |
|---|---|---|---|---|---|
| | | Mean | Standard Deviation | Mean | Standard Deviation |
| 1 | 10000 | 114.61 | 41.30594 | 61.04 | 11.69334 |
| 2 | 9000 | 130.716 | 53.25386 | 64.936 | 14.42169 |
| 3 | 8000 | 145.226 | 40.99068 | 68.551 | 13.31498 |
| 4 | 7000 | 145.046 | 40.4437 | 67.501 | 13.273 |
| 5 | 6000 | 128.423 | 34.95986 | 65.018 | 11.52023 |
| 6 | 5000 | 121.928 | 31.02369 | 65.473 | 10.96525 |

## COMPUTATIONAL STATIC THERMAL ANALYSIS

Solar rays were getting concentrated with the help of lenses and falling on the outer surface of copper pipe. This thermal heat was getting transfer from surface to oil and to inner copper pipe and finally to working fluid air. The analysis was done to understand the surface temperature distribution on heat exchanger for different Reynolds number with experimentally obtain results. Static thermal analysis is based on the below assumptions.

i. Conductivity of the material used in analysis has the total thermal conductivity of oil and copper pipe
ii. Whole day average of $T_4$ and $T_7$ obtain for different Reynolds number was taken for analysis purpose, neglecting the fluctuation. Refer Table 4 for obtain value.

### A. GEOMETRY & MESHING

The heat exchanger modeled exactly like the real constructed setup used in experiment. The copper pipe length and lenses focus spacing on copper surface also identical to the real experimental setup. Initial a relatively fine mesh is generated with fine smoothing and fine span angle center with element size of 1.e-002m and minimum edge length of 1.e-002m. The generated mesh contain 19957 nodes and 10201 elements. Figure 5 represent the orthogonal and cross section view of mesh component.

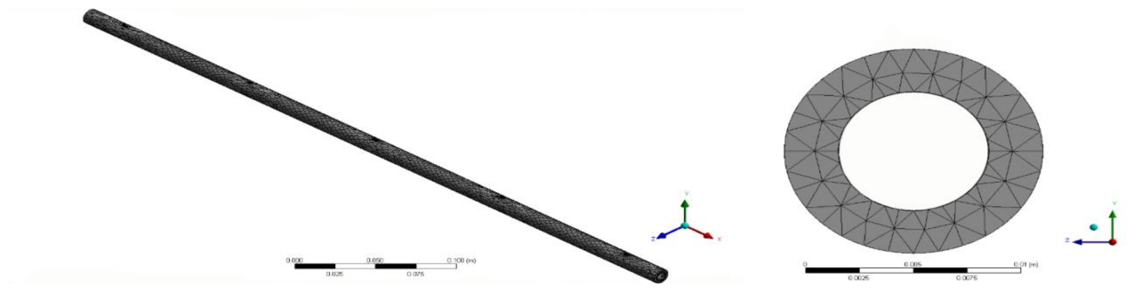

**Figure 5 Orthogonal and cross section view of mesh component**

## RESULTS AND DISCUSSION

The thermal surface condition achieve by static thermal analysis was different for different Reynolds number trials. The temperature pattern obtain resemble the same for every trial but they show variation in the maximum and minimum temperature range of the surface. The Table 4 show the surface temperature condition achieved by experiment and Figure 6 shows analytically obtain surface temperature distribution of the heat exchanger for different Re. At Re 8000, the maximum value of average $T_4$ was achieved about 145.226 °C with maximum average $T_7$ of 68.551 °C. For Re 10000, average $T_4$ was 114.61 °C with average $T_7$ of 61.04 °C. This shows that the average lenses focus temperature of whole day was directly proportional to the average heat exchanger outer surface temperature of whole day. Which explain the dependency of setup on the availability of solar intensity throughout the day.

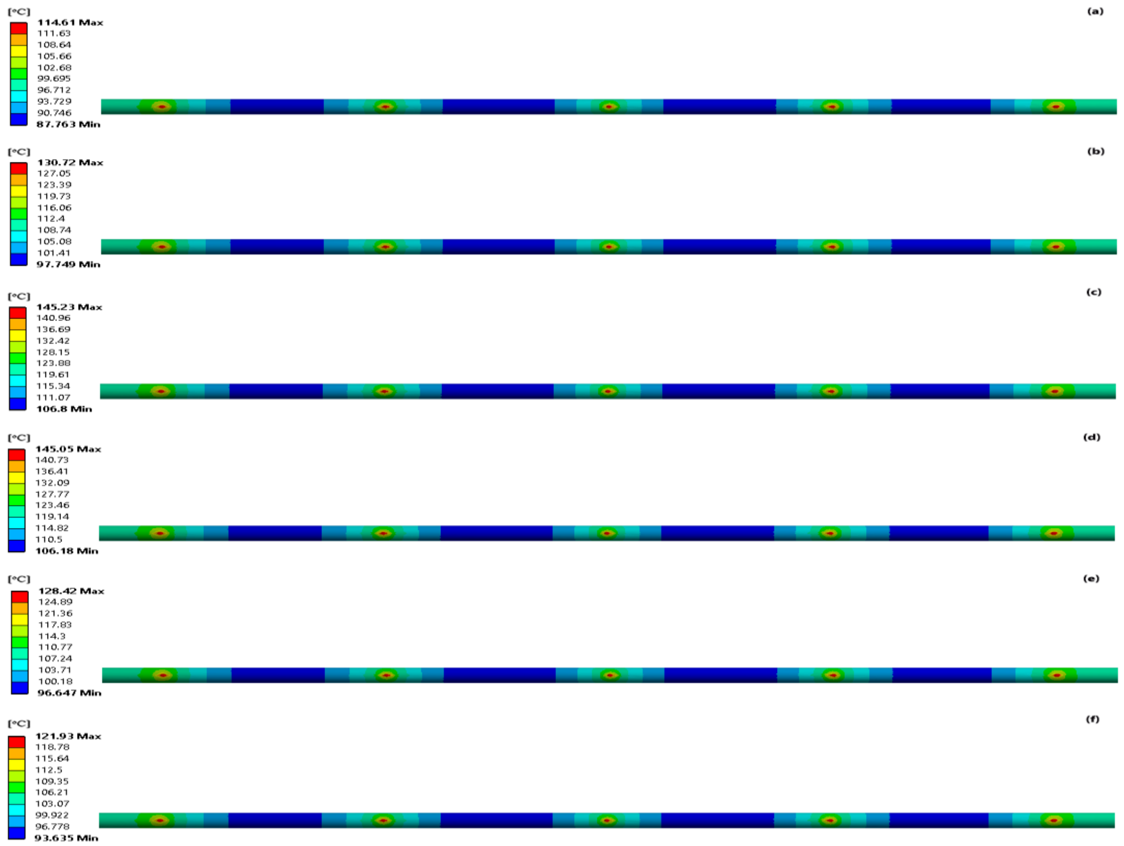


**Figure 6 Temperature distribution on heat exchanger surface at (a) Re 10000, (b) Re 9000, (c) Re 8000, (d) Re 7000, (e) Re 6000 and (f) Re 5000**

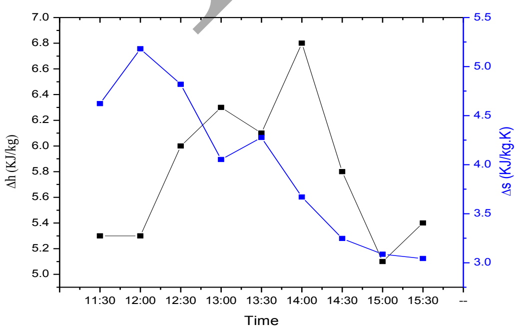


**Figure 7 Δh and Δs at Re 10000**

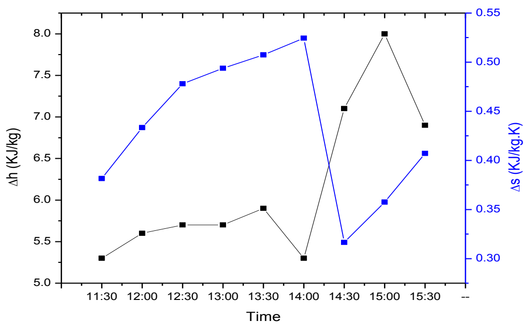


**Figure 8 Δh and Δs at Re 9000**

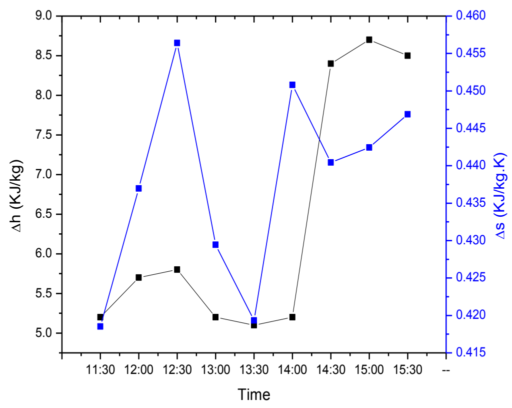


**Figure 9 Δh and Δs at Re 8000**

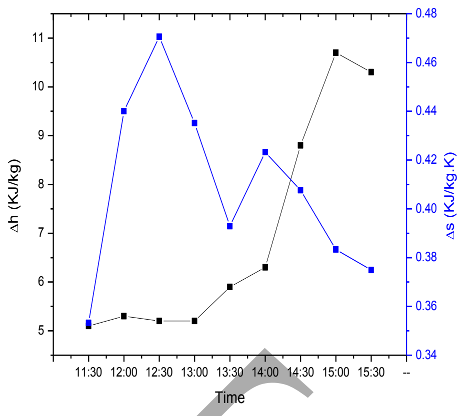


**Figure 10 Δh and Δs at Re 7000**

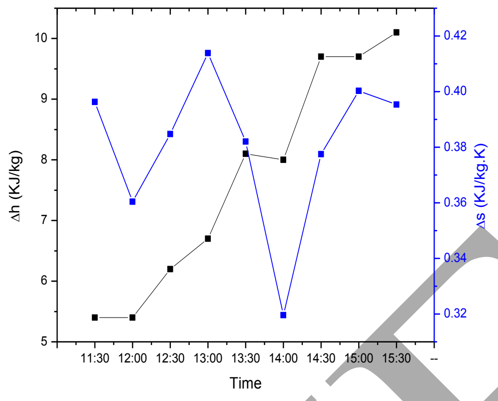


**Figure 11 Δh and Δs at Re 6000**

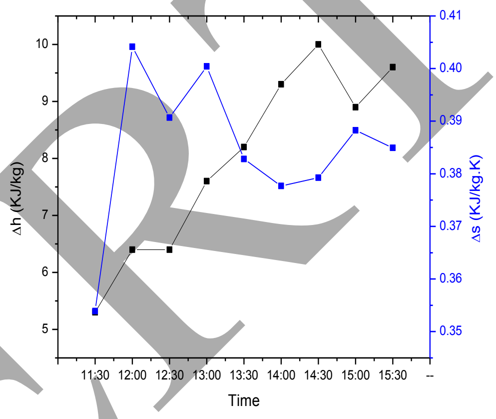


**Figure 12 Δh and Δs at Re 5000**

The study of Δ h and Δ s is used to understand the amount of thermal energy transferred from heat exchanger to air and the amount of energy lost due to irreversibility. Figures 7-12 shows the variation in enthalpy change and entropy change for 10,000 to 5,000 Reynolds number. Figure 7 show the rapid peak and valley of Δ h about 6.8 KJ/kg and 5.1 KJ/kg. It also show it dependency with solar intensity as its maximum value 6.8 KJ/kg was achieved at 14:00 hrs. when solar intensity was found maximum. Figure 8-9, shows the different result as compare to Figure 8. Sudden hike of Δ h about 7.1KJ/kg as obtain in the graph can be result of clear sky resulting in high solar intensity which leads to sudden increase of thermal energy at heat exchange and ultimately transferring it to the air but it was not consistent. Fig 10-11 shows different result then previous. The heat energy transferring from heat exchange to air show more gradually increased result with time irrespective of solar intensity. It because the mass flow rate for Re<8000 had sufficient retention time for air in heat exchanger to gain thermal energy from the heat storage medium. Fig. 12 showed a smooth graduation increase in Δ h for Re 5000 from 5.3 KJ/kg at 11:30 hrs. to 10 KJ/kg at 14:30 hrs. At 15:00 hrs. the value of Δ h drop little bit to 8.9 KJ/kg and then again start rising to 9.6 KJ/kg at 15:30 hrs. This fall of Δ h was also observe for Re 6000 after 14:00 hrs. to about 9.7 KJ/kg at 15:00 hrs., but at 15:30 the value of Δ h again raised up to 10.1 KJ/kg. This clearly state that the value of Δ h doesn't depend on the availability of local time solar intensity but the thermal energy stored in oil which ultimately heating the air.

Figure 7 of Re 10000 shows fine slop of decrease in Δ s from 0.3477 KJ/kg.K at 12:00 hrs. to 0.2253 KJ/kg.K at 15;30 hrs. This explain that the thermal energy doesn't got transfer from heat exchanger to air because of high mass flow rate. Therefore the energy lost while transferring thermal heat to air was decreased. Figure 8-11 shows sudden increase and decrease in Δ s, i.e. high fluctuations of energy loss due to irreversibility. This shows that for Re>6000 the Δ h value may increase but the loss of energy also increases. Figure 12 shows minimum value of Δ s variation about 0.3846 KJ/kg.K ± 0.0145 KJ/kg.K. This means that the energy loss due to irreversibility is dependent on mass flow rate. Higher the value of Re, higher will be Δ s. Re 5000 had minimum flow rate which provide maximum retention time for air in heat exchanger which leads to smooth gradual increase in Δ h with minimum Δ s.

Figure 13 shows the air outlet temperature ($T_3$) variation with respect to time for different Re. The graph obtain for 10000 ≥ Re > 7000 shows sudden increase and decrease of $T_3$ value. This because air does not get enough retention time in heat exchanger to gain heat from sensible heat store medium. For Re 7000, 6000 and 5000 the average $T_3$ obtain was 42.286 °C ± 3.2994 °C, 42.113 °C ± 2.1959 °C  and 42.288 °C ± 1.661 °C  respectively. Which explain that providing maximum retention time for air by reducing the mass flow rate into the setup result in high average $T_3$. Thus the maximum average $T_3$ achieved with minimum standard deviation for Re 5000 which was 42.288 °C with standard deviation of 1.661 °C.

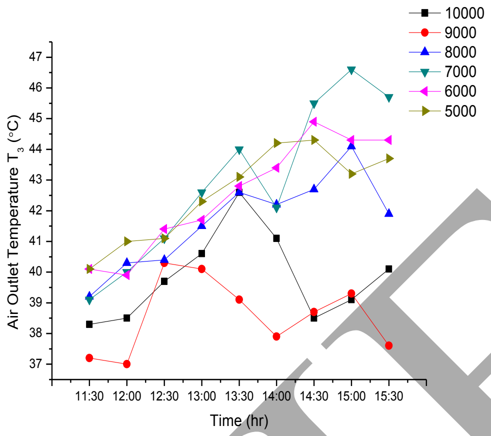


**Figure 13 Time vs. air outlet temperature ($T_3$)**

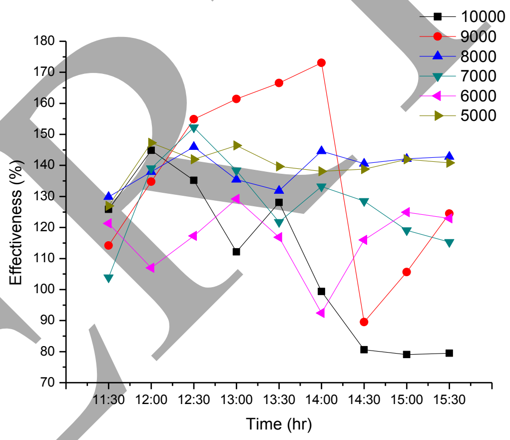


**Figure 14 Time vs. effectiveness for different Reynolds for different Reynolds number**

Figure 14 represent the effectiveness of heat exchanger with respect to time for Re 10,000 to 5,000. Highest effectiveness of 173.0396 % was achieved for Re 9000 at 14:00 hrs. but it was not consistent throughout the day. Re 10000, 9000 and 7000 shows effectiveness variation of 109.3903 % ± 25.7272 %, 136.0539 % ± 29.5761 % and 127.9205 % ± 14.5953% respectively. Re 8000 and 5000 shows minimum variation of effectiveness about 139.0137 % ± 5.6553 % & 140.2076 % ± 5.894 % respectively. Although the effectiveness percent of Re 8000 and Re 5000 seems to be nearly same but from graph it can be seen that the curve plotted by Re 5000 was much smooth then the curve plotted by Re 8000. This means that the fluctuation of effectiveness was less for Re 5000. This shows that this setup works best with low mass flow rate and Re≤5000. Here also from graph we can see that the maximum effectiveness is independent of time and local time solar intensity.

## CONCLUSION

A comparatively experimental investigation of novel solar air heater with sensible heat storage medium was conducted for different Reynolds number at Pune city in India. Their performance was experimentally analyzed based on enthalpy change and entropy change with computational static thermal analysis to visually inspect the temperature distribution on the surface of solar air heater. Experiment was conducted from 11:00 hrs. to 15:30 hrs. for Re 10000, 9000, 8000, 7000, 6000 and 5000. The interesting facts and findings from the comparison study could be summarized as follows.

i. From static thermal analysis of all Reynolds number, it was found that the surface temperature distribution considering the lenses focus temperature and surface temperature of solar air heater are dependent on solar intensity and fluctuate with time.
ii. For all cases, enthalpy change does not depend on local time solar intensity. That means the amount of thermal energy transferred from heat exchanger to air depends on the thermal energy stored in sensible heat storage medium.
iii. For all cases, entropy change only depend on mass flow rate of working fluid air and independent of local time solar intensity. This means lower the value of Reynolds number, lower will be energy loss due to irreversibility.
iv. For all cases, the air outlet temperature was independent of local time solar intensity and depends only on the mass flow rate of air. Which means higher the retention time for air in the setup, higher it temperature will get.
v. Effectiveness varies for different Reynolds number. The most stable effectiveness was achieved at Re 5000.

Thus, static thermal analysis, entropy change analysis and enthalpy change analysis of novel solar air heater conclude that it produce optimize result at Re 5000. The thermal heat stored in sensible heat storage medium act as an auxiliary source of heat when the sky is covered with clouds. The application of this novel solar air heater with sensible heat storage is where we have to maintain temperature of a control volume for about 7.76 °C ± 1.8129 °C above the ambient temperature. This type of need is mostly in food processing industry where we have to maintain such type of conditions.

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