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Performance Investigation On Solar Chminey For Building Ventilation Using Phase Change Materials

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Abstract– This study sought to demonstrate the potential applications of the solar chimney for the naturally ventilating a building To mitigate the cost and effort to use experiments to analyze building energy, . A relationship between small- and full-scale models was investigated using non-dimensional analysis. to predict the air velocity, where the predictions were in good agreement with experimental data as well as the numerical simulations from the present study. The second part of the study considered building design optimization to improve ventilation using air changes per hour (ACH) as a metric, and air circulation patterns within the building. An upper vent was introduced near the ceiling of the chimney system, which induced better air circulation by removing the warm air in the building. The study pursued to model realistic scenario for the solar chimney system, experiments were conducted and its validated

Index Terms: Wear track radius, EN 8, EN 31, Energy Dispersive X ray (EDX) analysis, Scanning Electron Microscope (SEM) studies

1. INTRODUCTION

Energy consumption is an important issue and has become a great concern during the last few decades. Fossil fuels (coal, oil, and natural gas) are currently the dominant energy resources, accounting for 82% of energy consumption in U.S [1]. However, burning fossil fuels for our convenience releases carbon dioxide and leads to a greenhouse effect, acid rain, and environment hazards [2]. According to a temperature analysis by Hansen et al. [3] at Goddard Institute for Space Studies (GISS), the average global Earth temperature has increased approximately by 0.8 C (1.4 F) since 1880, where most of the warming occurred in the last few decades at a rate of 0.2 C per decade since 1970.

Another concern is a rapid increase in energy consumption while energy resources are limited. The U.S. Energy Information Administration projected that world energy consumption will increase 56% between 2010 and 2040 [4], from 524 Btu to 820 Btu. Building energy utilization accounts for approximately 41% of total energy consumption in the U.S [5], where most of building energy is used for space heating and cooling purposes. While considering ventilation of the building, the indoor air quality must be considered. The average person in the U.S. spends more than 90% of their time in buildings [6]. Thus, it is important to maintain comfortable indoor

conditions. Natural ventilation has a potential to save energy costs as well as to maintain good air quality within the building [7-10], where natural ventilation is a method to deliver fresh air through buildings creating pressure difference. There are

\two types of natural ventilation: wind-driven ventilation and stack ventilation (buoyancy-driven ventilation), and occur by wind and buoyancy forces, respectively. Stack ventilation occurs due to presence of vertical pressure difference developed by thermal buoyancy [7]. There are two main ventilation 2 principles: single-sided and cross ventilation. Single-sided ventilation involves a room with one opening. Depending on climate and locations of the buildings, the required ACH may vary, and can be very high, around 50 to 100 ACH to supply sufficient air to enhance thermal comfort (scenario 3). ASHRAE [13] introduced acceptable temperature ranges for naturally conditioned spaces with respect to outdoor air temperature, C.°C and 33.5 °which is applicable when outdoor air temperature is between 10 The range of acceptability changes depending on T∞, where the upper and lower .∞limits have a linear relationship with a respect to T

2. EXPERIMENTATION

The experimental setup for the solar chimney system is made, it consists of absorber plate, the room with volume 1.5m×1.2m×1.8m insulated with 2.5 cm thick thermocol sheet outside the Chamber the air gap and Chimney inlet is carried from 0.1 to 0.3 incremental of 0.1 the window are placed 0.5 m high on the northern wall with dimension The wooden plywood sheets are constructed with names of size 8 d and 10 d which are used it represent denarius , in the penny system nails has thick shank, wide head and the round shaped point.Opening in one side and the three sides are joined by their nails, top part of the room is closed the opening part is meant for the absorber plate and back portion is to be cut in some form to make a window. Absorber plate of

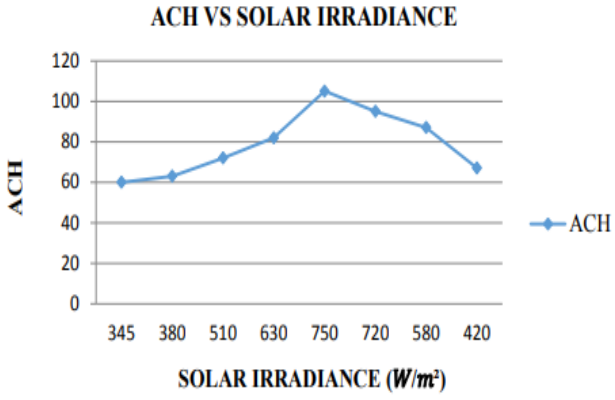
aluminium is chosen instead of copper, though copper has high thermal conductivity but cost of copper is considerably high when compared to aluminium, procurement of thermal conductivity is also good . It is constructed like a box inside with phase change material is poured into it aluminium sheet of gauge 30 is folded and joined by using nails of size 4d which had been used for the construction purpose ,in the fig the 2 separate plates are joined by placing the wood over the backside to provide stability .

Aluminium sheet of thickness 0.06mm is used and it is constructed with the volume of capacity 1.2 × 0.06 × 1.2 front hand part of the absorber plate is coated with the black plain to observe the more temperature. The heat in the infrared part has maximum intensity of it, the absorber plate is a good conductor of heat naturally, this heated plate will re-radiate when it is in contact with the air.

When the absorber plate is heated up it radiate back because the temperature is not as high as sun.it radiate almost whole energy in the form of infrared rays this has to be arrested by one surface. This surface should allow all the energy from the sun to pass through the absorber plate, but it should not allow radiation out from the absorber plate most of the form in infrared range .the best surface is glass cover.The visible range which is coming into the absorber plate, the infrared part is trapped into the region of absorber plate and the glass cover.

Table 1. Room specification

Parameter	Specification
volume	3.24m3



2.2 Testing Procedure

DSC analysis measures the amount of energy absorbed or released by a sample when it is heated or cooled, providing quantitative and qualitative data on endothermic (heat absorption) and exothermic (heat evolution) processes. The sample is placed in a suitable pan and sits upon a constantan disc on a platform in the DSC analysis cell with a chromel wafer immediately underneath. A chromel-alumel thermocouple under the constantan disc measures the sample temperature. An empty reference pan sits on a symmetric platform with its own underlying chromel wafer and chromel-alumel thermocouple. Heat flow is measured by comparing the difference in temperature across the sample and the reference chromel wafers. Temperature can range from -120°C to 725°C, though an inert atmosphere is required above 600°C. The temperature is measured with a repeatability of ±0.1°C. We have access to a higher temperature DSC/DTA instrument capable of a maximum temperature of 1500°C, though it has a lower sensitivity at temperatures below 725°C compared to our primary DSC.The basic principle underlying this technique is that when the sample undergoes a physical transformation such as phase transitions, more or less heat will need to flow to it than the reference to maintain both at the same temperature. Whether less or more heat must flow to the sample depends on whether the process is exothermic or endothermic

3. RESULTS AND DISCUSSION

3.1 Solar chimney without PCM

The experiments are conducted in the month of april 4th and 5th duration for 9:00 to 16:00 the solar irradiance are found using pyrometer available in the energy laboratory K type thermocouple is used and it is calibrated it is attached in absorber plate ,glass cover. when the solar radiation passes over the glass cover it allows all the electromagnetic radiation except Infrared rays , test duration is between 1hour duration the temperatures are calculated when the thermal stability occurs

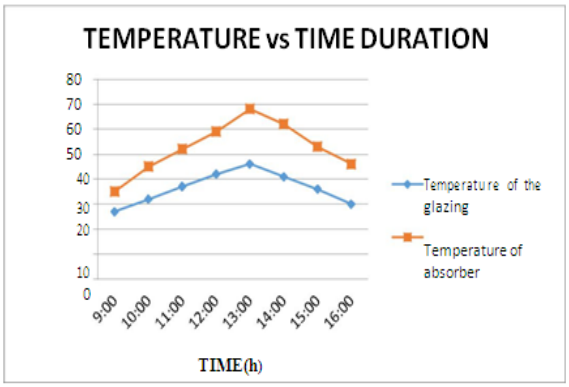
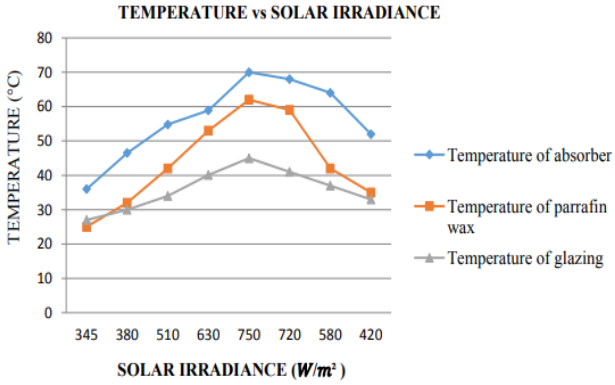


Fig 1.Temperature vs Time duration

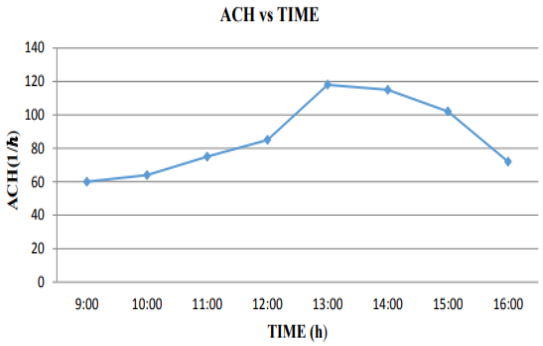
3.2 solar chimneys with PCM

The experiments are conducted in the month of April 23rd and 24th the results are obtained for same solar irradiance the obtained results are following



At 9:00 clock the south facing absorber plate the setup is stagnant and it is not altered the solar radiation fall on the glass cover is less so the temperature will be low. But when the times goes on increasing the absorber plate and the solar irradiance with the different wavelengths will strikes this tends to increase the absorber plate. This happens steadily as the time keeps on increasing. As the glass is an opaque surface it won't allow the radiated energy loss in the form of infraredrays.

This portion trapped IR frequency energy in the zone of absorber plate and the glass cover this makes further more to increase the temperature in absorber plate in the time duration of 13:00 and it is recorded as a highest temperature in the absorber plate 70° C the phase chase material temperature has recorded to be 62 ° C during this time exothermic reaction occurs the PCM release the heat in the form of sensible heat as well in the latent heat ,it also be noticed that once the temperature drops to 60º C , the energy release is maintain a steady state temperature for approximate 45 min

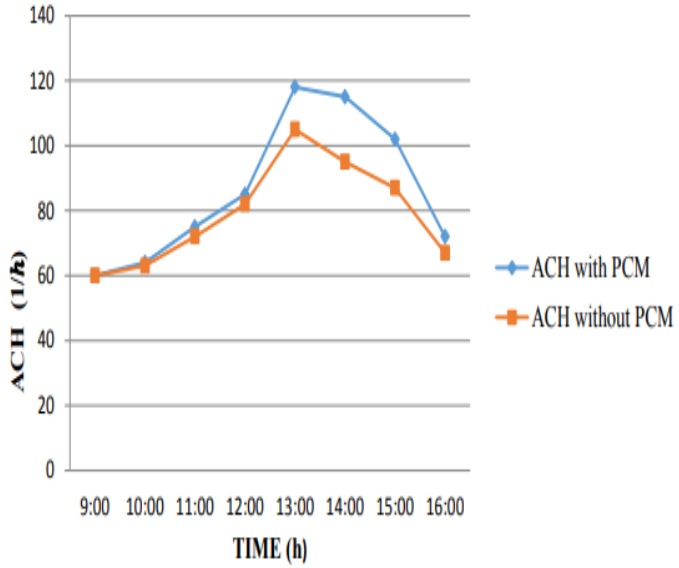


It shows the variation of air Flow meter cube per hour according to change in the absorber plate and the glass plate arrangement it note that the distance between the absorber and glass plate increases air flow in the chimney it is noticed air flow corresponding to temperature rise in the absorber plate increases the plastic flow inside the Solar chimney increases this leads to change in air inside the room.

DSC CURVE FOR PARAFFIN

The curve which is in positive x axis is said to exothermic heat flow(cooling)The curve which is placed below the y-axis is said to be heat flow (heating)□As we endothermic see in endothermic reaction (glass temperature) the temperature at which change in amount of crystalline structure occurs□Energy required for the transformation for phase change occur,solid to liquid transformation occurs□Two different peaks are identified in the curve of endothermic ,this shows that two different crystal morphology is present

The peak at 64 ºC shows that solid paraffin wax converted to liquid form heating followed by cooling occurs, while cooling at occurs at 57 °C the ability of molecules to get phase change.The curve while cooling shows the crystalline formation hence heat has be released



4. CONCLUSIONS

When the solar irradiance increases causing the heated air in the chimney to rise so the external ambient air to enter through the window.At the top window position ACH is less than the middle window position.From the fig it shows that by incorporating PCM over the absorber plate will increase the ACH when the solar irradiance intensity increases.The solar irradiance intensity makes temperature to increase the temperature in absorber plate. The plate releases heat to the PCM by conduction when the temperature of absorber plate reaches 70c the part of PCM in solid form gets converted to liquid form .The phase transition occurs after 45min it converts back to solid form by releasing the heat to the absorber plate this makes velocity to increase in the room , this leads to increase the ACH.

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