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PERFORMANCE ANALYSIS OF YEAR ROUND AIR CONDITIONING SYSTEM WITH THE USE OF PHASE CHANGE MATERIAL

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ABSTRACT **-**This report deals with performance analysis of year round air conditioning system with the use of Phase Change Material to increase its Co-efficient of Performance. The idea of phase change materials (PCM) used for the purpose of storing thermal energy is to make use of the latent heat of a phase change, usually between the solid and the liquid state. Since a change of phase involves a large amount of latent heat of energy at small temperature changes, PCMs are used for temperature stabilization and for storing heat with large energy densities in combination with rather small temperature changes. The usage of PCMs is on one hand a question of a high energy storage density, but on the other hand it is very important to be able to charge and discharge the stored energy with a thermal power, that is suitable for the desired application. In the work presented, the analysis on air conditioning system is done with and without the use of Phase change material and their respective co-efficient of performances is calculated. *KEYWORDS:* air conditioner, phase change material (PCM), latent heat storage, calcium chloride hexahydrate, copper, refrigerant (R22), co-efficient of performance.

I.INTRODUCTION

It is true that rapid industrialization has led to unprecedented growth, development and technological advancement across the globe. It has also given rise to several new concerns. Today global warming and ozone layer depletion on the one hand and spiraling oil prices on the other hand have become main challenges. Excessive use of fossil fuels is leading to their sharp diminution and nuclear energy is not out of harm's way. In the face of imminent energy resource crunch there is need for developing thermal systems which are energy efficient. Thermal systems like refrigerators and air conditioners consume large amount of electric power. So it is necessary to develop energy efficient refrigeration and air conditioning systems. Fossil fuels are used to produce energy. But these fossil fuels are present in limited amount under the earth's crest. So scientist from all over the world is trying to find new and renewable energy sources. One of the options is to develop energy

storage devices like thermal energy storage system which has the potential to attain energy savings, which in turn reduce the environment impact related to energy use. The pollutants coming from the combustion of these fuels are increasing the temperature of earth rapidly which caused the invention of air conditioning system to reduce the temperature of air inside a system. This led to increase in demand for air conditioning greatly during the last decade. Large demands of electric power and limited reserves of fossil fuels have led to surge of interest with efficient energy application. Electrical energy consumption varies significantly during the day and night according to the demand by industrial, commercial and residential activities. In hot and cold climate countries, the major part of the load variation is due to air conditioning and domestic space heating respectively. This variation leads to utilization of energy in different amount at different time due to which price of electricity changes according to use. Better power generation/ distribution management and significant economic benefit can be achieved if some of the peak load could be shifted to the off peak load period that can be achieved by thermal energy storage for heating and cooling in various application. Thermal energy storage (TES) is the temporary storage of high or low temperature energy for later use. It bridges the time gap between energy requirements and energy use. Among the various heat storage techniques of interest, latent heat storage is particularly attractive due to its ability to provide a high storage density at nearly isothermal conditions. Phase-change thermal energy storage systems offer other advantages, such as a small temperature difference between storage and retrieval cycles, small unit sizes and low weight per unit storage capacity. One of prospective techniques of storing thermal energy is the application of phase change materials. Cold thermal energy storage (TES) and the use of phase change materials (PCM) are an advanced energy technology that has recently attracted increasing interest in industrial refrigeration applications such as process cooling, food preservation and air conditioning.

II. PHASE CHANGE MATERIALS

Phase change materials are the materials which changes its state according to specific temperature. This state change takes place through the exchange of latent heat. Hence these materials are latent heat storage materials (LHSM).Phase change materials latent heat storage can be achieved through liquid-liquid, solid-liquid, solid-gas and liquid gas phase change. Initially, these solid–liquid PCMs perform like conventional storage materials. When a PCM freezes, it releases a large amount of energy in the form of latent heat at a relatively constant temperature.

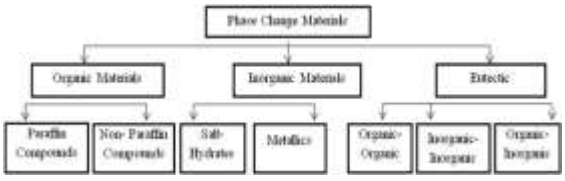

Figure:1 Types of PCM

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Conversely, when such material melts, it absorbs large amount of heat from the environment. PCMs recharge as ambient temperatures fluctuate, making them ideal for a variety of everyday applications that require temperature control.

III. WORKING PRINCIPLE OF PCM

The process of changing state from one form to another form is called as phase change. Any material exhibits four phases which are solid, liquid, gas and plasma. There are four phase change process by which material changes its state which are i) solid-liquid ii) liquid-gas iii) liquid-solid and iv) solid-gas. Each process requires use of thermal energy to change the phase. Thermal energy available can utilized by four ways which ae 1) sensible heat utilization 2) latent heat utilization 3) utilization of reversible chemical heat and 4) utilization of heat of dilution. While changing the phase material either absorbs the thermal energy or releases, this released or absorbed thermal heat is called as latent heat. Generally, phase change material with higher latent heat utilization with phase change process from liquid to solid or solid to liquid is used as it is easy to manufacture for heat storage. Modes of heat transfer are strongly depends on the phase of the substances involve in the heat transfer processes. For substances that are solid, conduction is the predominate mode of heat transfer. For liquids, convection heat transfer predominates, and for vapours convection and radiation are the primary modes of heat transfer.

Figure: 2 working of PCM

The process of phase change process of PCM from solid to liquid and vice versa schematically. During melting process of phase change material, the temperature of phase change material as well as surrounding system remains nearly constant causing less use of energy. Also at crystallization temperature the change in temperature of surrounding and phase change material us negligible.

IV. METHODLOGY

Before the experiment is carried out, certain arrangements are made for the introduction of Phase Change Material in Air Conditioning system. For the placement of the Phase Change Material, a definite method is chosen so that its presence has certain amount of influence on the working system and on the environment in which the Air Conditioning system is placed. Evaporator is the important component where refrigerant is expanded and evaporated and it acts as a heat exchanger that transfers the heat from the area to be cooled to a boiling temperature thereby achieving the effect of air conditioning. So, the evaporator coils are chosen for the placement of Phase ChangeMaterial and the effect on the coils has huge influence on the overallworking of the Air Conditioning system.

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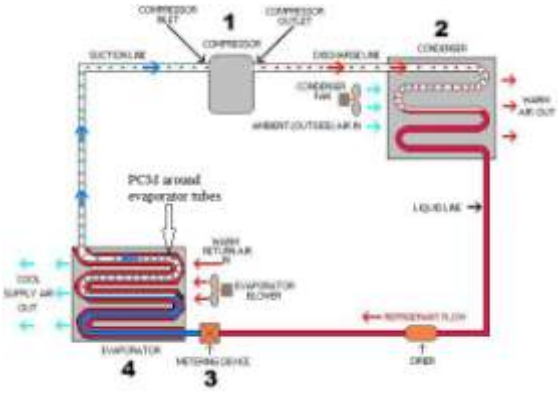

Figure :3 Air conditioner with pcm

Now, the technique by which the Phase Change Material is placed around the evaporator coil needs to be found. And hence, one of the ways in which the evaporator coils can be covered with Phase Change Material is by covering the evaporator coil with another coil of larger diameter than that of the evaporator coil and that is also made of the same material as that of the evaporator. Materials like aluminium can also used to cover the evaporator coils.Butdue to the following characteristics and properties, copper is chosen over aluminium.New copper tubes of diameter of the originally sized evaporator coils (0.5 inches) and copper hollow tubes of diameter larger than that (0.75 inches) are placed such that their axes are coaxial in nature. These tubes are bended manually such that they form 10 passes. And one end of both these tubes is welded to the openings that are present due to the removal of the previously present evaporator tubes. Before the other end of the tube is closed, the hollow space between the two copper tubes is filled with Phase Change Material (calcium chloride hexahydrate + Water). The Phase Change Material is pressured into the tube so that it is distributed uniformly through the tubes. Now the other end of the tube is either sealed with the help of a temporary joint such as M-seal or it is permanently sealed with by means of welding the two ends of the tubes.

Before charging the system with the refrigerant, the system was checked thoroughly for leaks. And finally, the system is filled with the refrigerant(R-22).

During above experimentation following parameters will be checked

1. Temperature and pressure measurement without PCM.
2. Temperature and pressure measurement with PCM.
3. COP of Air Conditioning system without PCM.
4. COP of Air Conditioning system with PCM.

To measure these following parameters, temperature and pressure gauges are incorporated at various places. The temperature sensors are incorporated at

- Evaporator inlet ($\mathbf{T_4}$)

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- Evaporator outlet ($\mathbf{T_1}$)
- Condenser inlet ($\mathbf{T_2}$)
- Condenser outlet ($\mathbf{T_3}$)

These temperature gauges are connected to the Digital temperature indicator so that the temperature measured is indicated in its display.

Pressure gauges are also placed to measure the pressure at various inlets and outlets. They are measured at

- Evaporator inlet ($\mathbf{P_4}$)
- Evaporator outlet ($\mathbf{P_1}$)
- Condenser inlet ($\mathbf{P_2}$)
- Condenser outlet ($\mathbf{p_3}$)

The temperature and pressure readings without the use of Phase Change Material are found before filling of the PCM in between the copper tubes.

V. EXPERIMENTAL SETUP

Figure : 4 working of air-conditioning system

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5.1 COMPARISON CHARTS:

5.1.1 cop vs time

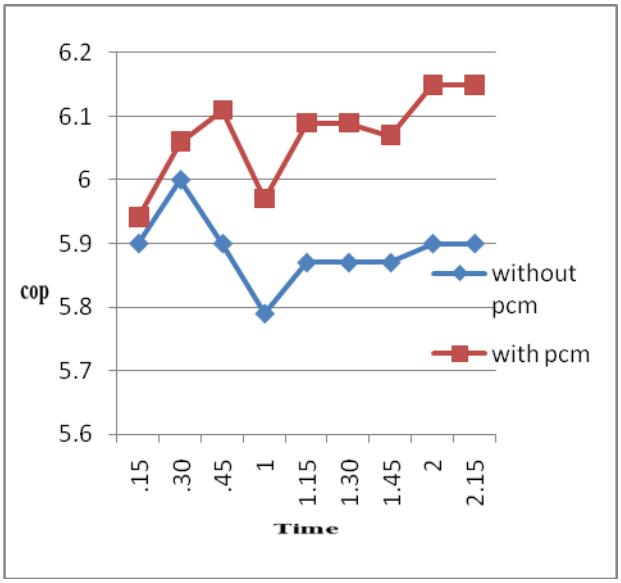

Figure :5 cop vs time

5.1.2 Mean evaporator temperature vs time

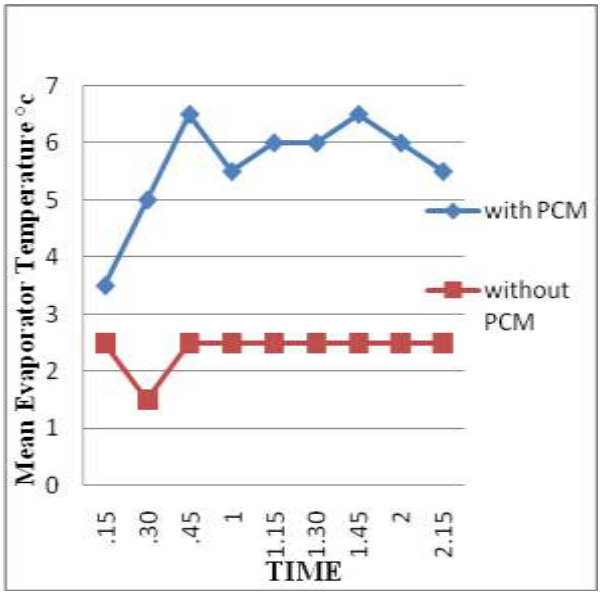

Figure :6 Mean evaporator temperature vs time

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5.1.3 Cop vs Mean evaporator temperature

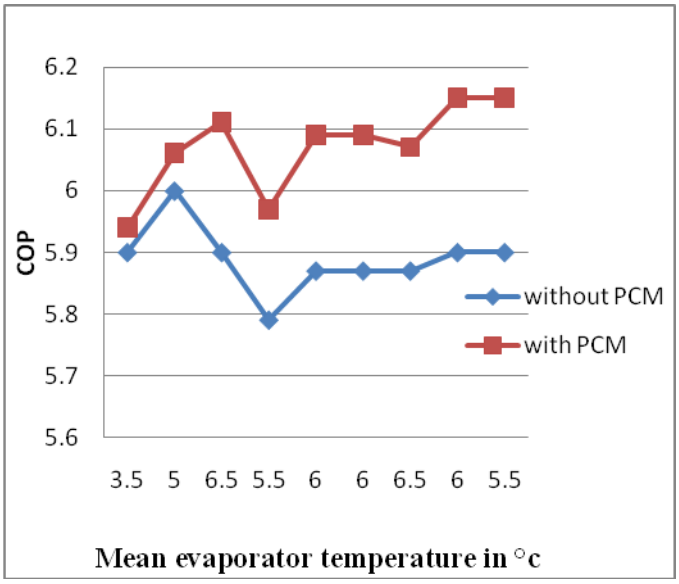

Figure :7 Cop vs Mean evaporator temperature

VI. CONCLUSION:

A very important criterion on today's world is to reduce the consumption of electricity. Since Air Conditioners have proved to be the need of near future. It is necessary to improve the working of Air Conditioners by increasing their coefficient of performance and reduce the use of electricity.

The various inlet and exit temperatures and pressures of different components of an air conditioning system were found on both (with and without the use of Phase Change Material) and their corresponding coefficients of performance were calculated.

So through this experimental analysis of air conditioning, it is found that the coefficient of performance of the air conditioning system has increased by the use of phase change material by a mean value of 0.15.

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