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ENHANCING THE PERFORMANCE OF THE HOUSHOLD REFRIDGERATOR USING DIFFERENT PHASE CHANGE MATERIALS

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ABSTRACT

Nowadays the temperature sensitive products transport and storage is an issue worldwide due to changes of the lifestyle population increase. This also consumes more electricity for the preservation of the products. To reduce the consumption of energy and to mitigate the CO2 we have been using the phase changing material [PCM].The household refrigerator has been the essential for everyone in the world to preserve food. In India it is very important because of the climatic condition. If is reported that the 17%of greenhouse gas is from the refrigerator only. This paper represents the experimental investigation of enhancing the performance of the household refrigerator using the PCM .The PCM is located at one side of the evaporator coil for improving the performance and supplying the refrigeration without power supply for several hours. The system has been tested with water mixed with poly ethylene glocol-400 to make the PCM. This mixture act as the phase changing material that allow the cooling to last for several hours. During the phase change from solid to liquid the heats is absorbed and during the phase change from liquid to solid the heat is liberated.

Keywords: Phase changing material, insulating material, pressure gauge, mitigation of CO2,enhancing the performance.

INTRODUCTION

Refrigeration is a process of moving heat from one location to another in controlled conditions. The work of heat transport is traditionally driven by mechanical work, but can also be driven by heat, magnetism, electricity, laser, or other means. Refrigeration has many applications, including, but not limited to household refrigerators, industrial freezers, cryogenics, and air conditioning. Heat pumps may use the heat output of the refrigeration process, and also may be designed to be reversible, but are otherwise similar to air conditioning units. Refrigeration has had a large impact on industry, lifestyle, agriculture and settlement patterns. The idea of preserving food dates back to at least the ancient Roman and Chinese empires. However, mechanical refrigeration technology has rapidly evolved in the last century, from ice harvesting to temperature-controlled rail cars. The introduction of refrigerated rail cars contributed to the westward expansion of the United States, allowing settlement in areas that were not on main transport channels such as rivers, harbors, or valley trails. Settlements were also developing in infertile parts of the country, filled with new natural resources. These new settlement patterns sparked the building of large cities which are able to thrive in areas that were otherwise thought to be inhospitable, such as Houston, Texas and Las Vegas, Nevada. In most developed countries, cities are heavily dependent upon refrigeration in supermarkets, in order to obtain their food for daily consumption. The increase in food sources has led to a larger concentration of agricultural sales coming from a smaller percentage of existing farms. Farms today have a much larger output per person in comparison to the late 1800s. This has resulted in new food sources available to entire populations, which has had a large impact on the nutrition of society.

LITERATURE REVIEW

A refrigerator is a popular household appliance that consists of a thermally insulated compartment and a heat pump(mechanical, electronic or chemical) that transfers heat from the inside of the fridge to its external environment so that the inside of the fridge is cooled to a temperature below the ambient temperature of the room. Refrigeration is an essential food storage technique in developed countries. The lower temperature lowers the reproduction rate of bacteria, so the refrigerator reduces the rate of spoilage. A refrigerator maintains a temperature a few degrees above the freezing point of water. Optimum temperature range for perishable food storage is 3 to 5 °C (37 to 41 °F).A similar device that maintains a temperature below the freezing point of water is called a freezer. The refrigerator replaced the icebox, which had been a common household appliance for almost a century and a half. For this reason, a refrigerator is sometimes referred to as an icebox in American usage. The first cooling systems for food involved using ice. Artificial refrigeration began in the mid-1750s, and developed in the early 1800s. In 1834, the first working vapor-compression refrigeration system was built. The first commercial ice-making machine was invented in 1854. In 1913, refrigerators for home use were invented. In 1923 Frigidaire introduced the first self-contained unit. The introduction of Freonin the 1920s expanded the refrigerator market during the 1930s. Home freezers as separate compartments (larger than necessary just for ice cubes) were introduced in 1940. Frozen foods, previously a luxury item, became common place. Freezer units are used in households and in industry and commerce. Commercial refrigerator and freezer units were in use for almost 40 years prior to the common home models. Most householdsuse the freezer-on-top-and-refrigerator-on-bottom style, which has been the basic style since the 1940s. A vapour compression cycle is used in most household refrigerators, refrigerator freezers and freezers. Newer refrigerators may include automatic defrosting, chilled water and ice from a dispenser in the door. Before the invention of the refrigerator, icehouses were used to provide cool storage for most of the year. Placed near freshwater lakes or packed with snow and ice during the winter, they were once very common. Natural means are still used to cool foods today. On mountainsides, runoff from melting snow is a convenient way to cool drinks, and during the winter one can keep milk fresh much longer just by keeping it outdoors. The word "refrigeration" was used at least as early as the 17th century. The history of artificial refrigeration began when Scottish professor William Cullen designed a small refrigerating machine in 1755. Cullen used a pump to create a partial vacuum over a container of diethyl ether, which then boiled, absorbing heat from the surrounding air.[3] The experiment even created a small amount of ice, but had no practical application at that time. In 1805, American inventor Oliver Evans described a closed vapour-compression refrigeration cycle for the production of ice by ether under vacuum. In 1820, the British scientist Michael Faraday liquefied ammonia and other gases by using high pressures and low temperatures, and in 1834, an American expatriate to Great Britain, Jacob Perkins, built the first working vapor-compression refrigeration system. It was a closed-cycle device that could operate continuously. A similar attempt was made in 1842, by American physician, John Gorrie, who built a working prototype, but it was a commercial failure. American engineer Alexander Twining took out a British patent in 1850 for a vapour compression system that used ether. The first practical vapor compression refrigeration system was built by James Harrison, a British journalist who had immigrated to Australia. His 1856 patent was for a vapour compression system using ether, alcohol or ammonia. He built a mechanical ice-making machine in 1851 on the banks of the Barwon River at Rocky Point in Geelong, Victoria, and his first commercial ice-making machine followed in 1854. Harrison also introduced commercial vapour-compression refrigeration to breweries and meat packing houses, and by 1861, a dozen of his systems were in operation. The first gas absorption refrigeration system using gaseous ammonia dissolved in water (referred to as "aqua ammonia") was developed by Ferdinand Carré of France in 1859 and patented in 1860. Carl von Linde, an engineering professor at the Technological University Munich in Germany, patented an improved method of liquefying gases in 1876. His new process made possible the use of gases such as ammonia (NH_3), sulfur dioxide (SO_2) and methyl chloride (CH_3Cl) as refrigerants and they were widely used for that purpose until the late 1920s.

In 1913, refrigerators for home and domestic use were invented by Fred W. Wolf of Fort Wayne, Indiana with models consisting of a unit that was mounted on top of an ice box. In 1914, engineer Nathaniel B. Wales of Detroit, Michigan, introduced an idea for a practical electric refrigeration unit, which later became the basis for the Kelvinator. A self-contained refrigerator, with a compressor on the bottom of the cabinet was invented by Alfred Mellowes in 1916. Mellowes produced this refrigerator commercially but was bought out by William C. Durant in 1918, who started the Frigidaire Company to mass-produce refrigerators. In 1918, Kelvinator Company introduced the first refrigerator with any type of automatic control. The absorption refrigerator was invented by Baltzar von Platen and Carl Munters from Sweden in 1922, while they were still students at the Royal Institute of Technology in Stockholm. It became a worldwide success and was commercialized by Electrolux. Other pioneers included Charles Tellier, David Boyle, and Raoul Pictet. Carl von Linde was the first to patent and make a practical and compact refrigerator.

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PHASE CHANGING MATERIAL

A phase change material (PCM) is a substance with a high heat of fusion which, melting and solidifying at a certain temperature, is capable of storing and releasing large amounts of energy. Heat is absorbed or released when the material changes from solid to liquid and vice versa. Latent heat storage can be achieved through liquid–solid, solid–liquid, solid–gas and liquid–gas phase changes. However, only solid–liquid and liquid–solid phase changes are practical for PCMs. Although liquid–gas transitions have a higher heat of transformation than solid–liquid transitions, liquid-gas phase changes are impractical for thermal storage because large volumes or high pressures are required to store the materials in their gas phase. Solid–solid phase changes are typically very slow and have a relatively low heat of transformation.

METHODOLOGY

The evaporator should be covered by the pcm on one side of the evaporator.This makes the perfect thermal energy storage by its own.The temperture sensors we used to measure temperature is thermocouple.Alumal –chromal thermocouple should be placed at where the temperature should measured.Pressure gauges should be connected at three places they are compressor inlet ,compressor outlet ,throttling device outlet. The insulating material that is to be used is the thermocol which is the perfect insulator and cost effective.when the insulating material called thermocol is placed at the back side of the evaporator the heat that was absorbed the refrigerant is being absorbed by the pcm which is at the distance of 10mm from the evaporator coil. By doing this we can enhance the performance of the refrigerator using the insulator induced phase changing material.

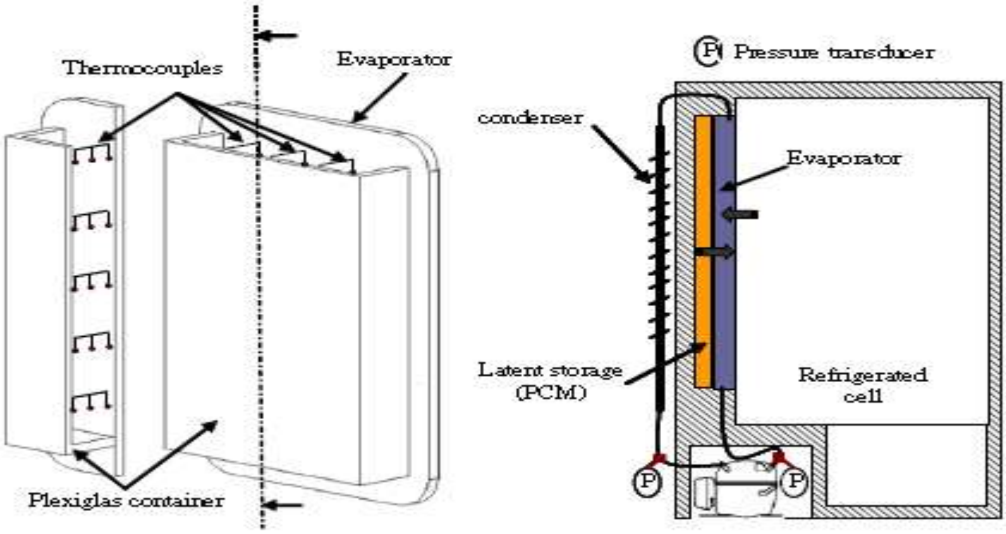

Figure 1 Experimental Setup

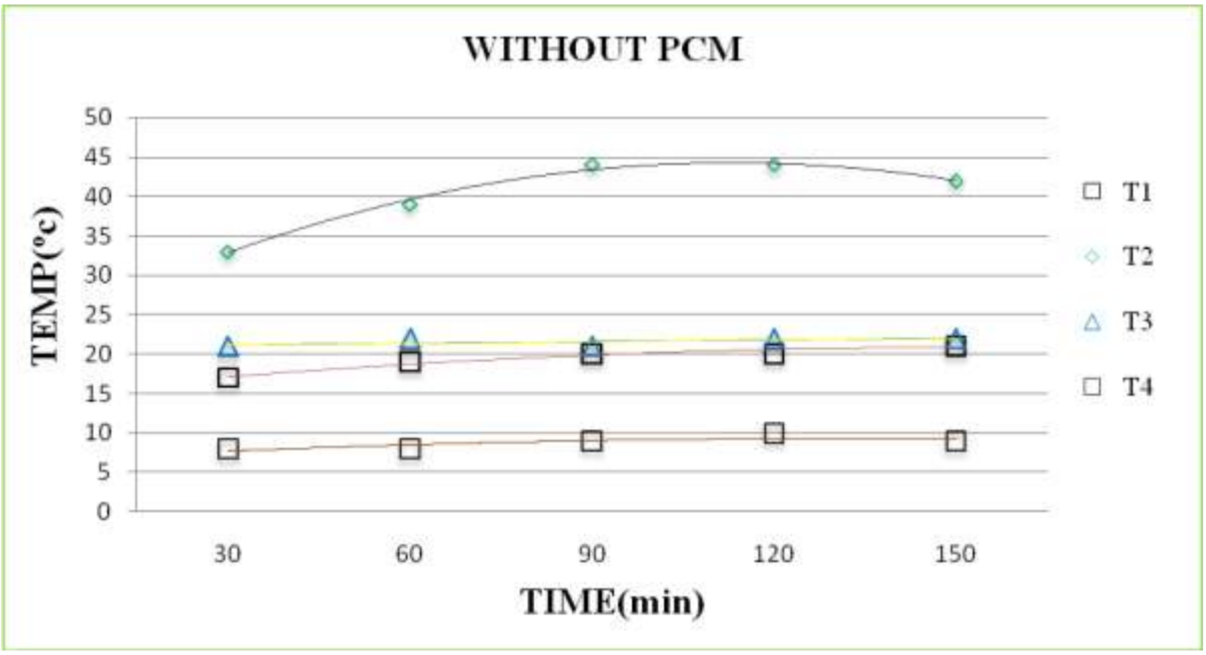

Figure 2 GRAPHICAL REPRESENTATIONS OF TEMP Vs TIME

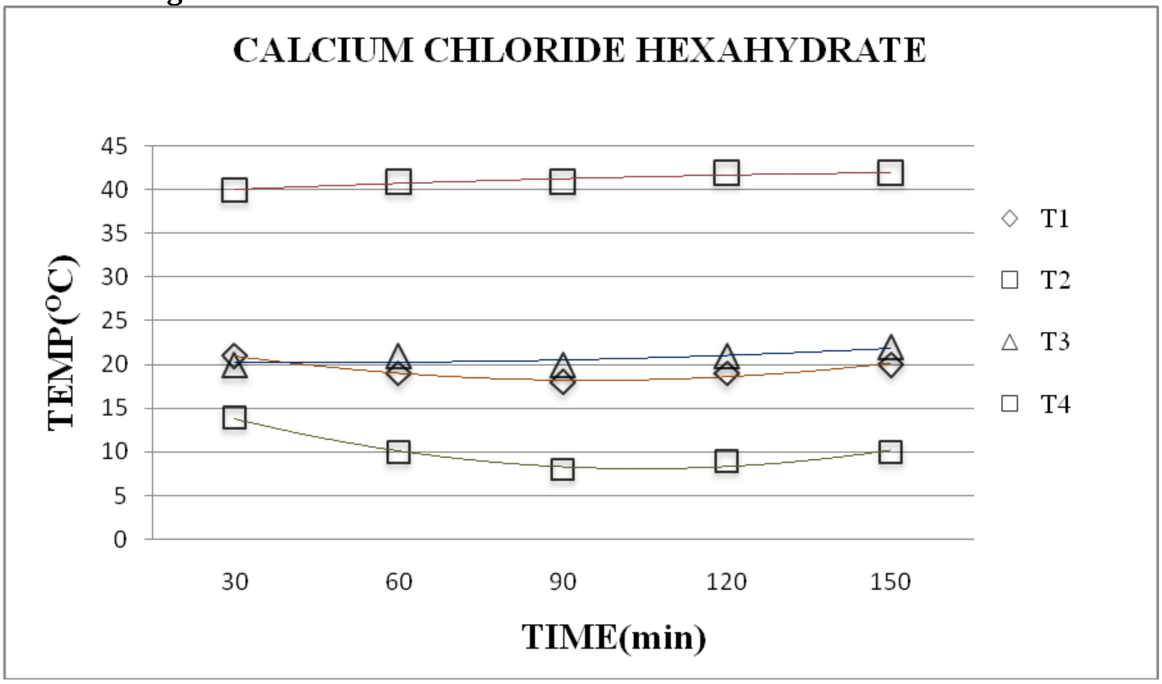

Figure 3 GRAPHICAL REPRESENTATIONS OF TEMP Vs TIME

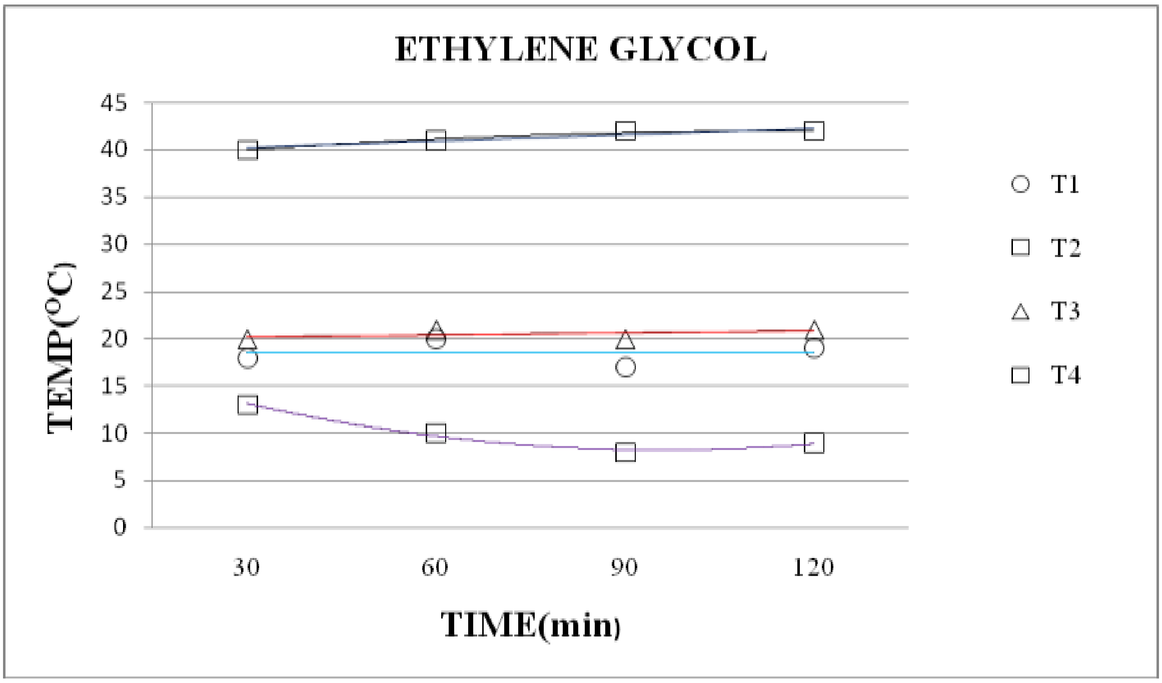

Figure 4 GRAPHICAL REPRESENTATIONS OF TEMP Vs TIME

TABLE 1 TEMPERATURE READING WITHOUT PCM

TEMP / TIME	COMPRESSOR INLET T1	COMPRESSOR OUTLET T2	CONDENSOR OUTLET T3	EVAPORATOR INLET T4
30 min	17^oc	33^o c	21^o c	8^o c
60 min	19^o c	39^o c	22^o c	8^o c
90 min	20^o c	44^o c	21^o c	9^oc
120 min	20^oc	44^oc	22^o c	10^o c
150 min	21^oc	42^oc	22^oc	9^oc

COMPRESSOR INLET PRESSURE (P1) = 0.980665 bar
COMPRESSOR OUTLET PRESSURE (P2) = 14.02 bar

TABLE 2 TEMPERATURES READING WITH PCM($CaCl_2.6H_2O$)

TEMP / TIME	COMPRESSOR INLET T1	COMPRESSOR OUTLET T2	CONDENSOR OUTLET T3	EVAPORATOR INLET T4
30 min	22^o c	36^o c	21^o c	14^o c

60 min	22^{o} c	42^{o} c	22^{o} c	12^{o} c
90 min	21^{o} c	41^{o} c	22^{o} c	11^{o} c
120 min	22^{o} c	41^{o} c	22^{o} c	8^{o} c
150 min	21^{o}c	44^{o}c	23^{o}c	6^{o}c

COMPRESSOR INLET PRESSURE (P1) = 0.980665 bar
COMPRESSOR OUTLET PRESSURE (P2) = 13.72931 bar

TABLE 3 TEMPERATURE READING WITH PCM(ETHYLENE GLYCOL)

TEMP / TIME	COMPRESSOR INLET T1	COMPRESSOR OUTLET T2	CONDENSOR OUTLET T3	EVAPORATOR INLET T4
30 min	18^{o} c	58^{o} c	42^{o} c	13^{o} c
60 min	20^{o} c	60^{o} c	39^{o} c	10^{o} c
90 min	17^{o} c	59^{o} c	37^{o} c	9^{o} c
120 min	19^{o} c	56^{o} c	40^{o} c	11^{o} c

COMPRESSOR INLET PRESSURE (P1) = 0.980665 bar
COMPRESSOR OUTLET PRESSURE (P2) = 13.72931 bar

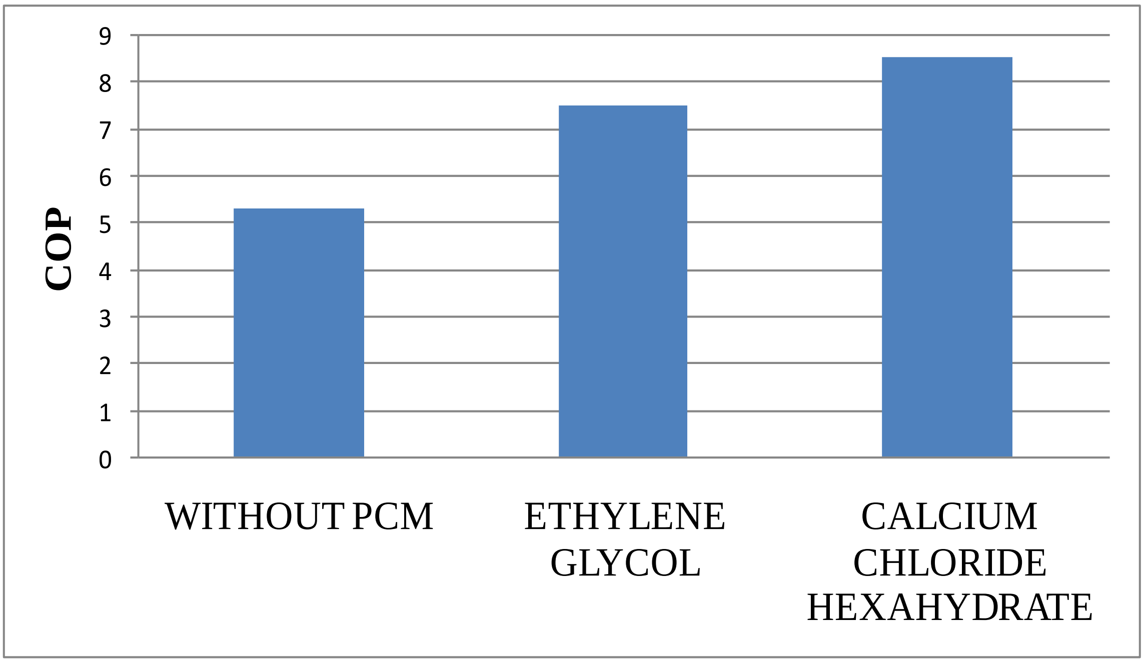

Figure 5 COMPARISON BETWEEN WITHOUT PCM,ETHYLENE GLYCOL,CALCIUM CHLORIDE HEXAHYDRATE

CONCLUSION

The experimental study of a household refrigerator equippedwith a latent storage unit on the unused face of the evaporatorshows an enhancement of the system performance anda reduction of the temperature fluctuations in the refrigeratedcell.Performance results and cold storage capacity measurements havebeen obtained and compared with the originalsystem without storage. The results indicate that the responseof the refrigerator to the addition of PCM and its efficiency arestrongly dependent on the thermal load. The integration of latent heat storage allows 5–9 h of continuous operationwithout electrical supply (to be compared to 1–3 h withoutPCM) and a 10–30% increase of the coefficient of performance,depending on the thermal load.The cool storage capacity of the system is slightly smallerwith an eutectic aqueous solution than with water as a PCM,but the advantage of the eutectic solution is the ability to maintain the air in the refrigerated cell at proper temperaturevalues recommended for the refrigerator. By using this principle we have done the investigation on the performance by inducing PCM in the refrigeration system. The PCM that has been used have less toxicity and easily available material. By inducing the PCM the performance of the refrigeration increases and the CO_2 mitigation also takes place. The analysis of result shows that the improvement of the performance compared to the conventional system.

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