Performance Improvement of Vapour Compression Refrigeration base Domestic Refrigerator using Phase Change Material: Research Paper

Samadhan Khaire[1] Sachin Nimbulkar[2] Ashish Sarode[3]
[1]Student [2,3]Assistant Professor
[1,2,3]Department of Mechanical Engineering
[1,2,3]G. H. Raisoni Institute of Engineering & Management, Jalgaon (MS) India

Abstract— The target of composing review on Thermal energy stockpiling through phase change material has been used for wide applications in the field of cooling and refrigeration. The particular utilization of this inactive warmth stockpiling has been for energy giving through low request and landing of this vitality en through most prominent weights with the likelihood to give vitality saving along these. As of late through the use of this sort of phase change materials in refrigeration spare energy or work amid the power lack has been under unique thought. The utilization of latent heat supply is particularly suited to the furthest reaches of energy to delay sustenance security time and also, utilize the over the best release vitality to enhance the ice chest cooling cycle by its discharge at a true blue time. The rule of latent heat supply using phase change materials (PCMs) can be blend into a hot supply framework legitimate for using substantial coolers. The evaporator is secured with another case which has a capacity limit and it covers the phase change material. The objective of this work is to expand the nourishment conservation time. . The energy store in the PCM is enhanced the fridge cell greatest the off cycle and permit a couple of hours of consistent operation without power supply.

Key words: COP, Compressor, House Hold Refrigerator, Phase Change Material

I. INTRODUCTION

As an interest for refrigeration and ventilating expanded during the most recent decade, substantial requests of electric power and restricted stores of petroleum derivatives have prompted a flow of enthusiasm with proficient energy application. Electrical energy utilization shifts altogether among the day and night as per the request by the modern, business and private exercises. This variety prompts a differential evaluating plane for supply and off supply times of energy utilize. Effective and economical innovation that can be utilized to store a lot of hot or cold heat in a definite volume is the subject of research for quite a while. A fridge is a typical family unit apparatus that contain a thermally protected compartment. The residential fridge is one found in every one of the homes for storing food, vegetables, natural products, drinks, and a great deal more.

A. Performance Improvement of Vapour compression Refrigeration base Domestic Refrigerator Using Phase change Material: Research paper

The most disturbing ecological issue to be specific "A dangerous atmospheric devotion" alludes to the rising temperature of Earth's environment and sea and its anticipated continuation. The heat from the Sun is trap in the Earth and in this manner increase the temperature of the climate by Greenhouse Effect. Refrigeration system is straightforwardly and imperceptibly in charge of Global Warming issue. For the average home of the mid 1990s, an ice free icebox or refrigerator was the second most costly home apparatus to work other than the water heater. Apparatus creators were required to organize names posting a measure of the yearly cost of running every machine so purchasers could look at expenses and energy use. A refrigerator (casually fridge) is a typical family unit apparatus that comprises of a thermally protected compartment and heat pump (mechanical, electronic, or substance) that exchanges heat from within the refrigerator to its outside condition so that within the fridge is cooled to a temperature below the surrounding temperature of the room. Local fridges are among the most energy requesting machines in a family because of their continuous operation. The local refrigerator is one found in every one of the homes for putting away sustenance, vegetables, organic products, drinks, and substantially more. Materials that can store thermal energy reversible over quite a while period are regularly refer to as latent heat storage materials. It likewise helped in heat exchange through conduction.

Thermal energy storage (TES) frameworks give elective answers for advantage from sustainable power source and waste heat. Thermal energy storage is acknowledged accordingly of the change in internal energy of a material. One or more of the accompanying heat is used in TES frameworks: sensible, latent and chemical reaction response. Change in temperature of a material is utilized for sensible heat storage. Heat going with a phase change of the material is utilized for latent heat storage. Heat energy may likewise be put away as the energy of a chemical compound, and energy can be store again put away and discharged in similar materials by reversible substance responses.

A Huge share of power utilization in private part is utilized for residential machines. The private part, taking after industry, use 37% of the power delivered in Turkey. The icebox has the greatest share (30.1 %) in this use, trailed by garments washers (7.5 %) and dishwashers (2.5%). The machines are judge between A (most hoisted) and G standards according to energy use. An Outstanding measure of the energy can be controlled when more energy productive device are used. A review made in Turkey indicate that CO2 discharge that could be cleaned by 120 million trees will be kept away from in 10 years if the greater part of the refrigerator purchased are over A standard

B. Performance Improvement of Vapour compression Refrigeration base Domestic Refrigerator Using Phase change Material: Research paper

The utilization of latent heat storage framework utilizing phase change materials (PCM) is a viable putting away heat energy and has the upsides of high storage thickness and the isothermal way of the capacity procedure. It has been shown

that, for the improvement of latent heat storage framework, decision of the PCM assumes an essential part

Sharma et al.[1], recommended different types of latent heat storage materials and points of interest of latent heat storage system. This paper is a collection of more data on different PCMs and latent heat stockpiling framework. Survey will locate the reasonable PCM for different purposes, appropriate warmth exchangers with approaches to improve the warmth exchange, and it will likewise give an verity of plans to store warm utilizing PCMs for various applications, that is space warming & cooling, sun oriented cooking, nurseries, sun oriented water warming and waste warmth recuperation frameworks.

Md. Imran Hossein Khan and HasanM.M. Afroz [2] explore that the major issue experienced in the nearby ice chest was of the sustenance quality and weight. The sustenance quality was altogether changed with temp vacillations due to the on-off cycle of the compressor. To dispose of the above issue Imran Hossein Khan and Hasan M.M Afroz played out the investigations on local fridge at various warm leads to reduced the vacillations in evaporator compartment by utilizing two types of PCM materials (Water and Eutectic solution (90% H2O +10% NaCl). As demonstrated by Md Imran et-all phase change material (PCM) is an inactive interior inert warmth putting away structure which diminishes and sets at particular temperatures. In the midst of the phase change handle, the material is fit for securing and releasing a considerable measure of warm energy and that is the reason it is called as latent heat storage system (LHS). The PCM was put around the five sides of the evaporator compartment in which the evaporator was submerged. The trial comes about with PCM declare the silent diminishment of the variance of the cabin temperature at lower load however at higher load, this impact is not all that empowering. Between two PCMs, the Eutectic arrangement was superior to water. This diminishment of temperature variance, at last, enhances the food conservation quality. By utilizing distinctive PCM we can increase cooling execution and COP local fridge.

1) Goal of this paper

- To complete the experimentation with PCM and without PCM
- To explore the achievability of PCM in household fridge to keep up detached cooling inside lodge
- To approve Coolpack reproduction comes about with trial comes about
- To watch temperature casualness in lodge with PCM

B. Zalba et al. [3], concentrated the execution of an latent heat storage framework with all phase change. This paper additionally gives the data managing thermal energy storage (TES) utilizing phase change materials. This paper incorporates a total survey of a wide range of

C. Performance Improvement of Vapour compression Refrigeration base Domestic Refrigerator Using Phase change Material: Research paper

Material which have been utilized as latent heat storage materials, their characterization. Attributes, points of interest and weaknesses and the different trial methods used to decide the way of these materials in softening and cementing. The paper contains recorded more than 154 materials utilized as a part of research as PCMs and around 45 financially accessible PCMs.

M.Cheralathan et al. [4], researched the transient conduct of a phase change material based cold heat storage system involved a barrel shaped capacity tank loaded with epitomized phase change materials (PCMs) in circular compartment coordinated with an ethylene glycol chiller plant. A reproduction program was created to assess the temperature histories of the heat exchange fluid and the phase change material at any pivotal area during the charging time frame. The consequences of the model were approved by comparison with exploratory after effects of temperature profiles of phase change material. The outcomes show that if porosity is increased then heat storage is also increasing.

K.Azzouz et al.[5], concentrated the impact of including a phase change material (PCM) chunk on the outside face of a refrigerator evaporator. A dynamic model of the vapour pressure cycle including the nearness of the phase change material and its test approval is displayed. The reproduction after effects of the framework with PCM demonstrates that the expansion of heat energy internationally upgrades heat exchange from the evaporator and permits a higher dissipating temperature, which increases the thermal proficiency of the system. The energy put away in the PCM is respected the refrigerator cell during the off cycle and takes into account a few hours of continuous operation without power supply. The phase change material considered in this review is an eutectic fluid arrangement whose phase change temperature might be picked in the range from - 9°c to 0°c. The PCM piece is situated on the behind of the evaporator, between the protection and the evaporator, and the surface of the PCM section is around 0.48m

D. S. Kalaiselvam et zal[6], examines the conduct of three kinds of paraffin, 60% ntetradecane+40% n-hexadecane, n-tetradecane, and n-pentadecane as latent heat stockpiling materials

J.P. Bedecarrats et al.[7], broke down a modern procedure of energy storage usable for air conditioning and cooling or refrigeration. Exploring a test plant which is a tank with a reduced size. Loaded with arbitrarily scattered commercial knobs, put in a refrigeration circle. The knobs are round containers in which phase change materials (PCM) are embodied. This test plant allows the learn finally of the conduct of the tank with, specifically, the charge mode considering the under cooling and the release mode. A reproduction program that considers parts of both the encompassing warmth exchange liquid and the stage change material stuffed inside the modules is produced here in the instances of the charge and the release forms.

E. Performance Improvement of Vapour compression Refrigeration base Domestic Refrigerator Using Phase change Material: Research paper

A.C. Marques et al. [9] explored the plan and operation of a thermal stockpiling fridge. Right off the bat the investigation of compressor is done which demonstrates bigger compressor gives higher productivity yet more begin/stop occasions, which diminishes general effectiveness. The high cooling limit yield of bigger compressor is put away in a phase change material (PCM), decreasing the quantity of on/off cycles. Numerical displaying and exploratory approval is done utilizing a model thermal storage icebox with PCM. The

outcomes demonstrated that the expansion of a 5 mm PCM section into the fridge considered 3 to 5 hours of consistent operation without a power supply. The numerical model was observed to be in great concurrence with the test comes about, with the mistake between the recreation and tests underneath 5% for generally explores

Rezaur Rahman et al [10] researched the execution of residential cooler change with utilization of PCM with the evaporator in a household fridge. The investigation of the examination demonstrates the extensive change in COP of a traditional refrigeration framework. Here the PCM utilized as a part of a load fabricated physically and which encompasses the Evaporator assembly of an ordinary fridge. Majority share of heat exchanges by conduction mode from load given to cooler bureau to evaporator and evaporator to PCM. So warm exchange rate of evaporator refrigerant increments significantly which enhances the COP of the refrigeration framework by roughly 18-26%

II. EXPERIMENTAL SET UP AND PROCEDURE

The trial setup comprises of a household fridge test ring of 165 liters limit, intended to work with R-134a refrigerant which has the four primary segments compressor, condenser, fine tube and evaporator loop. The trial setup comprises of the ordinary vapor-pressure refrigerating machine with appropriate instrumentation to quantify the temperature at evaporator segment and to gauge the vitality required by the framework.

A vitality meter is utilized to quantify the vitality contribution to the compressor engine and temperature marker is utilized to gauge the temperature of the evaporator. The schematic chart of the exploratory setup appears in Fig 1. The PCMs have attached to the evaporator on the external surface altogether not to diminish stockpiling limit. The PCM box is comprised of stirred iron (GI) sheet.

Here a deliberate amount of 1lit 300ml .arrangement with extents of KCl (19.5wt%)+H2O(80.5wt%). The evaporator is secured with another case which has capacity limit or section through stage change material and keeping in mind the end goal to delay the compressor off time and furthermore dissect the vitality productivity of the traditional framework. The readings were taken power on and control off conditions.

A. Performance Improvement of Vapour compression Refrigeration base Domestic Refrigerator Using Phase change Material: Research paper

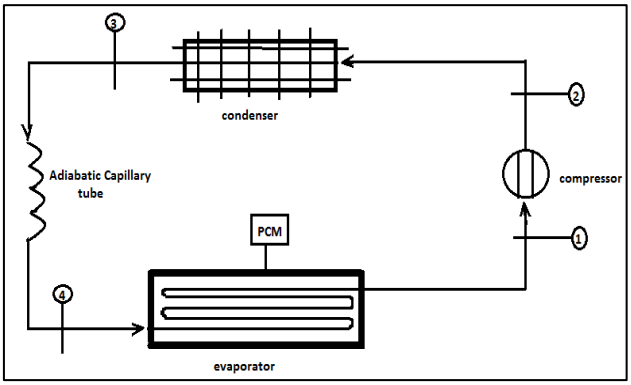

Fig. 1: Line Diagram of Experimental setup

B. Performance Improvement of Vapour compression Refrigeration base Domestic Refrigerator Using Phase change Material: Research paper

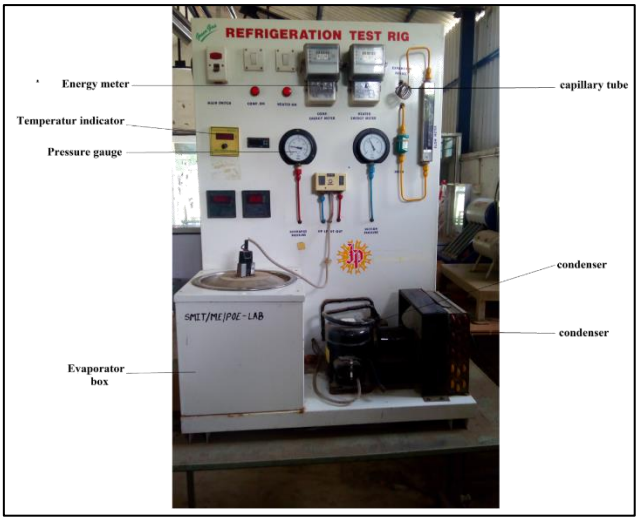

Fig. 2: Experimental Setup

Fig. 3: Phase Change Material

C. Performance Improvement of Vapour compression Refrigeration base Domestic Refrigerator Using Phase change Material: Research paper

Particulates	Specifications
Length	35cm
Height	13cm
Width	26cm
Thickness	1.7cm
Freezing point temperature	-15°C
Melting enthalpy	283kJ/kg

Table 1: PCM Box Specifications

Refrigerator model	Refrigerator test ring 165 liters
Ice making time	2h 30min
Voltage range	230% V 50Hz AC Supply
Rated energy consumption	2.00 kWh/24h max
Rated gross volume	165 Liters
Rated general storage volume	123 Liters
Fuse rating	5A
Refrigerant	R-134a

Table 2: Specifications of Refrigeration test ring

D. Performance Improvement of Vapour compression Refrigeration base Domestic Refrigerator Using Phase change Material: Research paper

III. PROCEDURE

- The domestic refrigerator test ring is selected which work on vapour compression refrigeration system
- Pressure and temperature gauges are installed at each entry and exit of the components.
- Flushing of the system is done by pressurized nitrogen gas.
- R134a refrigerant is charged in to the vapour compression refrigeration system.
- Leakage tests are done by using soap solution.
- After starting the test unit, pressure and temperatures are recorded at each point

IV. RESULTS AND DISCUSSIONS

By performing this experiment the following results were obtained.

Performance parameters	Without PCM	With PCM
Refrigerant effect KJ / kg	140	145
Work of compression KJ/kg	44	40
Coefficient of performance (load condition)	3.12	3.56
Coefficient of performance (no load condition)	3.51	3.62

Table 3: Coefficient of performance with and without PCM

A. Performance Improvement of Vapour compression Refrigeration base Domestic Refrigerator Using Phase change Material: Research paper

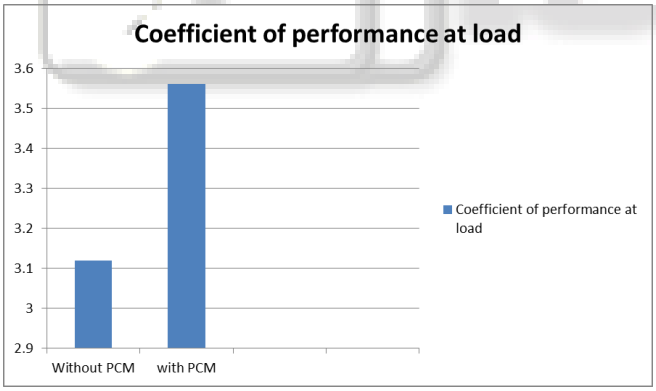

Fig. 4: Coefficient of performance with and without PCM at load

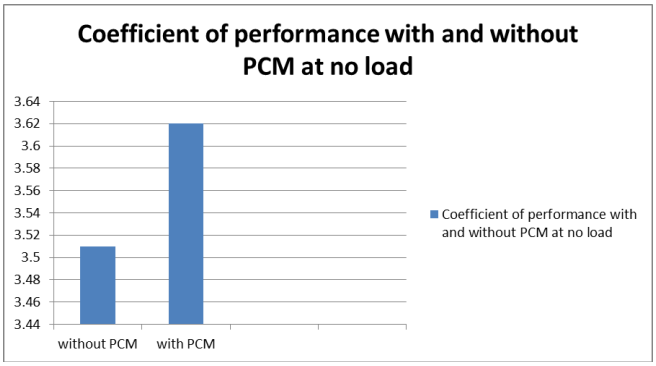

Fig. 5: Coefficient of performance with and without PCM at load

B. Performance Improvement of Vapour compression Refrigeration base Domestic Refrigerator Using Phase change Material: Research paper

C. CFD Results

We can also study this project in anasys for 1 month then we can conclude that pcm can store more heat than water. I design a pcm box of same dimension as above and apply the boundary condition. The pcm box has two temperatures one is at outer layer (20 c) and one is at inner layer (-19c) then following images are obtained

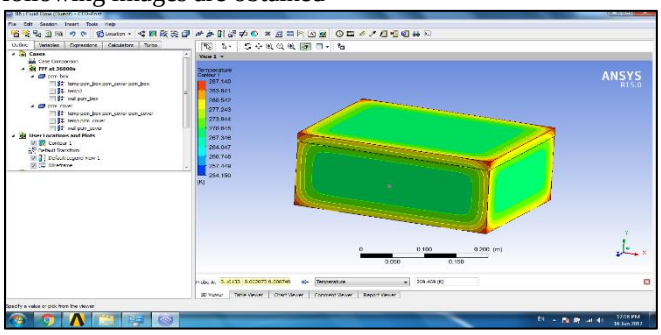

Fig. 6: Cooling effect of PCM in all side

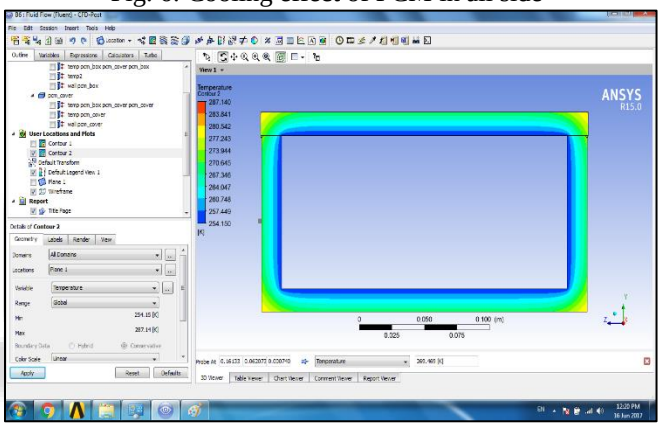

Fig. 7: Inner side temperature of PCM box (-19^0 C)

D. Performance Improvement of Vapour compression Refrigeration base Domestic Refrigerator Using Phase change Material: Research paper

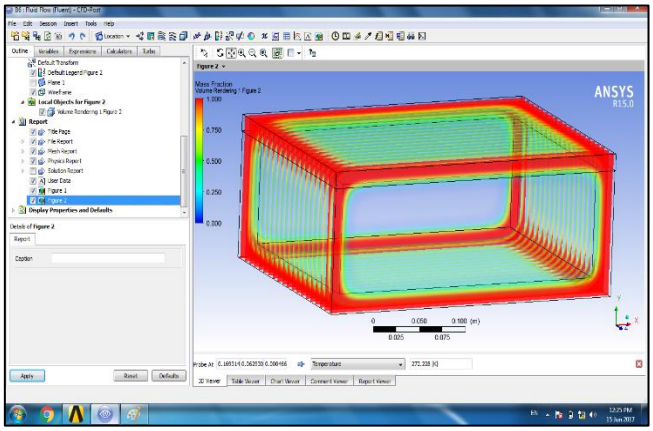

Fig. 8: Solidification inside of PCM box

E. Experimental result & CFD result

1) Experimental Result

Inside temperature of PCM box = -16.9˚c
Outside temperature of PCM box = 32˚c
Refrigerating effect =145kj/kg
COP = 3.5

2) CFD result

- Inside temperature of PCM box = -16.9˚c
- Outside temperature of PCM box = 32˚c
- Refrigerating effect (Heat flux) = A*hc*(surface temp - air temp)
- =0.38*0.13*15*(-19.1-25)
- =155.23kj/kg
- COP = 4.1

F. Performance Improvement of Vapour compression Refrigeration base Domestic Refrigerator Using Phase change Material: Research paper

V. CONCLUSIONS

Try tests have been completed to explore the execution change of a family unit fridge utilizing stage change material and tried with and without PCM.

- COP Without PCM and with load is 3.12
- COP With PCM and with load is 3.51
- COP Without PCM and without load is 3.51
- COP With PCM and without load is 3.62

The outcomes demonstrated that cooling impact is kept up inside the chamber without PCM is expanded 5 hours 35 minutes to 7 hours 22 minutes amid the energy of periods and expanded COP from 3.12 to 3.51 at full load. In the wake of changing to the framework an opportunity to achieve the temperature of the evaporator from 32 °c to - 16.9°c is noted 7hours 10 minutes. This is the time required to store the item without ruining inside the cooler at power off conditions.

A. Performance Improvement of Vapour compression Refrigeration base Domestic Refrigerator Using Phase change Material: Research paper

REFERENCES

[1] S.D Sharma, kazunobusagara, latent heat storage materials, and systems; A Review, International Journal of Green Energy,2(2002) 1-56.
[2] Blond, G., M. Le Meste, (2004) "Principles of frozen storage", In: Hui, Y.E., Cornillon, P., Legaretta, I.G., Lim, M.H., Murrell, K.D., Nip, W. (Eds.), Handbook of Frozen Foods. Marcel Dekker, New York. pp. 25-53.
[3] Belen Zalba, Jose Ma Maryn, Review on thermal energy storage with phase change materials, heat transfer analysis and applications, Applied Thermal Engineering, 23 (2003) 251-283.
[4] M. Cheralathan, R.Velraj, S. Renganarayanan, Heat transfer and parametric studies of an encapsulated phase change material based cool thermal energy storage system, journal of Zhejiang university 7 (2006) 1886-1895.
[5] K. Azzouza, D. Leducqa, D. Gobinb, performance enhancement of a household refrigerator by addition of latent heat storage, international journal of refrigeration 31 (2008) 892-901.
[6] S. Kalaiselvam, M. Veerappan, A.ArulAaronb, S. Iniyan, Experimental and analytical investigation of solidification and melting characteristics of PCM inside cylindrical encapsulation, International journal of Thermal sciences 47 (2008) 858-874.
[7] J.P. Bedecarrats, F. strub, B. falcon, J.P. Dumas, phase-change thermal energy storage using spherical capsules: performance of a test plant, International Journal of Thermal Science 19 (1998)119-152.
[8] A.C. Marques, J.A. Evans, G.F. Davies, G.G. Maidment, I.D. Wood, (2013). Theoretical modeling and experimental investigation of a thermal energy storage refrigerator, Energy, Volume 55, Pages 457–465.
[9] Rezaur Rahman, Md. Arafat Hossain, Shubhrakanti Das And Adnan Hasan (2013) "Performance Improvement Of A Domestic Refrigerator By Using PCM (Phase Change Material), Global Journal Of Researches In Engineering Mechanical And Mechanics Engineering Volume 13 Issue 10 Version 1.0 ,pp 2249-4596
[10] P. Subramaniam, C. Tulapurkar, R. Thiyagarajan, G. Thangamani, (2010), Phase Change Materials For Domestic Refrigerators To Improve Food Quality And Prolong Compressor Off Time, International Refrigeration and Air Conditioning Conference at Purdue
[11] M. A. Sattar, R. Saidur, and H. H. Masjuki, Performance Investigation of Domestic Refrigerator Using Pure Hydrocarbons and Blends of Hydrocarbons as Refrigerants, International Journal of Mechanical Systems Science and Engineering Volume 1 Number 1, pp 50-55
[12] E. Oro, L. Miro, M. M. Farid , L.F. Cabeza, (2012), Improving thermal performance of freezers using phase change materials, international journal of refrigeration 35, pp 984-991

