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Energy Saving Gas Stove Using PCM Heat Exchanger

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ABSTRACT:The main aim of project is experimentally investigating the feasibility of an expanded paraffin wax phase change material (PCM) heat exchanger operating as a condenser in an instant air source. The temperature distribution and volume expansion of an expanded paraffin wax were investigated and tested under different inlet water flow rates. However, in the PCM heat charging/discharging process, non-uniform temperature distributions played an important role in the heat exchanger efficiency. During the heat discharging process, the energy efficiency and the heat transfer rate were also analyzed using experimental data.

The main aim of project is to design and develop PCM heat exchanger. The 3D model is drawn. All the parts are manufactured and then assembled together and then the experimental testing of model is carried out.

.KEYWORDS:PCM , Paraffin Wax , Heat Exchanger

I.INTRODUCTION

Due increase of energy costs, buildings energy consumption has tended to decrease in the past decades. This gives an opportunity for developing innovative renewable technologies that are more adapted to recent buildings with low energy demand. So, the main challenge is to manage non-simultaneous availability of heat source or sink and the energy demand of buildings. Hence, different technologies dedicated to energy storage have been developed recently; one of them is the use of Phase Change Materials (PCM). These materials are considered because they exhibit a higher heat storage capacity than sensible storages and a tune able phase change temperature according to their composition. PCM are used in many applications, for instance, Campos-Caldor et al. (2014) designed a finned plate PCM energy storage for domestic application using RT60 and water. They developed and validated a mathematical model to cover the simulations of the system. They finally compared their prototype with a conventional 500 l hot water tank and concluded that the PCM storage can allow a volume reduction of more than 50% which leads to lower heat losses at the same time. The project focuses only on PCM heat exchanger. In the last decades, many researchers studied this type of heat exchanger. Ten years ago, Zeldi et al. (2004) studied an air-PCM heat exchanger for free-cooling application. They determined the thermos physical properties of two different PCM and developed an empirical model. They showed that this kind of system is technically feasible and economically advantageous.

Due to the increasing gap between the global energy supply and demand, reaching to a thermally efficient and cost optimized thermal energy storage system has received a considerable attention among researchers. There are three methods for storing thermal energy: sensible, latent and thermal– chemical. Among these methods, latent heat thermal storage (LHTS) using phase change materials (PCMs) is known as the most favorable for its high energy storage density with small temperature variation (Melling and Cabeza, 2007). In other words, PCMs are attractive as they are capable of absorbing and releasing a considerable amount of energy at a nearly constant temperature during melting and solidification processes. Latent heat energy storage systems can be used to store a considerable amount of available thermal energy to be utilized during energy demand period, hereafter providing a promising solution for smoothing the discrepancy between energy supply and demand. Thus, many authors have reported their results of

researches on PCM thermal storage during melting and solidification processes in energy storage systems. Fins, or more generally extended surfaces, are used to provide additional heat transfer surface in thermal systems. In LHTS systems, various researchers extensively studied the role of different configurations of fins on the performance improvement characteristics of LHTS systems. Subsequently, different numerical studies looking at the impact of fins on overall PCM melting and solidification can be found in literature (Ogun and Giroux, 2012; See Niraj and Narasimhan, 2008; Shatikian et al., 2005); typically, those studies still neglect natural convection in the liquid PCM phase. Although the cited numerical studies provide the tool to determine optimum fins geometry and LHTS configuration; the defect in natural convection simulations brings about the need to perform experimental studies.

In the present study, melting and solidification of a specific PCM is explored in a finned shell and tube heat exchanger for two fin heights and three Stephan numbers to study the effect of these two variables on some decision-making parameters. These criteria include temperature distribution, melting and solidification front and total melting and solidification time.

There are three types of thermal energy storage process, namely sensible heat storage, latent heat storage and thermo-chemical storage. Latent heat storage materials that are used to store thermal energy through change of state are known as phase change materials (PCMs). Latent heat-based TESs (LHTESs) show advantages of high storage density and small temperature swing. As an example, for the same amount of stored thermal energy, an ice storage unit would require 8 times less volume as compared to a typical water storage unit storing with 10°C temperature change. Furthermore, the wide variety of PCMs' phase change temperatures makes it possible to tailor each of the specific applications with suitable working conditions.

II. PROBLEM STATEMENT

The energy storage demand is increasing day by day. So, the efficiency of the devices is not more enough to increase the efficiency of the devices Phase change materials are used.

III. METHODOLOGY

We have started the work of our project with literature review. After referring several papers, we got many ideas. From these ideas we select best design of our project.

By referring the design, we will buy the standard component required for the projects. After this we will start manufacturing work in workshop. By taking proper dimensions we will manufacture components one by one.

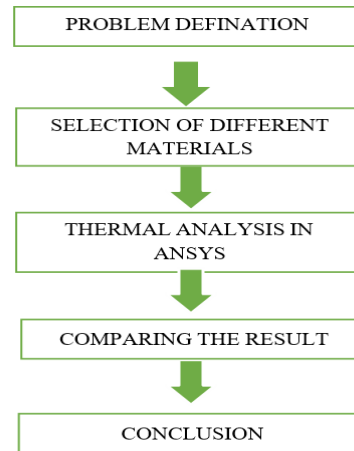
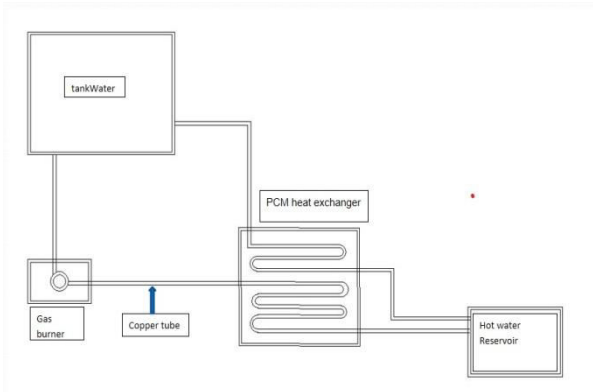
After this, assembly of different components will be done. Later testing will be started for getting various results. After completing testing work fair report will be done and submitted.[5]

IV. OBJECTIVES

- To design and develop PCM heat exchanger.
- The main objective of this project is to study the heat transfer rate in a PCM heat exchanger.
- To study and also analyzes the societal effects that more efficient heat storage might have.

V. BASIC DIAGRAM AND COMPONENTS

- Metal Sheet
- Copper tubes
- Paraffin Wax
- Iron bars
- Burner
- Thermocouple



VI. WORKING

The main component of our project is PCM heat exchanger. IN which paraffin wax is used. The property of wax is that when it is stored in a room temperature it stayed in a solid-state position and when it gets heated it absorb the heat in it and transfer from solid state into liquid state.

There are two sections and it is explained as following:

Section 1- (Burner on position)

In this case the burner will be in ON condition.

When the water will be at room temperature comes from roof tank through flow control valve. The water will then flow through copper tube which is revolving around the gas burner. So, in this case the waste heat from the burner transfers its heat to water which is revolving around the copper tube and thus the temperature of water will increase and then the hot water will go towards PCM heat exchanger in which the paraffin wax will be at solid state at room temperature. So, when the hot water goes into the PCM the paraffin waxes it will absorb the heat from hot water and get transfer into liquid state and will remains into that state up to 30 to 45 mins with temperature of 70 to 85 degree Celsius. (Can be vary according to environmental conditions). So, the remaining hot water will come out from PCM and can be stored in a thermoflask container for future use.

Section 2- (Burner off position)

In this case the burner will be in OFF condition.

So, in this case the water will comes from the roof tank at room temperature and it will flow through flow control valve for regulating the flow of water. So, after the FCV the water at room temperature flow through copper tube in PCM heat exchanger in which paraffin wax will be in liquid state because it is now holding heat in it (as we discuss in section 1) so when the water will flow through copper tubes inside the PCM the cold water absorbs heat from wax and the cold water get converted into hot water and then it will comes out from PCM and then the hot water will be stored in thermoflask for further use like washing dishes, finger bowl, etc.

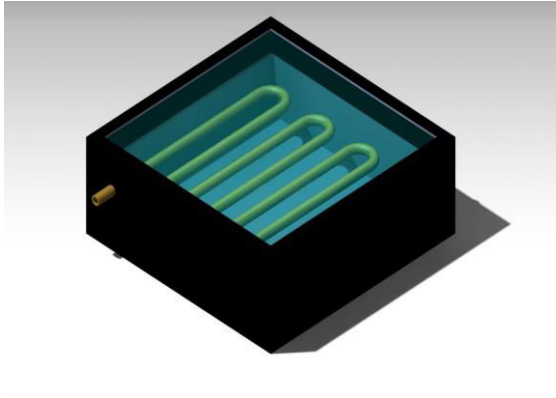


Fig: - 3.1.1 PCM Heat Exchanger

7. PROCESS SHEET & PCM MATERIAL

- Cutting
- Welding

Why Paraffin Wax Used

Heat of Fusion	High
Thermal Conductivity	Very Low
Melt Temperature (°C)	-20 to 100+
Latent Heat (kJ/kg)	200 to 280
Corrosive	Non-Corrosive
Thermal Cycling	Stable
Weight	Medium
Thermal Cycling	Stable

- Drilling
- Finishing
- polishing



VIII. CALCULATIONS

Data table (taken from experimental testing)

Sr.no	t (time interval) (in min)	Temperature (in C)
1	0	T0 = 30
2	5	T1 = 32.6
3	10	T2 = 38.9
4	15	T3 = 46.4
5	20	T4 = 58.5

$$QT = kA (Tf - Ti) d$$

Where Q = heat transfer

k = thermal conductivity of copper = 390

Tf = final temp

Ti = initial temp

A = Surface area of tube = 83.7 m²

D = thickness of copper tube = 0.00175 m

(Burner ON)

Case 1 (t = 5 min = 300 sec) (here Tf = 305.6 K, Ti = 303 K)

$$QT = 390 \times 83.7 \times (305.6 - 303) \times 0.00175 = 1454.94 \text{ KJ}$$

Case 2 (t = 10 min = 600 sec) (here Tf = 311.9 K, Ti = 303 K)

$$QT = 390 \times 83.7 \times (311.9 - 303) \times 0.00175 = 4980.38 \text{ KJ}$$

Case 3 (t = 15 min = 900 sec) (here Tf = 319.4 K, Ti = 303 K)

$$QT = 390 \times 83.7 \times (319.4 - 303) \times 0.00175 = 9177.34 \text{ KJ}$$

Case 4 (t = 20 min = 1200 sec) (here Tf = 331.5 K, Ti = 303 K)

$$QT = 390 \times 83.7 \times (331.5 - 303) \times 0.00175 = 15948.43 \text{ KJ}$$

Sr.no	t (time interval) (in min)	Temperature (in C)
1	30	T0 = 55.6
2	60	T1 = 54.2
3	90	T2 = 53.2
4	120	T3 = 52.7

(Burner OFF)

Case 1 (t = 30min = 1800 sec) (here Tf = 328.6 K, Ti = 303 K)

$$QT = 390 \times 83.7 \times (328.6 - 303) \times 0.00175 = 4775.2 \text{ KJ}$$

Case 2 (t = 60min = 3600 sec) (here Tf = 327.2 K, Ti = 303 K)

$$QT = 390 \times 83.7 \times (327.2 - 303) \times 0.00175 = 4514.06 \text{ KJ}$$

Case 3 (t = 90min = 5400 sec) (here Tf = 326.2 K, Ti = 303 K)



$$QT = 390 \times 83.7 \times (326.2 - 303)0.00175 = 4327.5 \text{ KJ}$$

Case 4 (t = 120min = 7200 sec) (here Tf = 325.7 K, Ti = 303 K)

$$QT = 390 \times 83.7 \times (325.7 - 303)0.00175 = 4234.26 \text{ KJ}$$

IX. RESULT

BURNER ON

Case	Time	Temperature	RESULT (Q)
1	0	T0 = 30	-----
2	5	T1 = 32.6	1454.94 KJ
3	10	T2 = 38.9	4980.38 KJ
4	15	T3 = 46.4	9177.34 KJ
5	20	T4 = 58.5	15948.43 KJ

BURNER OFF

Case	Time	Temperature	RESULT (Q)
1	30	T0 = 55.6	4775.2 KJ
2	60	T1 = 54.2	4514.06 KJ
3	90	T2 = 53.2	4327.5 KJ
4	120	T3 = 52.7	4234.26 KJ

FINAL EFFECIENCY

$$\text{Average heat transfer of burner ON} = 1454.94 + 4980.38 + 9177.34 + 15948.434 = 7890.27 \text{ KJ}$$

$$\text{Average heat transfer of burner OFF} = 4775.2 + 4514.06 + 4327.5 + 4234.264 = 4462.75 \text{ KJ}$$

$$\eta = \{ \text{Work Output} / \text{Work Input} \} \times 100 \%$$

$$\eta = \frac{\text{Average heat transfer of burner OFF}}{\text{Average heat transfer of burner ON}} \times 100$$

$$\eta = \frac{4462.75}{7890.27} \times 100 = 56.56 \%$$

X. CONCLUSION

This report presents a new application of PCM heat exchanger. It is generally used for reusing the heat which is getting wasted from burners.

The design and optimization process of heat exchanger are connected by means of numerical modelling, which is verified by full scale experiment. The non-linear properties and hysteresis of PCM are set in the model.

The numerical works are conducted based on a different heating range. The result shows that the heat energy getting wasted from burner is being utilized for heating of water, through convection via copper tubes. Thus, the heating of copper tube and hot water leads to melting of paraffin wax. So even if the burner is off we get the hot water which is being getting dissipated via conduction from hot molten paraffin wax .

New methods to get more accurate PCM heat capacity is essential for future works. In the next stage, the feasibility of applying the PCM exchanger for other general uses.



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