Design, Development and Analysis of PCM Heat Exchanger

[1]Sagar Somnath Salunkhe, [2]Sanjay Pawar,

[1]Student, [2]Head of Department,
[1]Mechanical Engineering,
[1]Fabtech College of Engineering and Research Centre Sangola, Sangola, India

Abstract : Our project's primary goal is to conduct an experimental investigation into the viability of using an expanded paraffin wax PCM heat exchanger to function as a condenser in an immediate air source. Under various inlet water flow rates, the temperature distribution and volume expansion of an expanded paraffin wax will be examined and tested. Non-uniform temperature distributions, however, are crucial to the heat exchanger efficiency during the PCM heat charging/discharging process. Using experimental data, the energy efficiency and heat transfer rate during the heat discharge process were also examined.

Index Terms— PCM, Paraffin wax, Box type HE & Heat Transfer, Development

I. INTRODUCTION

1.1.Overview

Building energy use has tended to decline over the years due to rising energy costs. This presents a chance for the creation of cutting-edge renewable technologies that are better suited for modern structures with minimal energy demands. Therefore, managing the non-simultaneous availability of a heat source or sink and the energy demand of buildings is the key difficulty. As a result, numerous energy storage-related technologies have lately been created; one of them is the utilization of phase change materials (PCM). These substances are taken into consideration because, compared to sensible storages, they have a larger heat storage capacity and a tunable phase change temperature.

A finned plate PCM energy storage for household application using RT60 and water was designed by Campos-Caldor et al. (2014) employing PCM, which are used in numerous applications. They created and tested a mathematical model to account for system simulations. They came to the conclusion that the PCM storage can enable a volume decrease of more than 50%, leading to lower heat losses at the same time, after comparing their prototype with a traditional 500 l hot water tank. The PCM heat exchanger is the only subject of the project. This kind of heat exchanger was extensively researched throughout the previous few decades. Zalba et al. (2004) investigated an air-PCM heat exchanger for a free- cooling application ten years ago. They assessed the thermo physical characteristics of two different PCM .

1.2 GLOBAL SUPPLY DEMAND

Reaching a thermally efficient and cost-optimized thermal energy storage system has drawn a lot of interest from researchers as a result of the widening energy supply-demand gap in the world. Sensible, latent, and thermal-chemical storage techniques are the three types of thermal energy storage. Latent heat thermal storage (LHTS) using phase change materials (PCMs) is regarded as the most advantageous of these techniques because of its high energy storage density and minimal temperature volatility (Memling and Cabeza, 2007) In other words, PCMs are desirable because they can absorb and release a sizable quantity of energy throughout melting and solidification processes at a practically constant temperature. A possible method for bridging the gap between energy supply and demand is to use latent heat energy storage devices to store a sizeable amount of thermal energy that may be utilized when there is a spike in energy demand. In order tobetter understand PCM thermal storage during the melting and solidification processes in energy storage systems, numerous authors have published their findings.

To investigate the impact of these two factors on some decision-making characteristics, the melting and solidificationof a particular PCM are investigated in a finned shell and tube heat exchanger for two fin heights and three Stephan numbers.The distribution of temperatures, the melting and solidification front, and the overall melting and solidification time are some of these criteria.

1.3 TYPES OF THERMAL ENERGY

Sensible heat storage, latent heat storage, and thermochemical storage are the three different forms of thermal energy storage processes. Phase change materials are materials for latent heat storage that are used to store thermal energy through state change (PCMs). High storage density and a minimal temperature swing are advantages of latent heat-based TESs (LHTESs). As an illustration, an ice storage unit would require 8 times less volume than a standard water storage unit when storing with a 10°C temperature change in order to store the same amount of thermal energy. Additionally, the wide range of phase transition temperatures for PCMs enables tailor-made conditions for each of the unique applications.

The processes used to store thermal energy fall into three categories: sensible heat storage, latent heat storage, and thermochemical storage. Phase transition materials are substances that can store latent heat by changing their physicalproperties (PCMs). Low temperature swing and high storage density are benefits of latent heat-based TESs (LHTESs). As an illustration, an ice storage unit would need 8 times less volume than a standard water storage unit to hold the same amount of thermal energy with a 10°C temperature change. Furthermore, the wide range of phase change temperatures forPCMs enables customization of each unique application with optimal working conditions.

1.4 PCM ADVANTAGES AND LIMITATIONS

PCMs provide many benefits, but there are still some problems that need to be fixed. Table lists the benefits and drawbacks of popular PCMs. The melting and freezing temperatures of non-eutectic latent heat storage materials often lie within a specific temperature range rather than having a fixed phase change temperature. Second, the melting and freezing temperatures frequently vary from one another; this is known as the material's hysteresis and results in atemperature swing in the thermal energy's charging and discharging

Third, sub cooling significantly reduces the nucleation temperature to a level much lower than the solidification temperature in inorganic salt hydrates. Fourth, organic material's flammability and inorganic salts' corrosiveness frequently impose further restrictions and limitations.

The challenges in adopting PCMs in indoor thermal comfort control systems where the allowed temperature swing is modest are highlighted by the above-mentioned limitations. Inorganic materials are non-flammable and have a higher volumetric energy storage density when compared to organic materials, which only experience a little amount of phaseseparation and some of which are not impacted by sub cooling

Organic materials have a low thermal conductivity of around 0.2W/m-K, but inorganic materials have a thermal conductivity of between double and triple that of water, between 0.4 and 0.6W/m-K. Convection in the melt stage, however, might help the thermal transfer of organic PCMs that have not gelled. In conclusion, the selection of PCMs for energy storage depends.

	Organic	Inorganic	Eutectic
Pros	• Low Cost (120Euro/kWh)(Ribberink, 2009) • Self nucleating • Chemically inert and stable • No phase segregation • Recyclable • Available in large temperature range	• Moderate cost (130 Euro/kWh) (Julin, 2008)(Ure, 2008) • High volumetric storage density (180-300 MJ/m³) • Higher thermal conductivity (0.6W/m-K) • Non flammable • Low volume change	• Sharp melting point • High volumetric storage density
Cons	• Flammable • Low thermal conductivity (0.2W/m-K) • Low volumetric storage density (90-200 MJ/m³)	• Subcooling • Phase segregation • Corrosion of containment material	• Limited availability

Figure Pros & cons of the PCM

Researchers and engineers are investigating the potential use of PCMs in TES in order to develop energy-efficient energy systems. The International Energy Agency (IEA) put into practice Annex 17: "Advanced Thermal Energy Storage through Phase Change Materials and Chemical Reactions"(Haier, et al., 2005), which looked into commerciallyavailable goods and novel chemicals that may be used inlatent heat-based TES.

Lab-grade goods and PCMs from five PCM vendors are offered in the temperature range of -40°C to 100°C. In general, water has a phase change temperature about 0°C, which makes it inappropriate for some applications, but it has the highest level of latent heat storage density when comparedto commercial and lab grade PCMs. The amount of chemical materials appropriate for TES in indoor climate control and thermal comfort application is still limited, despite the wide variety of PCMs. Below 0°C, 0°C to 40°C, and above 40°Care the three separate temperature ranges into which the commercial products described here can be divided.

The categorizations show that the commercially available goods are built on the same compounds combined with additions to attain new phase transition temperatures, which reduces the storage capacity. There is consequently an urgent need to develop and look for innovative materials that demonstrate excellent storage qualities for high thermal powerand capacity demanding storage applications.

1.5 PROBLEM DEFINATION (Heading 2)

- The world's population is growing, which is driving up demand for energy.
- The greenhouse effect is causing the earth's temperature to rise.
- Toxic gas emissions and refrigerant emissions, such as HFC and CFC, all contribute to increased pollution.
- Due to a lack of non-renewable energy sources, there will bean energy crisis.
- Electricity costs may be high in order to offer heating andcooling effects
- The efficiency of storage devices is insufficient; PCM can beused to boost efficiency.

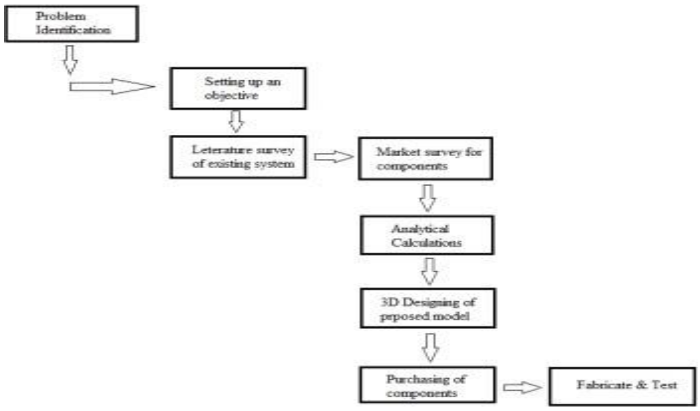
1.5 Objective• Because of the rising population around the world, there is a rising need for energy.
Due to the greenhouse effect, earth's temperature is rising.

- Emissions of harmful gases and refrigerants like HFC and CFC cause pollution to increase.
- Due to a lack of non-renewable energy sources, an energy crisis will be a problem.
- Electricity might be expensive to use for heating and cooling purposes.
- Since storage devices' efficiency isn't high enough, PCM can be used to boost efficiency.

1.7 Scope

The project's scope is broad; it includes component study, system study, and material investigation, among others. The work focuses on PCM property characterization at the material level. Heat transfer modeling, storage design, and experimental validation are all used at the component level. The study's focus on the system level is a techno-economic evaluation of the system's viability.

1.8 Methodology



Step 1: We began our project's work with a literature review in Step 2.: We gathered a lot of studies that are pertinent to this subject. After reading these papers, we gained knowledgeof ideology.

Step 3: - Subsequently, the parts needed for a dual axis solartracker are chosen.

The analytical calculation is prepared in Step 3.

Step 4: After choosing the components, CATIA software willbe used to create a 3D model and draught the design.

Step 5: The components will be produced and then puttogether in

Step 6: After the testing is completed, a determination andconclusion are made.

Organization of Dissertation

- A literature review served as the foundation for our project's work. We have a lot of thoughts after reading various papers. From these concepts, we choose the project's finest design.
- We will purchase the common component needed for the projects by reference to the design. Following that, we shall begin manufacturing tasks in the workshop. We will manufacture each component one at a time by acquiring accurate measurements.
- Following this, the various components will be put together. Testing will begin later with a goal of obtaining different outcomes. A fair report will be completed and submitted following the testing process.

2. LITERATURE REVIEW

Hamidreza Behi [1] el..

The idea of a passive thermal management system (TMS), which includes natural convection, heat pipes, and phase change materials (PCM), for electric vehicles is presented in this study.

Detailed Process

The thermal behaviour of a lithium-titanate (LTO) battery cell during a high current discharging process is predicted using experimental and numerical studies. Details of several thermal management strategies are described and contrasted. The commercial computational fluid dynamics (CFD) software, COMSOL Multiphysics®, resolves the mathematical models. With an acceptable error range, the simulation results are confirmed against experimental data. The highest cell temperature for natural convection, heat pipes, and PCM assisted heat pipes, according to the results, is 56°C, 46.3°C, and 33.2°C, respectively. When compared to natural convection, it was discovered that the maximum cell temperature was reduced by 17.3 and 40.7 percent using heat pipes and PCM-assisted heat pipe cooling systems, respectively.

Xi-li DUAN [2] el..

A prototype of PCM heat exchanger with a helical coil tube was designed and fabricated. for solar thermal energy storage, and was tested on a solar thermal experimental apparatus. This paper discusses the design concepts, selection of materials, as well as heat transfer analysis with the CFD tool Ansys Fluent.

The design, construction, and numerical and experimental analysis of an APCM heat exchanger for the latent storage of solar thermal energy. The device has a spiral tube for the flow of heat transfer fluid, a cylindrical shell, and paraffin wax. Fundamental understanding of the effects of design parameters was obtained by CFD simulation of this system. Successful assembly of a prototype heat exchanger for lab testing served as proof of ideas, confirmation of simulation assumptions, and important initial data for follow-up work to improve the design.

Lizhong Yang [3] el…

In order to store and release heat at a temperature that is almost constant, phase change materials are used in shell and tube latent heat thermal energy storage systems. These systems offer high heat transfer efficiency and high charging/discharging power. There has been relatively little research done on the design process for storage units, despite the fact that many studies have examined material formulation, heat transport through simulation, and experimental tests. This paper suggests a thorough process that incorporates material assessment utilising many criteria and objectives, the epsilon-NTU method, and cost minimization via genetic algorithms. The concept is put into practise in the optimization of a storage unit for a solar absorption chiller application and is supported by a number of experimental findings. It is reported with a unit cost of as little as USD 8396 per unit.

3. PROPOSED SYSTEM

3.1.1Paraffin Wax

The soft, colour less material known as paraffin wax is made of a mixture of hydrocarbon molecules with between 20 and 40 carbon atoms and is generated from petroleum, coal, or shale oil. Its boiling point is greater than 370 °C (698 °F), above which it starts to melt. It is solid at normal temperature. Candles, lubricant, electrical insulation, and crayons can all be manufactured from paraffin wax that has been colored. It is different from paraffin, which is a term sometimes used to refer to kerosene and other petroleum products. Unscented, odourless, and bluish-white paraffin candles are not coloured or scented. When paraffin wax was originally developed in Germany in 1830, it represented a significant improvement in candle making technology since it burned more consistently and cleanly than tallow candles and was less expensive.

In chemistry, paraffin and alkane are used interchangeably to refer to hydrocarbons with the general formula CnH2n+2. The word "paraffin" comes from the Latin words parum, which means "barely," and affinis, which means "lacking affinity" or "lacking reactivity," in reference to how unreactive paraffin is. The majority of paraffin wax is found as a white, odourless, and tasteless waxy solid with a density of roughly 900 kg/m3 and a typical melting point of between 46 and 68 °C (115 and 154 °F). It is soluble in ether, benzene, and certain esters but insoluble in water. The majority of typical chemical reagents have no effect on paraffin, yet it burns easily. 42 MJ/kg is the heat of combustion for it.

With a resistance ranging from 1013 to 1017ohm meters, paraffin wax is a superb electrical insulator. With the exception of some plastics, it is superior to almost all other materials (notably Teflon). In James Chadwick's 1932 neutron id tests, it served as a powerful neutron moderator.

With a specific heat capacity of 2.14–2.9 J g1 K1 and a heat of fusion of 200–220 J g1, paraffin wax is an efficient heat-storage substance. The electronics of the Lunar Roving Vehicle were cooled using paraffin wax phase-change cooling in conjunction with retractable radiators during the manned Moon missions in the early 1970s. Wax expands significantly when it melts, making wax element thermostats.

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Figure Paraffin Wax

3.1.2 Temperature Sensor:

- Temperature sensors are measurement tools that detect temperature through the detection of a matching physical property, such as electrical resistance, electromagnetic field (EMF), or thermal radiation.
- A typical thermometer, which includes a temperature sensing probe coupled with a display, can be used in various situations. Its temperature range is -50 to 110 degrees, and its display digits are 4 and a half, for example, 102.5, with the first digit being 1. Data flashes every two seconds.

***Features*:**

- Temperature measurement range: -50 ~ 110
- Temperature measurement error: ± 3
- Resolution: 0.1
- Sensor Type: NTC (10K / 3435)
- Operating voltage: 1.5V
- Working current: MAX 4UA
- Operating temperature: 0 ~ 50
- Storage temperature: -10 ~ 60
- Overall: 4.8cm × 2.8cm × 1.5cm
- Embedded hole: 4.6cm × 2.7cm
- Cable length: 1 meter

Application:

- Measuring body temperature
- measuring pond water temperature
- monitoring the temperature of baby bath water,
- measuring the temperature inside and outside of refrigerators
- measuring the temperature inside and outside of automobiles
- It is quite versatile, convenient, and reasonably priced.

Figure Temperature Sensor

3.1.3. Heater:

Water heating is a heat transfer technique that raises the temperature of water from its starting point. Hot water istypically used in the home for cooking, cleaning, bathing, and space heating. There are numerous uses for hot water and steam in the industrial sector.

Traditional water heaters, kettles, cauldrons, pots, and coppersare used to heat water in the home. These metal containers do not continuously supply heated water at a specified temperature. Instead, they heat a batch of water. Rarely does hot water appear naturally; it typically comes from hot springs. As the flow rate rises, the temperature drops as it fluctuates with consumption rate.

Water heaters, hot water heaters, hot water tanks, boilers, heatexchangers, geysers, or clarifiers are examples of appliances that continuously supply hot water. These terms vary by geography, energy source, and whether they heat potable or non-potable water for household or industrial use. Household hot water is another name for potable water that has been heated in domestic installations for purposes other than space heating (DHW).For heating water, fossil fuels like natural gas, liquefied petroleum gas, or oil are frequently utilized, as well as solid fuels. These can either be consumed directly or can generate power, which then heats the water. Any other electrical source, such as nuclear power or renewable energy, may likewise be used to generate electricity for heating water. Water can be heated using alternative energy sources like solar energy, heat pumps, hot water heat recycling, and geothermal heating, frequently in conjunction with backup fossil fuel- or electricity-powered systems.

Some nations' densely populated cities offer district heating for hot water. Particularly in Scandinavia, Finland, and Poland is this the case. District heating systems provide energy from combined heat and power (CHP) plants, industrial waste heat, incinerators, geothermal heating, and central solar heating for space heating and water heating. At the consumers' premises, heat exchangers actually heat the tap water. Due to the district heating systems' anticipated high availability, consumers typically do not have an internal backup system.

Power consumption = 200 W

Figure Heater

4.1.4. Copper tube

The chemical element copper has the atomic number 29 and the letter Cu, which comes from the Latin word cuprum. It is an extremely high thermal and electrical conductivity metal that is soft, malleable, and ductile. Pure copper has a pinkish- orange tint when it is first exposed to the air.

Thermal conductivity: 401 W/(m·K)

Figure Copper tube

Properties	Metric	Imperial
Density	9.40 g/cm^3	0.340 lb/in^3

Mechanical Properties

The mechanical properties of UNS C94500 copper alloy are outlined in the following table

Properties	Metric	Imperial
Tensile strength	170 MPa	24700 psi
Yield strength	83.0 MPa	12000 psi
Elongation at break (in 50 mm)	12%	12%
Poisson's ratio	0.34	0.34

Elastic modulus	117 GPa	17000 ksi
Compressive strength	250 MPa	36300 psi
Izod impact	5.40 J	3.98 ft-lb
Fatigue strength (@# of cycles 1.00e+8, rotating beam)	69 MPa	10000 psi
Hardness, Brinell	50	50
Machinability (UNS C36000 (free-cutting brass) = 100)	80	80

Thermal Properties

The thermal properties of UNS C94500 copper alloy are givenin the following table

Properties	Metric	Imperial
Thermal expansion co-efficient (@ 20-200°C/68- 392°F)	18.5 µm/m°C	10.3 µin/in°F
Thermal conductivity (@ 20°C/68°F)	52 W/mK	361 BTU in/hr.ft^2.°F

3.1.5 Material A36

S235J2 steel is a non-alloy structural steel that is mostly utilized in tanks and structural constructions. S235J2 steel is equivalent to Q235D, a Chinese steel grade. See the following

for further details on S235J2 steel technology:

- *235J2 steel specification:*
- *Grade: 235J2 Standard: EN 10025-2 Number: 1.0117*
- *Thickness: 1.5 – 200 mm, Width: 1000mm to 4000mm, Length: 1000mm to 18000mm*

S235J2 steel application:

Freight cars, transmission towers, dump trucks, cranes, trailers, bulldozers, excavators, forestry equipment, railroad waggons, dolphins, penstocks, pipes, highway bridges, building structures, oil and gas platforms, offshore structures, shipbuilding, power plants, palm oil equipment, fans, pumps, lifting equipment, and port equipment are just a few examples of the many applications for S235J2 steel.

Physical Properties	Metric	Imperial
Density	7.85 g/cm^3	0.284 lb/in^3
Mechanical Properties	**Metric**	**Imperial**
Tensile Strength, Ultimate	400 - 550 MPa	58000 - 79800 psi
Tensile Strength, Yield	250 MPa	36300 psi
Elongation at Break (in 200 mm)	20.0 %	20.0 %
Elongation at Break (in 50 mm)	23.0 %	23.0 %
Modulus of Elasticity	200 GPa	29000 ksi

Bulk Modulus (typical for steel)	140 GPa	20300 ksi
Poissons Ratio	0.260	0.260
Shear Modulus	79.3 GPa	11500 ksi

Table Mechanical Properties of A36 Material plate

4.1 Analytical Calculations

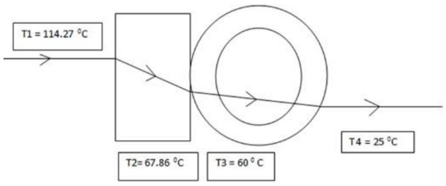

Figure Heat exchange

Heat transfer rate in tube

$$Q = \frac{T_i - T_o}{1/h_b A_i + \ln(r/r_1)/2\pi kl + 1/h_o A_o}$$

Where,

hi = 40 W/ m2K,ho = 10 W/ m2K,r1 = 5.45mm, r2= 6 mm,
l= 532.167mm,
k= 400 W/mK
Ti = 60 0 C,T0 = 25 0C,
Ai = πril, Ao = π rol

Inserting all the values in above equation we get,Q = (60 – 25) / (2.7438+0.115+9.969)

Q = 2.75 W

2. heat rate in container

Q = (T 1 – T 3) / (L/ k A)

L= 5 mm, A = 100mm* 100 mm, k= 0.25 W/mK Inserting all the values in above equation we get, Q = (114.27 – 60) \ (5/ 0.25 * 100*100* 10-3)Q = 27.1399 W

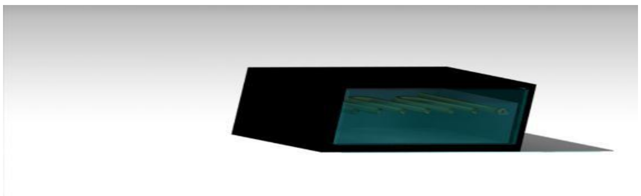

Fig. 1 PCM Heat Exchanger

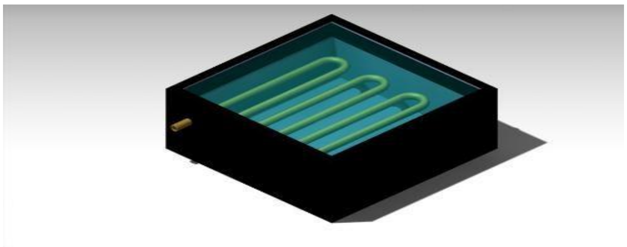

Fig.2 Full Box PCM Heat Exchanger

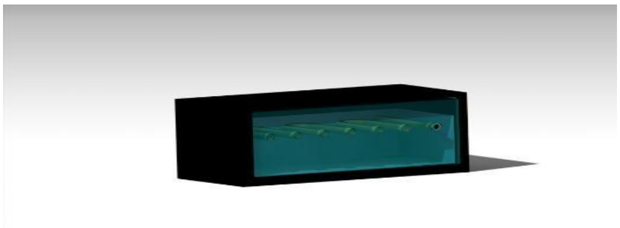

Fig. 3 Cut Section of PCM Heat Exchanger

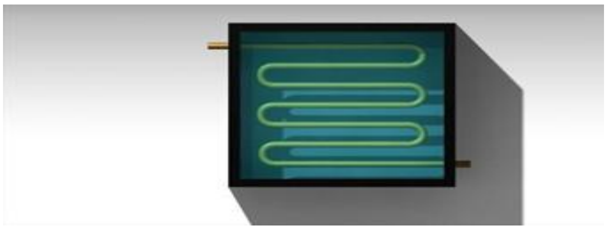

Fig. 4 Top View of PCM Full BoxHeat Exchanger

In this project, we'll build a PCM heat exchanger to look into the working medium's efficiency in transferring heat. and contrast with other data studies.

Cold water is circulated inside a copper tube in a container, where PCM, or paraffin wax, is poured after being preheated with the aid of a heater coil installed inside. Once the pcm reaches a steady state temperature, water is then allowed inside the tube, where the heat transfer rate is recorded and the pcm's efficiency is compared to that of other heat exchangers.

Sl No	Manufacturing Operation	Summary	Part	Time
		Manufacturing processes are the steps through which raw materials are transformed into a final product.		
1.	Cutting process	metal machining or cutting is the process of removing unwanted material from a block of metal or any other wood in the form of chips. Common cutting processes include sawing, shaping (or planning),broaching, drilling,grinding, turning and milling. Cold saws are saws that make use of a circular saw blade to cut through various types of metal, including sheet metal.	Sheet metal plate of thickness 2mm will be made cut for required dimension as per design.	1-2 days
2.	Welding or bolting	Welding is used for making permanent joints. It is used in the manufacture of automobile bodies, aircraft frames, railway wagons, machine frames, structural	Welding – it is a process of joining two sub parts to make a final assembly. plates which	1 day
		works, tanks, furniture, boilers, general repair work and ship building.	are sheared are welded here to make it as box type of heat exchanger.	
3.	Drilling	Drilling is a cutting process that uses a drill bit to cut or enlarge a hole of circular cross- section in solid materials. The drill bit is a rotary cutting tool, often multipoint.	On Plates to attach the tube blocks drilling is done the block via plates is inserted.	Halfday
4.	Polishing	Polishing is the process of creating a smooth and shiny surface by rubbing it or by applying a chemical treatment, leaving a clean surface	After conducting all the procedure surfaces becomes	1 day

		with a significant specular reflection (still limited by the index of refraction of the material according to the Fresnel equations).	harder and extensive so making is done though out metal and wooden blocks.	
5.	Painting	Painting is the practice of applying paint, pigment, color or other medium to a solid surface the medium is commonly applied to the base with a brush	To look good paint is done.	1 day
6.	Assembling	An assembly line is a manufacturing process (most of the time called a progressive assembly) in which parts (usually interchangeable parts) are added as the semi-finished assembly moves from work station to work station where the parts are added in sequence until the final assembly is produced.	Interstation of sub parts to make a final product.	1 day

CONCLUSION

1. We had finished the research component of this project. Phase change materials, paraffin wax, and other materials are used in heat exchangers.
2. Made a choice about the container, tube, and material's specifications.
3. CATIA v5 software has been used to create a 3D model.
4. The rate of heat transmission in both the tube and the container, or shell as we prefer to call it, was analytically calculated.
5. The proposed system was created using the intended criteria.
6. The paraffin wax keeps up the heat too well when it is in the liquid form and rejects the heat when it is in the solid state, which causes the water and paraffin wax to transfer heat at a certain pace**.**The system was designed, developed and testing results were noted after a steady state charge at 75 0C of PCM and are as

Sr. No.	**Time taken in min.**	**Temperature Before Supply or Inlet T1 ^{0}C**	**Temperature After Heat Exchange**	**Heat Transfer Average (T1+T2)/2**
1	**1**	**24**	**39**	**31.5**
2	**3**	**24**	**46**	**35**
3	**5**	**24**	**57**	**40.5**

COST ESTIMATION:

The process of predicting the costs involved in producing a product can be referred to as cost estimating. These costs include every cost associated to design and production, including all facilities for related services like tool and pattern creation, as well as a share of general administrative and marketing costs.

PURPOSE OF COST ESTIMATION:

i. To determine the selling price of a product for a quotation or contract so as to ensure a reasonable profit to the company.
ii. Check the quotation supplied by vendors.
iii. Determine the most economical process or material to manufacture the product.
iv. To determine standards of production performance that may be used to control the cost.

TYPES OF COST ESTIMATION:

1. Material cost
2. Machining cost

Material Cost Estimation

The entire amount needed to gather the raw materials, which must then be processed or manufactured to the desired size and functionality of the components, is provided by the material cost estimation.

These resources are separated into two groups.

1. Material for fabrication: In this case, the material is acquired in its raw form and manufactured or processed to the component's final size.

2. Commonly purchased parts: This category contains items like allen screws that are easily accessible on the market. A list with the quality, size, and standard components, the weight of the raw material, and the price per kilogram is predicted by the estimation. to the manufactured component.

Machining Cost Estimation

This cost estimate makes an effort to predict all costs, except material costs, that might be associated with manufacturing. Cost estimates for manufactured parts can be seen as judgments made after comprehensive analysis of factors such as labour, materials, and factory services needed to produce the desired part.

PROCEDURE FOR CALCULATION OFMATERIAL COST:

Following project design, a bill of material that is split into two categories is created as part of the general process for estimating material costs.

Fabricated parts (a).

a. Regularly bought components

2. All regular item prices are collected and added.

Calculate the price of the purchased raw materials

SR.NO.	COMPONENTS	SPECIFICATION	COST
1.	Paraffin wax	35 liters	4500/-
2.	Mild steel plats	2-4 mm thickness 1*1 meter	2450/-
3.	Heater coil	1x	245/-
4.	Copper tube	2x	1250/-
5.	Temperaturesensor	2x	345/-
6.	HDPE	2x	375/-
7.	Water motor	2x	150/-
8.	Plastic tubes	1x	275/-
	Total		9590/-

Annexure

Figure Preparation of model

Figure Box filled with paraffin wax Figure after steady state condition paraffin wax

Figure two chambers at steady state condition when in solid mode

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