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Waste Heat Recovery in Refrigeration System by Using Sodium Acetate (Trihydrate) as Phase Change Material

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ABSTRACT:

Refrigeration is a process where the heat transfers from low temperature reservoir to high temperature reservoir. Heat is rejected by the condenser of a refrigerator of low quality which means the temperature is low. In this project it is made to utilize this waste heat from the condenser of a household refrigerator. It is impossible to recover the entire energy lost by the refrigerator, this project aims at minimizing the losses and recovery of maximum heat on the system by replacing the condenser with shell and tube heat exchanger coated with molten salt (Phase Change Material) which acts as a heat absorbent. The recovered heat can be utilized for small heating applications. Here the heat from the system is used for boiling water of small quantity and oven heating.

Keywords: Refrigeration system, Energy savings, Waste heat recovery, Water cooled condenser, water Heating.

INTRODUCTION :

The project is based on Thermal energy storage. Thermal energy storage that refer to a number of technologies that store energy. It can be employed to balance energy demand between day time and night time. The thermal reservoir may be maintained at a temperature above or below than that of the ambient environment. The principal application today is the production of ice, cold water. Thermal energy storage technologies store heat, usually from active solar collectors to generate electricity. Thermal energy storage has great potential for providing the means for efficient use of various forms of energy being wasted in the industry, homes, and large building to use renewable energy sources, which includes solar, wind, geothermal, and tidal energy.

Energy storage systems provide efficient for matching of power generation and demand, and the energy is recovered during low load periods and the energy is recovered during peak load periods. Storing of thermal energy as latent heat of fusion has attractive features over the sensible heat due to its high storage density and isothermal nature of storage process at melting point temp.

Solid-liquid transformation is most commonly utilized. The energy storage could be discharged at a constant crystallization temperature. Most of the solid phase materials have low thermal conductivity. During the discharging process, a material solidifies onto the heat transfer surface, high thermal resistance is obtained.

1.1 REFRIGERATION:

The term refrigeration means cooling a space, substance or system to lower and maintain its temperature below the ambient one (while the removed heat is rejected at a higher temperature). In other words, refrigeration is artificial cooling. The form of heat energy is removed from a low-temperature reservoir and transferred to a high-temperature reservoir. The energy transfer is traditionally driven by mechanical, it can also be driven by heat, magnetism, electricity, or other means. Refrigeration system has many applications, including household refrigerators, industrial freezers, cryogenics, and air conditioning.

1.2. HEAT EXCHANGER

A heat exchanger is a device designed to efficiently transfer or "exchange" heat from one matter to another. When a fluid is used to transfer heat, the fluid could bea liquid, such as water or oil, or could be moving air. The most well-known type ofheat exchanger is a car radiator.

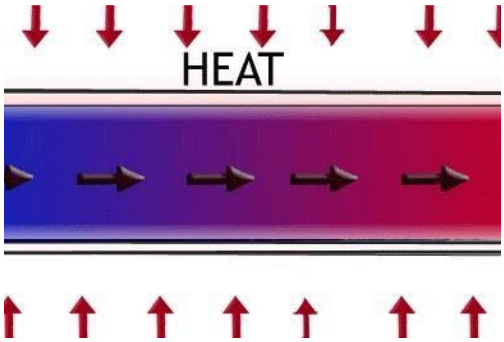

Fig.1 Heat Exchanger

1.3. SHELL AND TUBE HEAT EXCHANGER

A shell and tube heat exchanger is a class of heat exchanger designs One fluidruns through the tubes, and another fluid flows over the tubes (through the shell) totransfer heat between the two fluids.

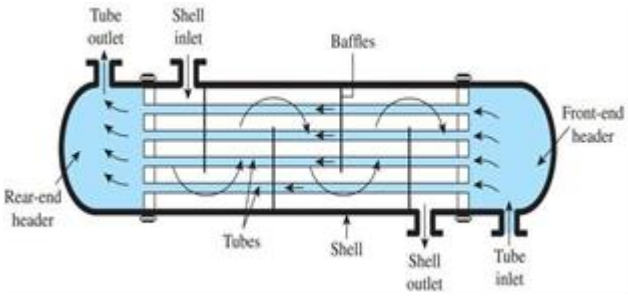

Fig.2 Shell And Tube Heat Exchanger

1.4. PCM-PHASE CHANGING MATERIAL

A phase change material (PCM) is a substance which releases/absorbs sufficient energy at phase transition to provide useful heat/cooling By melting an solidifying at the phase change temperature (PCT), a PCM is capable of storing and releasing large amounts of energy compared to sensible heat storage. A phase change material (PCM) is a substance which releases/absorbs sufficient energy at phase transition to provide useful heat/cooling By melting and solidifying at the phase change temperature (PCT), a PCM is capable of storing and releasing large amounts of energy compared to sensible heat storage.

1.5. SODIUM ACETATE (TRIHYDRATE) - PHASE CHANGE MATERIAL

Molten salt is known as an LHTES due to it being a Phase change material(PCM) meaning it has a high heat of fusion. This property allows the Molten Salt the ability to release and store large amounts of energy when the material transforms from a solid to liquid or the reverse process.

2. BASIC REFRIGERATION SYSTEM SETUP:

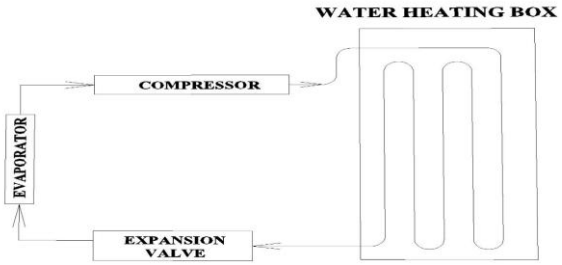

Fig.3 Basic Refrigeration System Setup

In this experimentation setup, Refrigerator is placed in the base stand. In the refrigerator, we replaced condenser to heat exchanger in the behind of refrigerator. Heat exchanger makes the connection between the compressor and expansion valve. Heat exchanger is shell and tube type. It connects with compressor outlet end and another one is inlet of the expansion valve. In this connection only the refrigerant will flow. There will be in small temperature circuit is placed in the experimental setup and effective heat absorb to make coating on copper tube by use molten salt.

3. DESIGN:

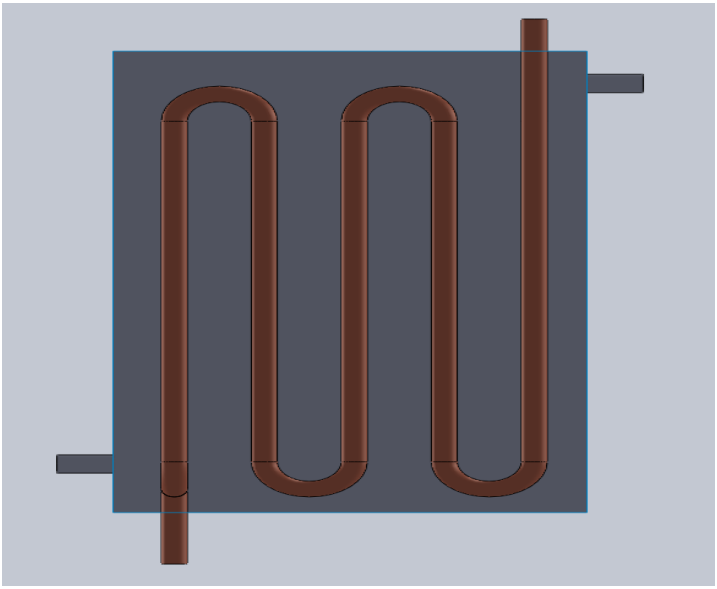

Fig 4. Water Heating Box

4. RESULTS AND DISCUSSION:

From the experimental work the following temperature difference has been obtained.

Table 1: Experimental Results

BEFORE PCM				
TRAIL	**REFRIGERANT**		**WATER**	
	T1 ˚C	T2 ˚C	T1 ˚C	T2 ˚C
1	59.5	47.6	26	44.5

2	57.6	46.6	26	47.6
3	58.9	48.4	26	44.2
AFTER PCM				
TRAIL	**REFRIGERANT**		**WATER**	
	T1 ˚C	**T2 ˚C**	**T1 ˚C**	**T2 ˚C**
1	67.9	32.1	26	51.7
2	72.6	33.3	26	48.1
3	72.8	31.8	26	51.5

Table 2: Results

BEFORE PCM		
S.NO	**Trial**	**Heat Transfer in Refrigerant Kw**
1.	1	0.360
2.	2	0.369
3.	3	0.590
AFTER PCM		
S.NO	**Trial**	**Heat Transfer in Refrigerant Kw** / **Heat Transfer in PCM Kw**
1.	**1**	1.493 / 0.711
2.	**2**	1.369 / 0.825
3.	**3**	1.590 / 0.753

4. CONCLUSION:

From the experimental work it is found that loss of heat is high in most of the thermal system. In this current work we have made an attempt to recover the waste heat from the domestic refrigeration system using sodium acetate trihydrate as an heat absorbent. A small addition in cost helps to recover and reuse the waste heat it contributing to energy savings.

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