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PERFORMANCE ANALYSIS OF COOLING CHAMBER USING LPG CYLINDER

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Abstract- *Now-a-days energy conservation is vastly researched and renowned topic. The domestic fuel, iso butane gas is stored in liquefied state at high pressure before utilization. If pressurized gas is expanded in controlled manner, it will give cooling effect which can be used for producing cooling chamber such as refrigeration and air conditioning. The expanded gas is then also used for combustion process in burner or generator for producing electricity. This study provides analysis and design of a cooling chamber using LPG gas. The LPG gas is stored at high pressure in cylinder then it is passed through the small internal diameter of capillary tube. The pressure of LPG gas inside the cylinder is decreased for expansion as well as phase change process which occurs during the isenthalpic process. During evaporation latent heat has been absorbed by the liquid refrigerant and the temperature has decreased. Therefore, LPG produces cooling (refrigerating) effect in the surrounding of cooling chamber and it has calculated the COP of LPG for comparing with existing refrigerators. The experimental results show that the coefficient of performance for both single and double line capillary tube system are higher than the domestic refrigerator. It is also observed that LPG used cooling chamber is less costly and also more ecofriendly*

Keywords: LPG cooling chamber, enthalpy, refrigerating effect, COP

1. INTRODUCTION

As the electricity has huge demand over the world, people should think of recovering the energy which is spent already but not being utilized further and try to overcome this crisis with less investment [1]. The climatic change and global warming are increasing demand for accessible and affordable cooling systems in the form of refrigerators and air conditioners. Billions of dollars are spent annually for serving this purpose. Therefore, it suggested for less costly cooling Systems [2]. Although government agencies are not able to continuously supply a major portion of electricity in both the urban and rural areas. Still people of rural regions require refrigeration for socially relevant purposes such as cold storage or storing medical supplies and domestic kitchens etc. This project has novelty of using LPG cylinder pressure as instead of electricity for refrigeration. And this solution is convenient for refrigeration in regions which are facing scarcity in electricity [3].

The term 'refrigeration' is used in a broad sense for the process of removing heat (i.e. cooling) from a substance. It includes the process of reducing and maintaining the temperature of a body below the general temperature of its surroundings. Moreover, the refrigeration means continuous extraction of heat from a body, whose temperature is already below the temperature of its surroundings [4]. If some space (say in cold storage) should be kept at -3 ^{o}C, one must continuously heat is extracted which flows into it due to leakage through the walls and also the heat, which is brought into this with the articles stored after the temperature is reduced to -3 ^{o}C [5]. Refrigerator, where heat is being pumped virtually from a lower temperature to a higher temperature. Since the middle nineteenth century the refrigeration system is known to the man. Scientist of that time, developed a few stray machines to achieve some pleasure. But it had been paving the way by inviting the attention of scientist for proper study and research [6].

There are numerous researches works have been carried out for the enhancement of the LPG refrigeration systems. LPG is a mixture of Propane and butane. But no work has been done for specific mixture how much refrigerating effect is produced and how the coefficient of performance is increased with increase of mass flow rate. In this paper, it was optimized for certain mixture and mass flow rate, how much refrigerating effects and COPs are increased.

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2. EXPERIMENTAL

In this study for the double line 12 feet and single line10 feet of capillary tube is considered. LPG mixture properties was 78% propane and 22% butane. For simplification in experimental analysis the following data were consider.

2.1 Copper tubes

According to the pressure 100 psi in this project

Type 1	3/8 grade
Material	Copper
Outer diameter	9.5mm
Length	4 feet (1.2192m)
Type 2	3/4 grade
Outer diameter	22.225mm
Length	1feet (0.3048m)

2.2 Capillary tube

By considering the pressure and flow rate

For single line,

Diameter	7mm (inner)
Length	10 feet or 2.97 m

For double line

Type	Adiabatic, size 80
Length	12 feet (3.6578m)

2.3 Evaporator

Type: Copper tube, plate and tube type

The evaporator has following dimensions: Length = 35cm, Breadth = 14 cm and Height = 32 cm.

2.4 High pressure pipe

10 feet high pressure pipe is used.

2.4 LPG Cylinder

12.5 kg cylinder is used.

After determining the dimensional parameter and doing the experimental set up the problem was analyzed, for two different mass flow rate as specified later. For analysis of the problem software refprop 7.1 was used.

3. EXPERIMENTAL SETUP

The basic components of the system are shown in setup diagram and the changes in thermodynamics properties of the fluid flowing (LPG) is shown in the systems line Fig. 1.

To test the performance of the cooling chamber two point temperature and pressure such as LPG cylinder outlet, evaporator outlet were determined. The temperature was obtained by using temperature sensor.

Fig. 1: Experimental setup.

The experiment of this project was conducted for single and double line. The data readings were taken at 10 minute's interval for single line tube and 5 minutes interval for double line tube, respectively as shown in Figs. 2 and 3.

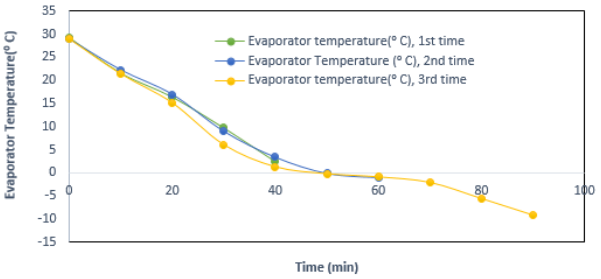

Fig. 2: Graphical representation of evaporator temperature vs. time for single line capillary tube.

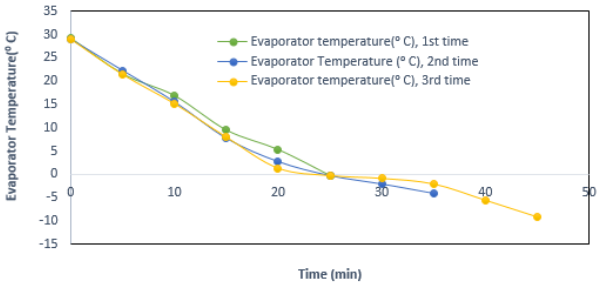

Fig. 3: Graphical representation of evaporator temperature vs. time for double line capillary tube.

4. DATA REDUCTION

The refrigerating effect and co-efficient of performance of cooling chamber are determined based on the measured temperature and pressure data.

The refrigerating effect can be calculated as- Refrigerating effect (RE) $=Q_R$,

$$Q_{1\text{-}2} = m\,(h_2\text{-}h_1) \quad \ldots\ldots (1)$$

Work input (W),

$$W_{2\text{-}3} = m\,(h_3\text{-}h_2) \quad \ldots\ldots (2)$$

where, m = mass flow rate (kg/s), h = enthalpy at defined point (KJ/Kg)

The co-efficient of performance is the ratio of heat extracted in the refrigerator to the work done on the refrigerator. It is also known as theoretical co efficient of performance. Mathematically,

$$COP = \frac{Q}{W} \quad \ldots\ldots (3)$$

where, Q = amount of heat extracted in the refrigerator

W= work input

The co-efficient of performance is reciprocal to the efficiency of heat pump. So it is higher than unity. Hence, input work is the amount of power required for filling 1 cylinder. According to PCRA energy audit report power required to refill 1 cylinder is required 3.1345 KWh. Therefore filling 1 KG of LPG gas required 0.2136 KWh [7].

5. RESULTS AND DISCUSSION

The research has showed for refrigerating effect and co-efficient of performance in different mass flow rate.

The COP for single line and double line capillary tube cooling chamber are shown in Figs. 4 and 5. The investigational study of a pressure and temperature of two different points and with the help from refprop 7 software the enthalpy of two specified point were measured. For single line 2.98 m capillary tube and for double line 3.66 m capillary tube was used.

The experiment was done for 30, 60, and 90 minutes, respectively, for single line capillary tube as shown in Fig. 4. The result show the evaporator temperature is decreased with the increased of time and the co-efficient of performance is increased. The same result was found for double line capillary tube. In this case, the experiment is done for 25, 35, and 45 minutes, respectively.

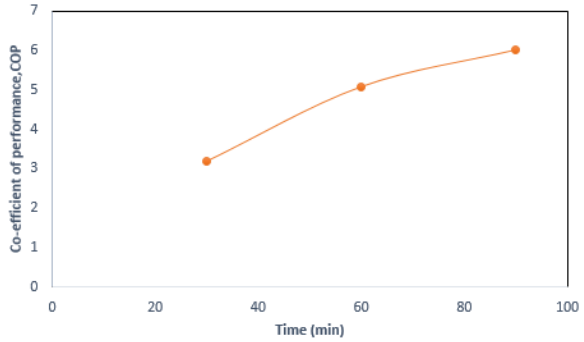

Fig. 4: COP vs. time for single line capillary tube.

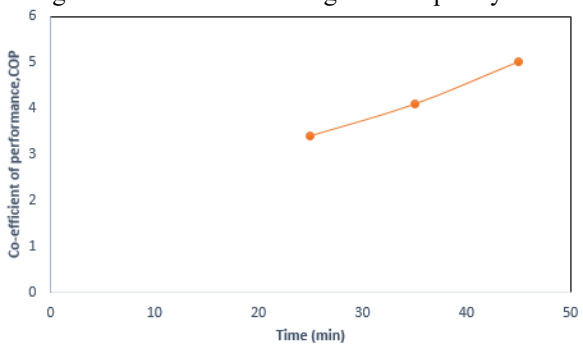

Fig. 5: COP vs. time for double.

From calculating the weight of the LPG cylinder after each time period experiment, the mass flow rate is calculated. The LPG cylinder pressure for 12 kg mixture of 78% propane and 22% butane is approximately 12.45 bar which is decreased around 1.2 to 1.41 bar through the capillary tube. From this pressure and temperature, the refprop 7 software give the exact value of enthalpy.

After calculating the refrigerating work on 1st day for single line capillary tube were 330 kj/kg, 303 kj/kg, 270 kj/kg and the COP were 3.2, 5.08, and 6.03 for three different time period. From this, it was shown that by increasing the time period, the evaporator temperature and refrigerating effect were decreasing, and increasing the COP.

Similarly, on 2nd day of experiment the refrigerating work for double line capillary tube was 290 kj/kg, 281 kj/kg, 269 kj/kg and the COP was 3.41, 4.1 and 5.045 for three different time period. In this case the same result was observed. However, the COP of double line capillary tube is slightly higher than single line capillary tube. The single line and double line capillary tube, for reaching the lowest evaporator temperature double line is better. It should be noted that double line capillary tube works more rapidly hence decreased the evaporator temperature however, it has less COP. In conversely, when it is used for single line capillary tube the evaporator temperature decreased slowly so it needs more time but higher COP. The experimental result for both single and double line capillary tube system observed the coefficient of performance is higher than domestic refrigerator which has COP up to approximately 2.95.

6. CONCLUSION

The basic purpose of the experiment is using the high pressure inside the LPG cylinder for cooling purpose without any extra power system. It was compared between two line systems of capillary tube for two different lengths. By using the capillary tube decreasing the pressure before it passes to the burner and the refrigerating effect was calculated by varying the LPG properties like (pressure, temperature and enthalpy) to and fro. As it cannot be predicted the quantity of energy that might be used up in filling of 1 kg LPG in the refinery and no data available in any energy audit report of refinery, therefore it is considered the input energy from the refilling plant only. There also might be a change in future scope if the energy input for 1kg of LPG filling would be taken from any of the refinery energy audit report. There may be leakage in this system, but this can be improved by precise manufacturing technique and method.

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