DESIGN & CONSTRUCTION OF AN LPG REFRIGERATION SYSTEM WITH LOW OPERATING COST

A project report submitted to the Department of Mechanical Engineering, Sonargaon University In partial fulfillment of the requirements for the degree of Bachelor of Science in Mechanical Engineering.

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DECLARATION OF AUTHORSHIP

We hereby solemnly declare that the project report on **"Design & Construction of an LPG Refrigeration system with low operating cost"** is submitted to Sonargaon University (SU) for partial fulfillment of the requirement of the Degree of B.Sc. in Mechanical Engineering. It has not been submitted to any other University/College/Organization or Institute previously for an academic qualification or for professional degree. We hereby ensure that the project report that has been presented does not breach any provision of copy right act. Materials of Work found by other researcher are mentioned by reference. We further undertake to indemnify the university against any loss or damage arising from breach of the forgoing obligation.

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Abstract:

Supply of continuous electricity is still not available in several areas of the country and the world. At such places, this work will be helpful for refrigeration of food, medicines, etc... This paper investigates the result of an experimental study carried out to determine the performance of domestic refrigerator when a liquefied petroleum gas (LPG) which is locally available which comprises of 24.4% propane, 56.4% butane and 17.2% isobutene which is varied from company to company is used as a Refrigerant. The LPG is cheaper and possesses an environmental friendly nature with no Ozone Depletion Potential (ODP) and no Global Warming Potential (GDP). It is used in world for cooking purposes.

The refrigerator used in the present study is designed to work on LPG. The performance parameters investigated is the refrigeration effect in certain time. The refrigerator worked efficiently when LPG was used as a refrigerant instead of R134a.

Also from the experiment which done in atmospheric condition, we can predict the optimum value of cooling effect with the suitable operating condition of regulating valve and capillary tube of the system. The use of LPG for refrigeration purpose can be environment friendly since it has no ozone depletion potential (ODP). Usually LPG is used as a fuel for cooking food in houses, restaurants, hotels, etc.. and the combustion products of LPG are CO2 and H2O. In this project we have designed and analyzed a refrigerator using LPG as refrigerant.

LPG is available in cylinders at high pressure. When this high pressure LPG is passed through the capillary tube of small internal diameter, the pressure of LPG is dropped due to expansion and phase change of LPG occurs in an isoenthalpic process. Due to phase change from liquid to gas latent heat is gained by the liquid refrigerant and the temperature drops. In this way LPG can produce refrigerating effect for a confined space. From experimental investigations, we have found that the COP of a refrigerator which uses LPG is higher than a domestic refrigerator.

To

Our Family

Table Of CONTENTS

SL NO		DESCRIPTION	PAGE
1	CERTIFICATE		01
2	DECLARATION OF AUTHORSHIP		02
3	ACKNOWLEDGEMENT		03
4	ABSTRACT		04
		CHAPTER – 01 INTRODUCTION	
1.1	INTRODUCTION		09
1.2	OBJECTIVE		10
1.3	LITERATURE REVIEW		11
1.4	THEORY		12
1.5	PHYSICAL PROPERTIES& CHARACTERISTICS OF LPG		13
		CHAPTER -02 METROLOGY	
2.1	WORKING PRINCIPLE		15
2.2	WORKING ELEMENT		16
2.2.1	FIG. EVAPORATOR		17
2.2.2	FIG. COPPER PIPE		18
2.2.3	FIG. CAPILLARY TUBE		19
2.2.4	FIG. PRESSURE GAUGE METER		20
2.2.5	FIG. BURNER		21

2.2.6	FIG. GAS CYLINDER		22
2.2.7	FIG. TEMPERATURE METER		23
2.2.8	FIG. DRYER STRAINER		24
2.2.9	FIG. REGULATOR		25
2.2.10	FIG. EVAPORATOR BOX		26
2.3	EXPERIMENTAL SETUP		27
2.4	FIG. BLOCK DIAGRAM		28
2.5	FIG. LPG REFRIGERATION HEATING SYSTEM		29
		CHAPTER - 03 RESULT & DISCUSSION	
3.1	DATA ANALYSIS		30
3.2	TEMPERATURE GRAPH		31
3.3	ADVANTAGE		32
	DISADVANTAGE		32
3.4	FUTURE SCOPE		33
3.5	APPLICATION		34
	DISCUSSION		35
		CHAPTER – 04 CONCLUSION	
4.1	CONCLUSION		36
4.2	REFERENCE		37

List of figure:

1. Figure 2.2.1 ..... Page- 17
2. Figure 2.2.2 ..... Page - 18
3. Figure 2.2.3 ..... Page -19
4. Figure 2.2.4 ..... Page -20
5. Figure 2.2.5 ..... Page -21
6. Figure 2.2.6 ..... Page -22
7. Figure 2.2.7 ..... Page -23
8. Figure 2.2.8 ..... Page-24
9. Figure 2.2.8 ..... Page-25
10. Figure 2.2.9 ..... Page-26
11. Figure 2.2.10 ..... Page -28
12. Figure 2.3 ..... Page-29
13. Figure 2.4 ..... Page-30
14. Figure 2. 5 ..... Page-31

CHAPTER- 1

Introduction:

Although government agencies are not able to continuously supply a major portion of electricity in both the urban as well as in rural areas. Still the people in these regions require refrigeration for a variety of socially relevant purposes such as cold storage or storing medical supplies and domestic kitchens this project has the novelty of using LPG instead of electricity for refrigeration. This solution is convenient for refrigeration in regions having scares in electricity.

As we know the uses of refrigerator for cooling effect that means store a body at Lower temperature than atmosphere. The area where electricity is not available Because of where huge demand all over the world, then LPG refrigeration system Is to be used for cooling or Store items. LPG refrigeration system is easy to use and Operating cost is zero. By the second law of thermodynamics it is impossible to heat Flow from low temperature to high temperature without giving any work, but in Case of LPG refrigeration system expansion of LPG from liquid state to vapour state Decrease in pressure and increase in volume and the LPG gas temperature is drop. The LPG gas is work as refrigerant. Thousands of metric ton chlorofluorocarbon Gases uses as refrigerants which it is very harmful for depletion layer.

In LPG refrigeration system, LPG contains in a cylinder in which pressure is 0 to 24 bar. When the valve is open gas flows to the pipe to the pressure gauge. After that it goes through the capillary tube to the evaporator into which LPG expand and absorb heat and cooling effect is done.

While going through the literature review in LPG refrigeration system, Conventional VCR (Vapour Compression Refrigeration System) uses LPG as refrigerant and produced the refrigerating effect. But in our proposed very simple type of refrigeration system in which the

high-pressure LPG is passing through a capillary tube and expands. After expansion the phase of LPG is changed and converted from liquid to gas and then it passes through the evaporator where it absorbs the heat and produces the refrigerating effect. After evaporator it passes through the gas burner where it burns.

OBJECTIVES:

1. To determine the benefits of LPG refrigeration system over the domestic refrigeration system.
2. Use liquid LPG as a refrigerant
3. Run LPG refrigerator without electricity by eliminate the compressor and condenser.
4. To produce the eco friendly refrigerator.
5. To make aware of non-conventional energy sources to reduce environmental pollutions.
6. This product preferably suitable for villages, because they face lot of power cut problems in summer (around 12 to 14 hrs in day). And for offices and schools which runs in day to which save energy.
7. To identify the form of residual waste in traditional refrigeration system.
8. Compare the important characteristics between LPG refrigeration system and traditional refrigeration system.
9. To distinguish between the current existing refrigerator cost and estimated cost of LPG refrigerator.

LITERATURE REVIEW:

A Performance Comparison of Vapour Compression Refrigeration System Using Eco Friendly. Refrigerants of Low Global Warming Potential VCR system with the new R290/R600a refrigerant mixture as a substitute refrigerant forCFC12 and HFC 134a. The refrigerantR290/R600a had a refrigerating capacity28.6% to 87.2% higher than that ofR134a.

Have use of propane in domestic refrigerators and conclude that the implications of using propane in domestic refrigerators are examined in relation to energy consumption, compressor lubrication, costs, availability, environmental factors and safety propane is an attractive and environmentally friendly alternative to cfcs used currently.

A Performance Comparison of Vapour Compression Refrigeration System Using Eco Friendly Refrigerants of Low Global Warming Potential.R600a have a slightly higher performance coefficient (COP) than R134 a for the condensation temperature of 50 C| and evaporating temperatures ranging between -30 C| and 10| C. Hence, the coefficient performance (COP) of this mixture was up to 5.7% higher.

Theory:

Its work on the principle that the expansion of liquid LPG to gaseous state. Due to expansion a pressure drop occurs and volume increases that results in drop of temperature and producing refrigeration effects. It is the modification of vapour absorption cycle. In VAC's Ammonia, water or Lithium Bromide is used as refrigerant.

The refrigerant gets condensed into condenser and Evaporated into evaporator. The refrigerant produce cooling effect into the evaporator and release heat into the atmosphere. In LPG refrigeration system, LPG contains in a cylinder in which pressure is 0 to 24 bar. When the valve is open gas flows to the pipe to the pressure gauge. After that it goes through the capillary tube to the evaporator into which LPG expand and absorb heat and cooling effect is done.

PHYSICAL PROPERTIES AND CHARACTERISTICS OF LPG

1. **DENSITY**

LPG at atmospheric pressure and temperature is a gas which is 1.5 to 2.0 times heavier than air. It is readily liquefied under moderate pressures. The density of the liquid is approximately half that of water and ranges from 0.525 to 0.580 @ 15 deg. C. Since LPG vapour is heavier than air, it would normally settle down at ground level/ low lying places, and accumulate in depressions.

2. **VAPOURPRESSURE**

The pressure inside a LPG storage vessel/ cylinder will be equal to the vapour pressure corresponding to the temperature of LPG in the storage vessel. The vapour pressure is dependent on temperature as well as on the ratio of mixture of hydrocarbons. At liquid full condition any further expansion of the liquid, the cylinder pressure will rise by approx. 14 to 15 kg./sq.cm. for each degree centigrade. This clearly explains the hazardous situation that could arise due to overfilling of cylinders. 1.2.3 FLAMMABILITY LPG has an explosive range of 1.8% to 9.5% volume of gas in air. This is considerably narrower than other common gaseous fuels. This gives an indication of hazard of LPG vapour accumulated in low lying area in the eventuality of the leakage or spillage. The auto-ignition temperature of LPG is around 410-580 deg. C and hence it will not ignite on its own at normal temperature. Entrapped air in the vapour is hazardous in an unpurged vessel/ cylinder during pumping/ filling-in operation. In view of this it is not advisable to use air pressure to unload LPG cargoes or tankers.

3. **COMBUSTION**

The combustion reaction of LPG increases the volume of products in addition to the generation of heat. LPG requires up to 50 times its own volume of air for complete combustion . Thus it is essential that adequate ventilation is provided when LPG is burnt in enclosed spaces otherwise asphyxiation due to depletion of oxygen apart from the formation of carbon-dioxide can occur.

4. **COLOUR**

LPG is colourless both in liquid and vapour phase. During leakage the vapourisation of liquid cools the atmosphere and condenses the water vapour contained in them to form a whitish fog which may make it possible to see an escape of LPG.

5. **ODOUR**

LPG has only a very faint smell, and consequently, it is necessary to add some odourant, so that any escaping gas can easily be detected. Ethyl Mercaptan is normally used as stenching agent for this purpose. The amount to be added should be sufficient to allow detection in atmosphere 1/5 of lower limit of flammability or odour level 2 as per IS : 4576.

6. **TOXICITY**

LPG even though slightly toxic, is not poisonous in vapour phase, but can, however, suffocate when in large concentrations due to the fact that it displaces oxygen. In view of this the vapour posses mild anesthetic properties.

CHAPTER - 2

Working principle

It works on the principle that during the conversion of LPG into gaseous form, expansion of LPG takes place. Due to this expansion there is a pressure drop and increase in volume of LPG that results in the drop of temperature and a refrigerating effect is produced.

1. LPG is extracted at high pressure in liquefied state from the storage device. Its pressure and flow rate is controlled by a valve connects it to the evaporator at requisite pressure in requisite quantity.

2. An evaporator is housed through which LPG flows. It gets converted from liquefied state to gaseous state and expands. So it absorbs heat in the form of latent heat. Due to this process, heat from surrounding is absorbed so cooling effect is produced.

3. This effect is magnified by an evaporator. A network of pipes containing gas is covered by thin and closely spaced fins which help in effective and fast cooling. The insulating material helps in storing the cooling effect for a longer period of time.

4. The LPG leaves the evaporator in gaseous form; it is then directed towards the burner, engine, or any other application where it is to be used. Thus, no LPG is consumed for cooling purpose.

Working Elements :

1. Evaporator
2. Copper pipe
3. Capillary tube
4. Pressure gauge meter
5. Burner
6. Gas cylinder
7. Temperature meter
8. Dryer strainer
9. Regulator
10. Evaporator box

Evaporator

Fig – 2.2.1: Evaporator

In the evaporator LPG is converted into the vapor from with low pressure. After passing through the evaporator low pressure and temperature LPG vapor absorbs heat from the chamber system. When the cooling effects happen during the drying cycle, the evaporators in the cooling system produce the cooling impact. The evaporators are units that exchange the heat from the cooling material and thus take the heat off the medium. After passage through the capillary tube at low pressure and temperature, the coolant reaches the evaporators. This refrigerant captures the moisture from the cooling substance so that the

refrigerant is heated during the cooling process. The refrigerant from the evaporator is even lower than the evaporator used by cooling water plants.

Copper pipe

Fig- 2.2.2: Copper Pipe

Copper pipes are commonly used for a gas line for water supply lines in the manufacturing industry and for refrigerant lines in HVAC (heating, ventilation, cooling and air conditioning) systems. Copper tubing may be rendered as soft or strong copper which has outstanding corrosion resistance which stable connections.

Capillary tube

Fig- 2.2.3: Capillary Tube

The capillary tube is a solid device, like a long, tight tube, that binds the condenser directly to the evaporator. Because of the following two friction parameters, the pressure flow through the capillary tube results in flashing of the liquid refrigerant into the vapour, consequential in a decreasing friction pressure and an acceleration. The tube has a small inner copper tube with an inner diameter 1.05mm. It is lengthy and spiraling in several directions to take up less volume. For cooling applications, the inner diameter of the capillary tube varies between 0.5mm to 2.5 mm. The prevention of coolant pressure through capillary relies on the diameter and capillary length of the capillary. The diameter is smaller, and the capillary is more distant than the refrigerant's pressure drop when it passes via the capillary tube.

Pressure gauge meter

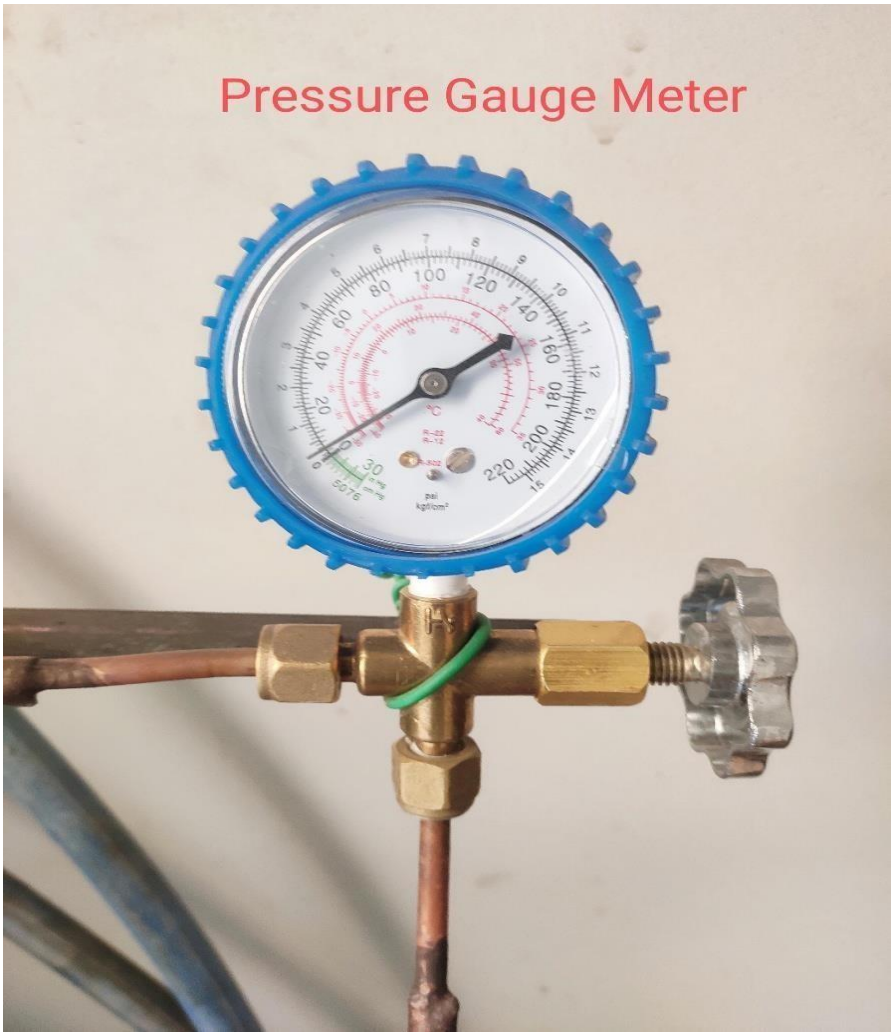

Fig-2.2.4 : Pressure gauge meter

The Bourdon pressure gage is the best regularly utilised mechanical gauge. It is a stiff, flattened, curved steel tube. The fluid flows inside the tube, which must be evaluated by pressure. The side of the tube is fixed, and the other end is to move freely to or from within. The free-end movement inside and outside has a pointer. The indicator displays the pressure of the indicator (the difference between fluid and ambient pressure). These measurements can be accessed in different pressures.

Burner

Fig- 2.2.5: Burner

After performing the cooling effect, low pressure LPG gas goes into the burner where the burns. As we know whenever the fluid flow through the narrow pipe there is a pressure drop. The amount of pressure drop in our system is calculated.

Gas cylinder

Fig- 2.2.6: Gas Cylinder

The symbol within the pictogram is a gas cylinder. This symbol indicates that hazardous products with this pictogram are gas esthatare contain edina receptacle under pressure, or which are liquefied or liquefied and refrigerated.

Temperature Meter

Fig- 2.2.7 : Temperature Meter

A temperature meter is an instrument used to measure the temperature of beings or things. The most widely recognized temperature meter is a mercury thermometer used to measure the temperature of people. These thermometers consist of a graduated glass capillary with a pool of mercury in one end.

Dryer steiner

Fig- 2.2.8: Dryer Steiner

Filter driers are devices used in a HVAC system that are a combination of filter and dryer (or drier). A filter is used to remove any particle such as dirt, metal or chips from entering the refrigerant flow control. The refrigerant flow control device could be thermostatic expansion valve or simply a capillary tube.

Regulator

Fig- 2.2.9: Regulator

An automatic voltage regulator (AVR) is a device that maintains the voltage at the desired level supplied to your refrigerator, by regulating any voltage fluctuations (both over and low voltage) that might occur.

Evaporator box

Fig- 2.2.10 : Evaporator box

The refrigeration box is made of wood or Thermopolis, which is insulator of heat in this box two chamber are made one used as evaporator and other is used as cooling chamber.

EXPERIMENTAL SETUP:

The low-pressure LPG refrigerant flows through the evaporator after the tube. The capillary tube translated into the capillary tube through the LPG. The LPG is transformed into small pressure vapour and processes to the evaporator that absorbs heat in the chamber, making it comfortable and cooling the refrigerant. The LPG passes through the pipe to burner after passing through the evaporator. The VCR system goes as follows. The LPG refrigerant operates with the vapour compression cooling mechanism. The simple idea after the LPG refrigerant is the use of LPG for heat absorption. Whenever the control gas tank is unlocked, the LPG placed under high pressure in the LPG cylinder where LPG passes through the high-pressure tube. The LPG high-pressure tube transformed with the remaining enthalpy constant at low pressure. The low-pressure LPG refrigerant flows through the evaporator after the tube. The capillary tube translated into the capillary tube through the LPG. The LPG is transformed into small pressure vapour and processes to the evaporator that absorbs heat in the chamber, making it comfortable and cooling the refrigerant. The LPG passes through the pipe to burner after passing through the evaporator. The VCR system goes as follows.

Fig- 2.3 Experimental setup

Block Diagram :

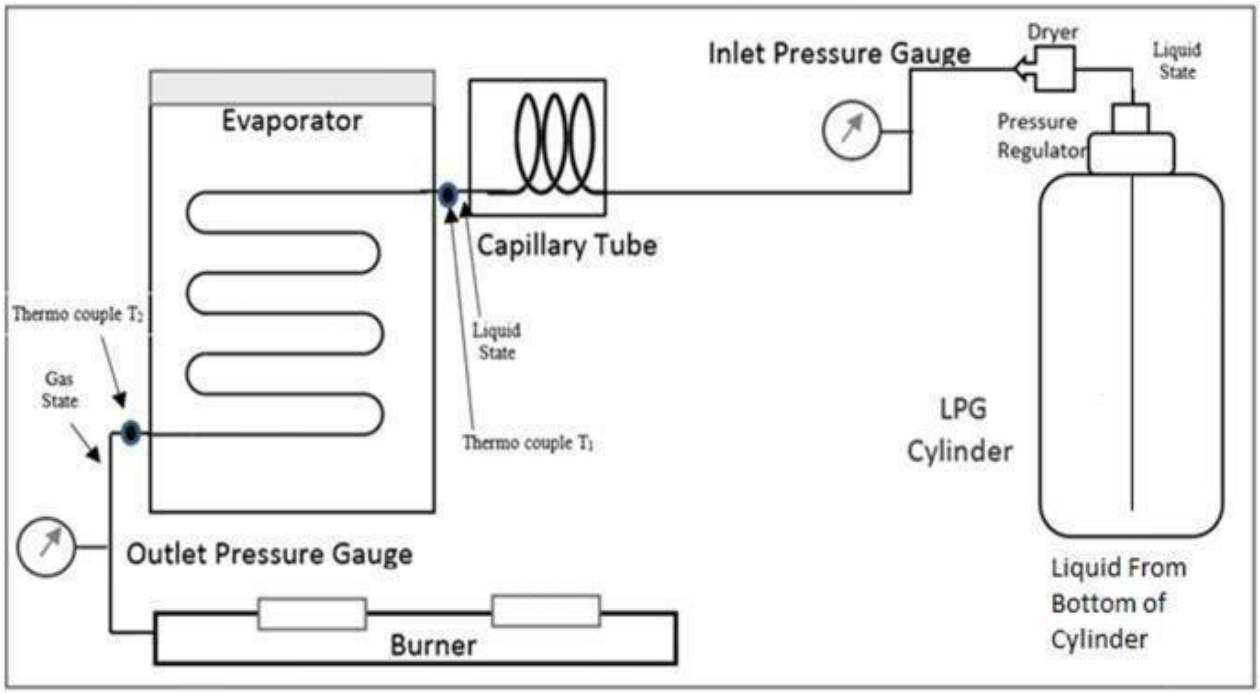

Fig- 2.4: Block Diagram

LPG refrigeration heating system

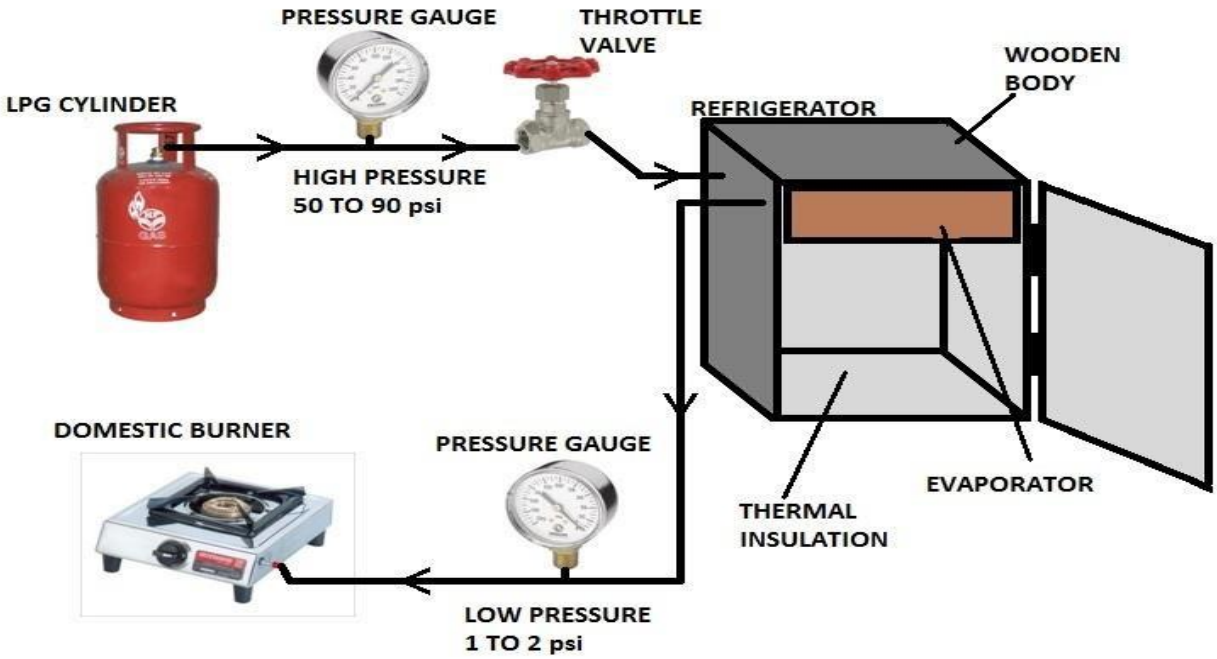

Fig- 2.5: LPG refrigeration heating system

CHAPTER-3

Data analysis :

The experiment of this project was done on 13 May, 2022 at 1:00 p.m. and readings were taken at 10 minute's interval, for 1 hour which is as shown in table 1 below:Temp.

Table -1

Time	Inlet pressure (Psi)	Outlet pressure (Psi)	Evaporator temp. C°
15	75	15	24
25	70	14	21
35	67	13	19
45	64	11	16
55	60	10	14

Again we were taken reading on this project on second day on 14 May, 2022 at 1:00 p.m. and readings were taken at 10 minute's interval, with same cylinder for 1 hour which is as shown in table 2 below:Temp.

Table -2

Time	Inlet pressure (Psi)	Outlet pressure (Psi)	Evaporator temp. C°
10	70	15	23
20	67	13	20
30	64	12	17
40	62	10	14
50	60	10	11

Temperature Graph:

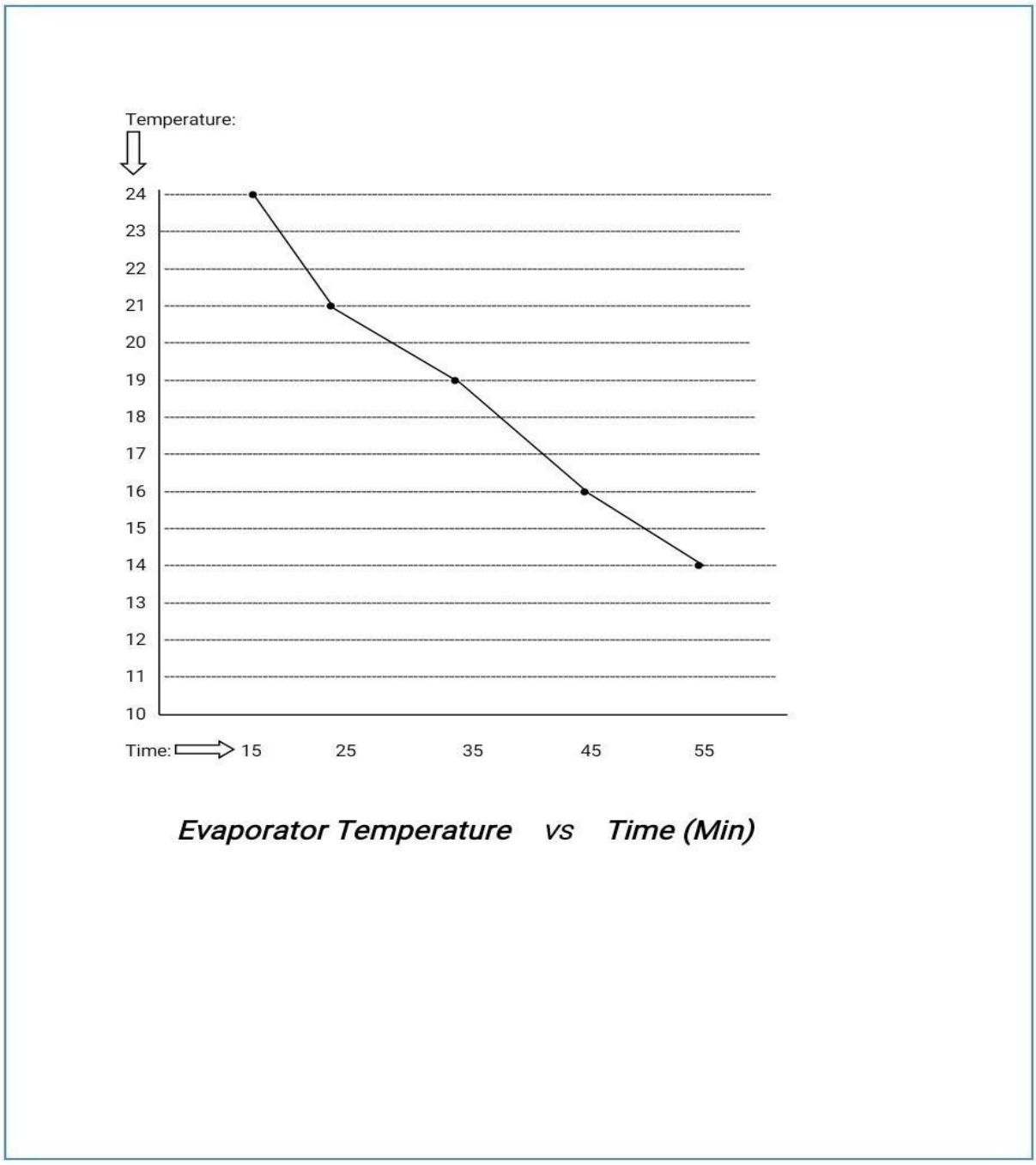

Fig : 3.2 Temperature Graph

ADVANTAGES AND DISADVANTAGES:

Advantages –

1. The usage of LPG as a refrigerant also increases the overall performance by between 10% and 20 %.
2. LPG's ODP is zero, and GWP is 8, which in contrast with other refrigerant is substantially negligible.
3. The system's weight reduced by 60% because of LPG lower capacity.
4. If power is off, this refrigerator works.
5. Besides being environmentally friendly, LPG use also has many advantages in terms of costs.
6. The components are quiet during service.
7. The Price of operation is zero.
8. Large amount of refrigeration at lower initial purchase and operating cost.
9. Very efficient
10. Very compact system for small to very large heat loads.
11. Cycle can be reversed for heat pump operation.

Disadvantages-

1. Efficiency is ineffective.
2. LPG leak triggers the explosion.
3. The system is difficult to repair and manage.
4. The system is a vast Structure.

Future Scope

1. This system is cheaper at initial and running cost is almost zero. It does not require an external energy sources to run the system and no moving part in the system. So maintenance cost is also very low. This system is most suitable for hotel, industries, refinery, chemical industries where consumption of LPG is very high.

2. Propane is an attractive and environmentally friendly alternative to CFCs used currently.

3. Mass flow rate increases with increase in capillary inner diameter rand coil diameter where as mass flow rate decreases with increase in length. It was observed that the COP of system increases with similar change in geometry of capillary tube.

4. High COP values were obtained No operation problems have been encountered compressor. The use of LPG as a replacement refrigerant can contribute to the solution of (ODP) problem and global warming potential.

5.Mass flow rate increases with increase in capillary inner diameter rand coil diameter whereas mass flow rate decreases with increase in length. It was observed that the COP of system increases with similar change in geometry of capillary tube.

6.The coefficient of performance of refrigeration appliances improves in case of retrofitting the capillary tube.

7. The future scope of this project is to focus on implementation of the project in the restaurant and community hall for preserving vegetables, dairy products with the refrigeration, where it serves the purpose of preservations.

8. This kind of system can be implemented on the food trucks as well where it can store in various quantities .

9. To create working model for LPG refrigeration.

APPLICATION

1 It can play an important role in restaurants where continuously cooling and heating is required.

2 It can be used in chemical industries for refrigeration purpose.

3 It can be useful in remote parts where electricity is not available.

4 It can be used in refineries where consumption of LPG is high.

5 The system can universally be used in industrial central cooling and domestic refrigeration and air conditioning as well.

6 It can be used in automobiles running on LPG or other Gaseous fuels for air conditioning.

7 It can be useful in remotes parts where Electricity is not available.

8 Cooling and storage of essentials in remote areas and in emergency vehicles, such as storage of essential bio-chemicals, injections, etc in an ambulance, is easily possible.

9 It can be used for zero cost air-conditioning of spaces like airports, shopping malls, etc which have their own gas turbine power-plants.

Discussion

An effective refrigeration system should able to reach low temperatures in a short period of time. An experiment was setup in order to determine how effective the LPG refrigeration system designed is. In this experiment, a thermocouple thermometer was used to measure the temperature in the evaporator at time intervals of (15 and 10) minutes. The experiment was carried out over a time of 60 minutes. In this experiment, the temperature was taken in two sections of the evaporator which are the freezing section and the non-freezing section, as shown in experiment evaporator box. The freezing section is inside the tube and plate heat exchanger while the non-freezing section is outside the heat exchanger. [Table 1] and [Table 2] below shows the temperature of the freezing section and nonfreezing section of the evaporator over a time of 60 minutes at (15 and 10) minutes time intervals respectively. A graphical representation of the temperature variation is shown in below.

LPG as refrigerant, still outperforms this refrigerant in both the evaporator temperature and coefficient of performance. These results show that LPG can be used to substitute R134a as a refrigerant as it is more environmentally friendly and performs better than R134a in refrigeration systems.

CHAPTER-4

Conclusion:

The aim of the LPG refrigerator was to use LPG as a refrigerant and utilising the energy of the high pressure in the cylinder for producing the refrigerating effect. We have the LPG at a pressure of 12.41 bar in Domestic 14.5 kg cylinder equipped with a high-pressure regulator and this pressure has reduced up to 1.41 bar with the help of capillary tube. But if we use a low-pressure regulator as is the practice in conventional domestic LPG gas stove, the pressure of LPG after the expansion device and before the burner would be different. So, we have calculated the refrigerating effect with the help of changes in properties of LPG (pressure, temperature, and enthalpy) before and after the evaporator using high pressure regulator and the amount of refrigerating effect is 323kJ/Kg. Since we don't have the actual amount of energy that will be consumed in producing 1 Kg of LPG in the refinery and were not available in any of the Energy Audit Report of Refinery, that's why we have taken the energy input from refilling plant only. For energy input we have taken the amount of energy required for refilling 1 Kg of LPG in the bottling plant (PCRA energy audit report, HPCL LPG bottling plant Asauda Bahadurgarh (Haryana) Dec. 2006.) is 0.216 kWh. With this energy input the COP of the LPG refrigerator is 5.08 and it is greater than the domestic refrigerator. But in the future scope the result may differ if energy input for 1Kg of LPG production, would be taken from the energy audit report of any refinery.

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