

# LPG Cooling System (Eco-Friendly Refrigeration Using LPG)

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**Abstract** - Refrigeration has made the milestone in human life. Since from very long time the human being has developed so many ways of refrigeration for preserving food, cooling water, etc. but yet the techniques are developing. The science of refrigeration has developed so many ways to improve our lifestyle. Our project considers law of conservation of energy maximum utilization of the fossil fuel and saving energy. This project has done LPG as refrigerant, instead of using closed cycle as it is used in normal practice (VCR); the open cycle has been used. Before burning the LPG in burner, it is passed through the expansion device and evaporator and produces the refrigeration effect without using electric energy.

LPG is cheap and possess environmental friendly nature with no ozone depletion potential.

**Keywords:** - LPG, Refrigeration Cycle, Low cost cooling

## 1.INTRODUCTION

The energy crisis persists all across the globe. We think of recovering the energy which is already spent but not being utilized further, to overcome this crisis with no huge investment. The climatic change and global warming demand accessible and affordable cooling systems in the form of refrigerators and air conditioners. Annually billions of dollars are spent in serving this purpose. Hence forth, we suggest NO COST Cooling Systems.

Petroleum gas is stored in liquefied state before its utilization as fuel. The energy spent for pressurizing and liquefying is not recovered afterwards. If it is expanded in an evaporator, it will get vaporized and absorb heat to produce cooling. This property has been used for refrigeration and air conditioning. So that the liquefied form of LPG can be used for cooling and the expanded gas (LPG) can be further used for combustion as a fuel.

The ozone depletion potentials (ODPs) of HFC-134a relative to CFC-11 are very low ( $<5 \cdot 10^{-4}$ ), the global warming potentials (GWPs) are extremely high (GWP<sub>1300</sub>) For this reason, the production and use of HFC-134a will be terminated in the near future.

The applications of new refrigerant mixtures to replace conventional refrigerants in domestic refrigerators have been studied by a number of researchers. Jung and Radermacher, performed a computer simulation of single evaporator domestic refrigerators charged with many pure and mixed refrigerants. The study attempted to find the best potential replacement for CFC- 12. James and Missenden studied the use of propane in domestic refrigerators. Energy consumption, compressor lubrication, costs, availability, environmental factors and safety were the criteria for investigation. The results revealed that propane showed as an attractive alternative to CFC-12. Richardson and Butterworth determined the performance of a vapor compression refrigeration system working with propane and a mixture of propane and isobutene. The obtained performance was higher than that obtained from CFC-12 under the similar experimental conditions. Alsaad and Hammad, investigated experimentally the refrigeration capacity, compressor power and coefficient of performance (COP) to determine the performance of a medium size CFC- 12 domestic refrigerator working with a propane/butane mixture. The results indicated the successful application of the mixture of propane and butane for the replacement of CFC-12 in domestic refrigerators. Jung et al., examined the performance of a mixture of propane and isobutene used in refrigerators. A thermodynamic analysis showed that the coefficient of performance of the system was increased up to 2.3% as compared to

CFC-12 when the test was run at a mass fraction of propane ranging between 0.2 and 0.6.

## 2. PROBLEM STATEMENT

1. Today world is facing the major problems regarding energy crisis. According to the Indian Government, the refrigerator is the 3rd heaviest consumer of power amongst household appliances. It is one of the few appliances that is running 365 days a year. Still the people in rural areas 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. So we use LPG as refrigerant to minimize the use of electricity.
2. Along with this we are facing major environmental trouble due to increase in harmful gases which are evolved from nowhere else but the combustion of these conventional energy sources.
3. Pollution is minimized when any gas burn.

## 3.OBJECTIVES

The Objectives of this project “Performance evolution of Domestic Refrigerator using LPG Cylinder” are as follows:

- 1) To identify the form of residual waste in traditional refrigeration system.
- 2) Compare the important characteristics between LPG refrigeration system and traditional refrigeration system.
- 3) To distinguish between the current existing refrigerator cost an estimated cost of LPG refrigerator.
- 4) The performance of existing refrigerator and LPG refrigerator is to be compared.

## 4.DESIGN METHODOLOGY

Considering LPG as refrigerant, the system for cooling water is as designed below.

In this section the layout & various components like cylinder, regulating valve, pipe, heat exchanger, etc used in the system are explained. Also considering various properties of material properties, standard specimens, & various theories of design & heat transfer the system is designed.

Layout-

The main principle behind this project is of making use of liquid LPG as coolant for this latent heat required for phase transformation of liquid LPG in to gaseous state is taken from water which is to cooled thus the layout of system is as shown in following fig.

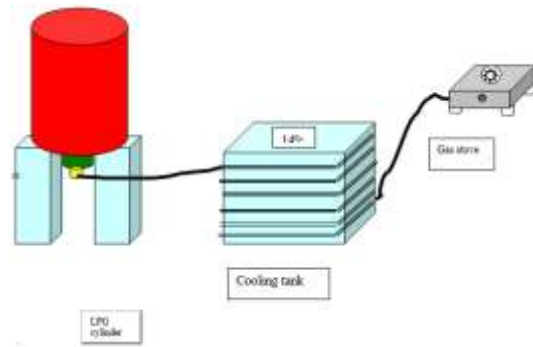


Fig. - Basic layout of system

The layout consist of cylinder ,regulator , suraksha pipes, heat exchanger, burner, etc. cylinder is as shown in inverted form & regulating valve connected to it so as to get liquid LPG at the outlet of the valve . The heat exchanger is placed in between burner & cylinder with the help of pipe (wire reinforced). The length of pipe between cylinder & heat exchanger is less as compare with length between heat exchanger & burner. So as to allow liquid LPG to enter in heat exchanger & pipe connected between heat exchanger is long enough so as to convert remaining liquid LPG into gaseous state.

## 5.DESIGNMATERIAL SELECTION

### RAW MATERIAL & STANDARD MATERIAL

S.N	Name Of The Component	Material	Qty
1	Gas Stove	Steel	1
2	Gas Pipe	Steel - Rubber	1
3	Evaporator Pipe	Cu	1
4	Regulator	Std	1
5	Pipe Clip	Ms	4
6	Tank	Steel	1
7	Temp Indicator	Std	1

### CALCULATIONS-

Evaporator design-

The heat absorbed or heat transfer capacity of an evaporator is given by

$$Q = UA(T_2 - T_1) \text{ W or J/S}$$

U = Overall heat transfer coefficient W/ m<sup>2</sup>k

A = Area of evaporator surface in m<sup>2</sup>

T<sub>2</sub>= Temperature of medium to be cooled

T<sub>1</sub>= Saturation temperature of refrigerant at evaporator pressure

C<sub>p</sub> = Specific heat at constant pressure of LPG  
= 1.64244 KJ/Kgk

$C_V$  = Specific heat at constant volume of LPG  
 = 1.4534KJ/Kgk

$\rho$  = Density of LPG = 496.47Kg/m<sup>3</sup>

$D_i$  = Inside diameter of evaporator coil

$D_o$  = Outside diameter of evaporator coil

$\mu$  = Viscosity = 7.7 N-Sec / m<sup>2</sup>

$h_i$  = Internal corrective heat transfer coefficient

$h_o$  = Water side coefficient

**The evaporator has following dimensions:**

Length = 300 mm, Breadth = 250 mm and Height = 400 mm The evaporator is made from six plywood sheets of 10mm thickness which enclose six thermocol sheets of 10 mm thickness. The areas for these sheets are as follows:

Area1 = 400×300 = 0.12 m<sup>2</sup>,

Area2 = 400×250 = 0.1 m<sup>2</sup>,

Area3 = 400×300 = 0.12 m<sup>2</sup>,

Area4 = 400×250 = 0.1 m<sup>2</sup>,

Area5 = 300×250 = 0.075 m<sup>2</sup>,

Area6 = 300×250 = 0.075 m<sup>2</sup>

Thermal conductivity of plywood  $k_p$  = 0.12 W/mk

Thermal conductivity of thermo coal  $k_t$  = 0.02 W/mk

Thickness of plywood = 10 mm

Thickness of thermo coal = 10 mm

Temperature of atmosphere = 35o C = 308 K

Temperature of evaporator = 25o C = 298 K

Heat flow from area 1 due to conduction

$$Q_1 = (T_a - T_e) / (R_{thp} + R_{tth})$$

$$= (T_a - T_e) / ((L_p / K_p \cdot A) + (L_t / K_t \cdot A))$$

$$= (308 - 298) / [(0.694) + (4.167)]$$

$$= 2.25524W$$

Heat flow from area 2 due to conduction

$$Q_2 = 5.58 W, Q_3 = 2.32 W, Q_4 = 5.58 W, Q_5 = 2.84 W$$

$$Q_6 = 2.84 W$$

Total heat flow from all areas due to conduction

$$= 10.0962 W$$

Heat flow from evaporator due to convection

Inside heat transfer coefficient = 30 W/m<sup>2</sup>.K

Outside heat transfer coefficient = 10 W/m<sup>2</sup>.K

Rate of heat transfer Q [12]  $Q = U \cdot A \cdot (T_a - T_e)$

The overall heat transfer coefficient

$$1/U = (1/U_o) + (L_p/k_p) + (L_t/k_t) + (1/U_i)$$

$$1/U = 0.649 \quad U = 1.54 W/m^2.K$$

Rate of heat transfer from area 1

$$Q_1 = 1.54 \times 0.03578(298 - 264) = 1.848W$$

$$Q_2 = 1.54 W,$$

$$Q_3 = 1.848 W,$$

$$Q_4 = 1.54W,$$

$$Q_5 = 1.155 W$$

$$Q_6 = 1.155W$$

Total heat flow from all areas due to convection = 9.086 W

Heat transfer due to radiation Q

$$Q = \sigma T^4$$

$$= 5.67 \times 10^{-8} (35 - (25))^4$$

$$= 5.67 \times 10^{-4} W$$

Total heat flow from evaporator due to conduction, convection and radiation  $Q_t$

$$Q_t = 10.0962 + 9.086 + 5.67 \times 10^{-4}$$

$$= 19.1827W$$

$$(h_2 - h_3) = 105.651$$

[values are taken from PH chart of LPG]

For filling of 1 LPG cylinder of 19.5 kg

the power input is = 3.1354kWh

So 1 kg of LPG is = 3.1354/19.5 = 0.1607 kWh

We run the set up for 1 Hr

$$W = 0.1607 \times 1000 / (9.45 / 10000) \times 3600 = 47.2369W$$

$$COP = (h_2 - h_3) / w = 105.65 / 47.2369 = 2.236598$$

## 6. TESTING OF SYSTEM

Working-

The working of LPG cooling prototype may be described as follows-

Before starting the experiment some arrangements are necessary which may have given high priority. Firstly, LPG cylinder is placed in inverted position on stand properly. Then proper connections are made to evaporator & expansion device. After this regulator is operated & equipment is checked for leakage keeping the regulator in open position. If any leakage is found, it is rectified.

For safety, the everything is kept away from burner. The first step is lightening the burner. The flow of LPG is controlled by regulator fitted on cylinder. Thus the controlled flow is maintained to avoid the frosting & liquid accumulation at the burner inlet. After performing many trials, we got proper position of valve, at which burner works properly. In our refrigeration there is no need of compressor & condenser, because in LPG cylinder it is stored under high pressure & very low temperature. So the compression process is adopted directly by LPG cylinder.

In case of condensation process high pressure vapour is converted into liquid form. The LPG heavier than air. It is stored in liquid form in cylinder. By keeping cylinder vertically downward position, we get high pressure liquid LPG. The liquid form LPG coming out from cylinder is passed through expansion device. Where they converted in low pressure & low temperature & then passed through evaporator. The vapour state LPG coming out

from evaporator chamber is then passed through gas chamber to gas burner. Where it burns & gives energy for cooking purpose. The liquid coming out from cylinder takes heat from surrounding to change the phase from liquid to gaseous. For that purpose, the length of rubber pipe have kept longer, so it will give enough time for change in phase.

The digital thermocouple is used to measure the temperature readings in the experiment. The readings are taken out for varying temperature & time. Thus from that readings we will come to know the change in temperature for specific time.

### 7.OBSERVATION & RESULTS

#### Demo Test No -1 (with domestic regulator)

Demo test readings -Duration of test is  $\frac{3}{4}$  hour.

S.No.	Time(Min.)	Readings In (°c)
1	Initial	34.7
2	3	34.7
3	6	34.6
4	12	34.5
5	15	34.3
6	18	34.1
7	21	33.8
8	24	33.4
9	27	33.1
10	30	32.8
11	33	32.5
12	36	32.2
13	39	31.8
14	42	31.8
15	45	31.9

Table - Observation table for demo 1

The above readings are taken in demo test. That time we used the household/domestic regulator. The flow of liquid LPG through this regulator is very small as compare to industrial regulator. Thus because of this reason the readings we got are not accurate. The above chart shows those readings, they shows very minor cooling effect thus for solving that problem in next demo tests us used industrial regulator.

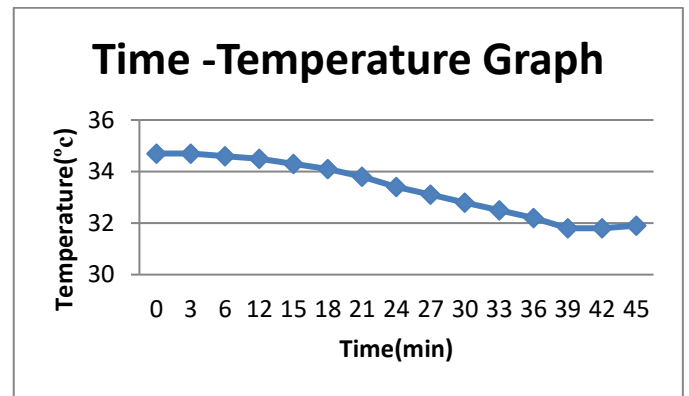


Fig - Time –temperature graph for demo 1

The above graph shows the readings taken during first demo test. The test readings taken may show very minor temperature change. The test readings shows the temperature difference of approximately 2.8°c .Thus in refrigeration this temperature difference is very low as compare to other refrigerating techniques. There is loss of energy which causes decrease in efficiency of refrigerating effect.

#### Demo Test No -2 (with industrial regulator)

Demo test readings - Duration of test is  $\frac{1}{2}$  hour.

S.No.	Time(Min.)	Readings In (°c)
1	Initial	29.1
2	2	27.3
3	4	26.1
4	6	24.8
5	8	23.8
6	10	22.7
7	12	21.5
8	14	20.1
9	16	19.1
10	18	18.3
11	20	17.8
12	22	16.3
13	24	15.4
14	26	14.5
15	28	13.7
16	30	12.9

The above readings are taken in demo test .In previous test we have used the domestic regulator because of its

low flow rate, we used industrial regulator in place of it. They show gradual decrease in temperature as time gets lapsed. The initial reading is 29.1°C & final reading is 12.9°C. Thus the difference between them shows decrease in temperature. In this case the temperature difference we get is very high as compared to previous test. It shows approximately 16.2°C decrease in the initial temperature within ½ hour.

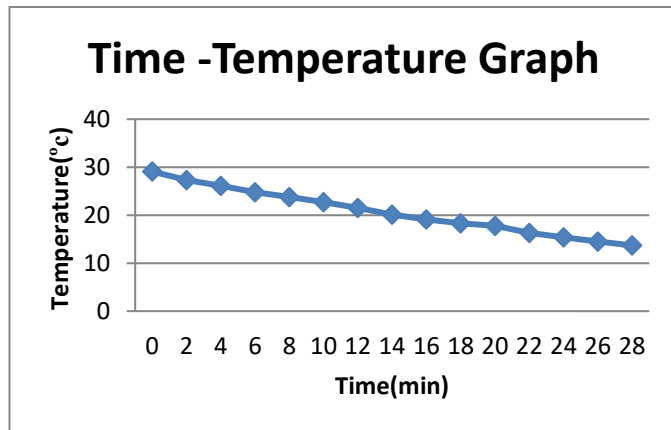


Fig -Time-Temperature Graph

The above diagram shows the readings taken during demo test with industrial regulator. The time temperature diagram shows the change in temperature & time. As in first case flow rate is less due to domestic regulator but in this case the industrial regulator is used which increases flow of liquid LPG through regulator. This causes the increase in efficiency of refrigeration. The temperature difference given is approximately 16.2°C for 30 min. But as time increases the refrigerating effect also increases.

## 8. CONCLUSION

Studying all aspects of LPG it can be stated that, LPG is versatile fluid can be utilized as better cooking gas. A better fuel for IC engine as well as better & eco friendly refrigerant. The zero phenomenon of system is most existing one of this project, which the potential of LPG is directly harnessed from commercial LPG cylinders.

Actually the system employed is designed for chilling effect equal to 5°C & practically the result obtained are in the range of 6°C to 6.6°C indicating the efficacy & accuracy of the system. Hence it can be concluded that, whatever the consumption of commercial LPG is considerably high, the system will definitely work positively

This system in beginning fruitful in case of restaurant, hotels, where consumption of LPG is high enough. The only limitation of the system can be inflammable property of LPG. But the proper arrangement & operation can easily evade these limitations, as the construction & operation made during the process are very handy.

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