

Study, Analysis of Instantaneous water cooling Using LPG as a Refrigerant

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ABSTRACT: Study of instantaneous cooling effect on water using LPG gas as a refrigerant in today's life. A refrigerator serves many and useful purposes such as cooling water, storing food items, medicines, beverages, and other such materials. Among this all the consumption of chilled or cold water is more. The household refrigerator that we use in our homes and hotels requires opening and closing the door several times and also we have to fill the bottles or containers each time they are emptied. This reduces the efficiency or performance of the refrigerator. The refrigerant use in our refrigerator has an adverse effect on environment and also the power consumption is huge.

So, to solve this problem out making just a water cooler or chiller that will give you chilled and cold water in the minimum time (instantaneous) as compared to our daily refrigerator by using LPG gas as a refrigerant. This system will be atomized with Automatic filling arrangements, Temperature controlling sensors, leakage detecting device. LPG (liquefied petroleum gas) as refrigerant used for supportive way to contribute towards our environment. LPG is easily available gas stored in the cylinder for household purposes. which consists of 24.4% propane, 56.4% butane and 17.2% isobutene. It is cheaper and eco-friendly towards global warming. It works efficiently when used instead of R134a to obtain good cooling effect and this may be a small step towards power saving, supporting towards environment.

KEYWORDS: Evaporator Tube, Condenser, Refrigeration, Compressor, Capillary Tube, LPG Gas, Water Flow Tube.

I. INTRODUCTION

Cooling effect is referred as Refrigeration, Refrigeration is process of removal of heat from element. which means cooling of that element. This also helps in reducing and maintaining the temperature of a certain element below the temperature of its surrounding and it is a continuous process. vapour-compression refrigeration is the refrigeration cycle for use. It is most widely used method for cooling. The main purpose of this water cooler system is to provide water set temperature and make it constantly available. The output temperature of water will be obtain in the range of 7°C to 10°C. There are many types of water coolers but the cooler which is compact, portable and gives instant water cooling will be most widely used.

The Refrigeration consists of Capillary Tube, Evaporator tube, Pressure gauge, High pressure pipes. This type of water cooler has the Evaporator formed by refrigerant tubing and refrigerant uses LPG in compressed form (liquid form). The evaporator coil is engaged with the another coil in which there is flow of water which is to be cooled in concentric or composite manner. This second tube is fabricated such that it makes maximum contact with the evaporator coil. so, that there is maximum removal of heat from water and water cooled down quickly. Thus, cooling effect is obtain at very instant. It works on the principle that the expansion of LPG will be take place during

International Journal of Innovative Research in Science, Engineering and Technology

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The conversion of liquid LPG into gaseous form. The material used for second tube is also copper as copper has good thermal conductivity.

II. RELATED WORK

- 1) By studying this system we realized that the model of instantaneous water cooler is advantages for the purpose of cooling the water.
- 2) It can also use instantaneously and quickly for purpose because it requires least and minimum time to the water and perform its function.
- 3) If anywhere like (railway stations, restaurants and hotels, colleges hospitals) the load on water cooler is more and there big quantity of cooled in minimum time then our water cooler can be use.
- 4) This type of system is not used by any of the companies, if this project or cooler is made by any standard companies, then some standardization and excellent quality will be achieve economically and cost will also be reduced.
- 5) This system is eco friendly and non polluting machines so we can prefer this water cooler over the other coolers. The total energy consumption is none because the work done is instantly.

III. WORKING PRINCIPLE

The instantaneous water cooler consists of vapour compression cycle and its working is mentioned below

- It consists of four process

1) Compression-

The process starts from compressor as it is started, it sucks the low pressure vapour from the evaporator and compresses it to high pressure sufficiently. as the compressor compresses it to high pressure the temperature of refrigerant increases subsequently and changes its state from liquid to high temperature vapours.

2) Condensation-

This high temperature vapours with high pressure than move to condenser where this vapour are condensed in liquid form and it is still with high pressure. The cooling medium in condenser is generally air. The cool air from surrounding absorbs the latent heat from vapours and cools it to liquid state.

3) Expansion-

The liquefied refrigerant with high pressure is now ready to move towards the evaporator. Its amount is controlled by capillary/throttle device. It reduces the pressure of liquefied refrigerant and due to which liquefied state of refrigerant is again change to gaseous and vapour state. The temperature of refrigerant reduces as per its pressure.

4) Vaporization-

The low temperature and low pressure vapour of refrigerant then passes through the evaporator where the actual cooling takes place. Here its absorbed the latent heat from the water and makes the water cool. As the phenomenon of heat transfer says that heat always travels from high temperature towards low temperature while, absorbing the heat from surrounding. The temperature of refrigerant increases and it changes from liquid state to high temperature vapour state. **Fig no. (1)**

Thus, this high temperature low pressure vapours are again sucked by compressor and whole process repeats again giving cooling effect.

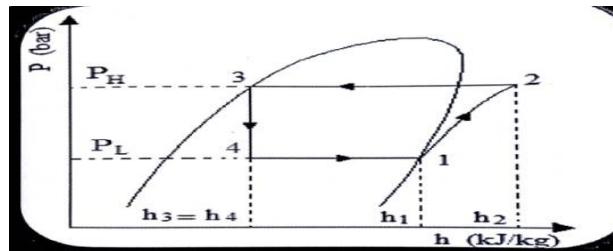
- refrigerating effect = RE = $m(h_1 - h_4)$
- compressor power = $m(h_2 - h_1)$
- COP of vapor compression cycle = RE/compressor power
= $(h_1 - h_4)/(h_2 - h_1)$

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Fig(1):- Vapour compression refrigeration cycle

The main aim of using LPG as a refrigerant that it is quickly and easily available from our household gas cylinder. In cylinder it is stored under pressure of **80psi**. In the evaporator tube it is reduced up to **15psi** to obtain cooling effect by using throttling device to absorb heat isentropically. The high pressure LPG passes through the gas tube. This high pressure LPG goes into the capillary tube and thus, we get refrigerating effect in the refrigerator. After the work is obtained from evaporator coil the low pressure LPG is passed through the burner and we can use for further cooking operation in houses or in hotels, etc. In this system **compressor and condenser are not used** hence, it is cheap and eco-friendly.

Around the world 17500 metric tons of conventional refrigerants is consumed by domestic refrigerators like CFC and HFC which are the main elements in depletion of ozone layer causing global warming. The use of LPG replacing CFC have obtained good results just by modifying our domestic refrigerators. So, LPG can be used instead of R134a refrigerant in the system.

IV. DETAILS OF COMPONENT USED IN SYSTEM

1. Throttling device-

It is known as capillary tube or pitot tube. the material used for capillary tube is copper. The pressure drop of refrigerant take place due to this device to obtain cooling effect. It has small bore diameter, length of capillary is more as the evaporator pressure is low.

2. Evaporator-

The evaporator acts as a heat exchanger. Evaporator tube can be given any shape according to dimensions and air circulates around the evaporator thus cooling effect take place at evaporator coil.

3. Pressure gauge-

The pressure gauge is most commonly used which is mechanical type known as bourdon type pressure gauge. The fluid whose pressure is to be measured is inside the tube. one end of tube is fixed and other is free to move inward or outward. The inward and outward movement of free end moves a pointer through a gear arrangements on the dial graduated in the pressure unit.

V. WORKING OF INSTANTANEOUS WATER COOLER

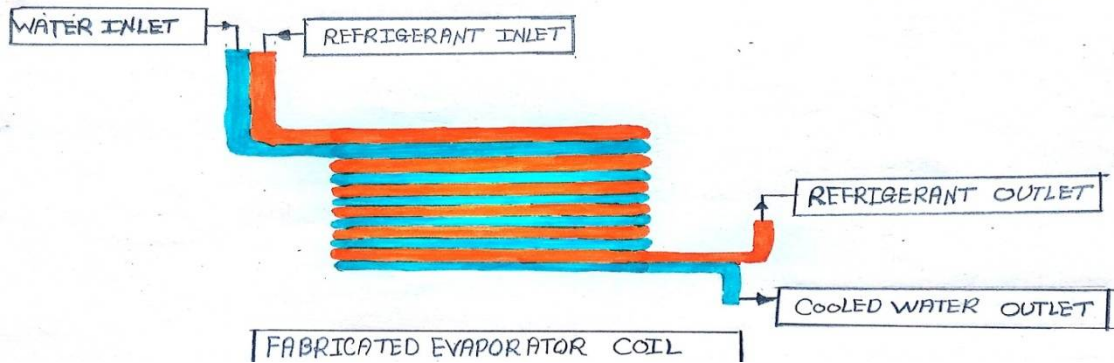
Our main purpose of this system is to cool water instantly and make it available when in need .So, instant cooling is achieved with the help of evaporator tube. In this system the evaporator tube is given a spiral shape which will be holded vertically and main thing is, another copper tube except the evaporator tube which we have called as 2nd Tube (1st tube= evaporator tube, 2nd tube= water flowing tube) is installed in between the spirals of evaporator coil as shown in fig.(2)

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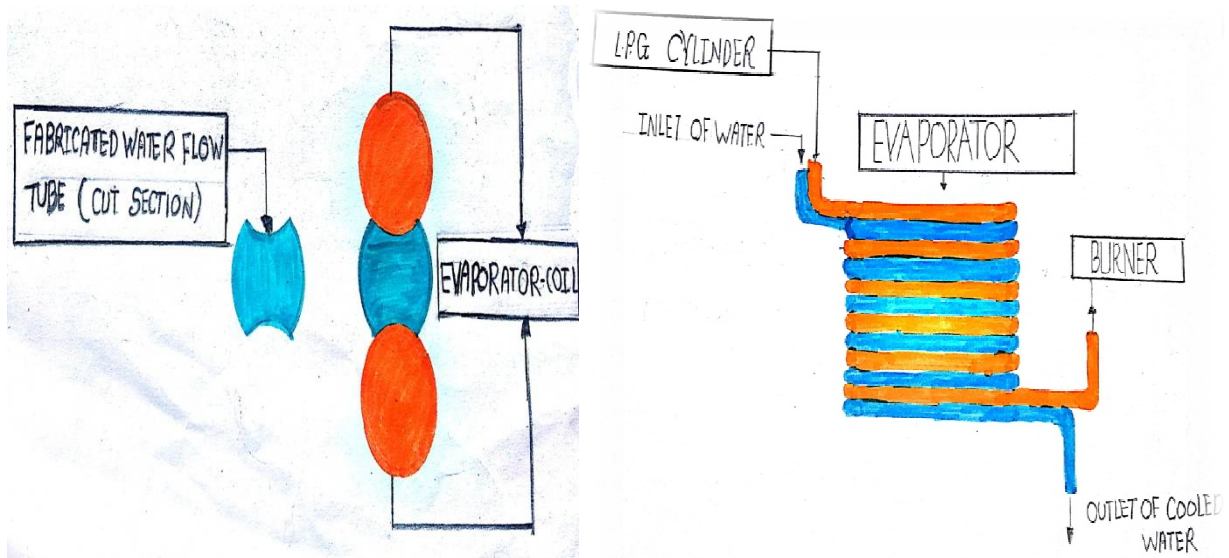
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Fig(2):- Fabricated Evaporator Coil

This 2nd tube contains the flow of water which is to be cooled. It is made so that intermediate contact is established between evaporator coil and water flow tube. The diameter of 2nd tube is less than evaporator coil. So that conduction takes place quickly. Thus, water is cooled within less time

This can only be possible when there is large area of 2nd tube is in contact with evaporator tube. The simple copper tube can make only a line or point contact with each other but in this case the 2nd tube is fabricated such that it makes maximum contact with each other. The tube is given shape as shown in **fig. (3)**



Fig(3):- Cut Section and Design of Water Flow Tube and Evaporator Tube

The fabrication of 2nd tube makes maximum possible contact with the evaporator tube. The evaporator tube absorbs latent heat from 2nd tube quickly and cools water quickly. This type of design also provides proper grip (holding) between the two coils. So, that there is no need to weld the two coils with each other and if 2nd tube is made seamless through its length, that means it has no joints in between. Then there is no chance of improper conduction and intermediate contact will always be maintained between the coils.

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When the two surfaces of copper tube do not fit tightly together a thin layer of fluid which can be air is filled between them, As air has low thermal conductivity ,the conduction is very less between the two copper tube surfaces supporting thermal resistance. To maintain a good and direct contact between the solid surfaces of copper tube above design is very applicable it avoids the layer of air between them, supporting thermal conduction. This can be proved by following equation:-

Consider, A hollow cylinder of internal radius r_1 and external radius r_2 with respect to internal and external temperature of T_i and T_o as shown in figure. Let L be the length of cylinder and K is the thermal conductivity of cylinder. Heat transfer takes place radial. Consider the ring of radius r and thickness dr . **fig no. (4)**

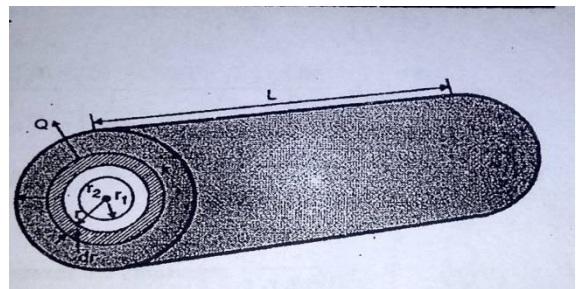
From **Fourier's law** of heat conduction,

$$Q = -K \times A \times \frac{dT}{dx}$$

$$Q = -k \times (2\pi r L) \times \frac{dT}{dr}$$

$$Q \int_{r_1}^{r_2} \frac{dr}{r} = -K 2\pi L \int_{T_i}^{T_o} dT$$

or,
$$Q = \frac{2\pi K L (T_i - T_o)}{\log_e \frac{r_2}{r_1}} = \frac{T_i - T_o}{\log_e \frac{r_2}{r_1} / 2\pi K L} = \frac{T_i - T_o}{R}$$



Heat Transfer in Hollow Tube

In order to control the temperature of chilled water either Thermostat or Temperature sensors are installed with water flow tube. Thus, water will get in the tube from upper section and cooled water will be obtained from lower section of the setup as water will flow down due to gravity. There will be continuous flow of cold water.

The water coming out from 2nd tube, now can be stored in containers having proper insulation. so, that water remains cool for long period of time and can be supplied when in need. The LPG refrigerant gas after leaving the evaporator coil is supplied to the burner for various cooking operations in houses, hotels or etc.

For such purposes like our 2nd tube soft copper tubing is used, soft copper tubing can be bent easily, can be given any shape to travel around obstacles in the path of tubing. Work Hardening of the Drawing process are used to size the tubing makes the copper tube hard. It is carefully annealed to make it soft again. Soft copper is the most popular choice for refrigerant lines.

LPG is stored in the LPG cylinder under high pressure. when the gas tank of regulator is open than high pressure LPG passes through the High pressure pipe, this LPG is going to capillary tube. High pressure LPG is converted into low pressure at capillary tube with enthalpy remains constant.

After capillary tube, low pressure LPG is passed through the evaporator converted into low pressure low temperature vapour from and passes the evaporator which absorbed heat from the water. Thus the water cooled down. thus we achieve cooling effect. After passing through the evaporator low pressure LPG is passed through the pipe to burner where it is used in burning process.

The working of instantaneous water cooler is similar to that of storage type Aqua guard water cooler but only difference in between them is that the water is instantaneously cools due to excellent and much better design of evaporator fittings and arrangement of system.

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VI. PROPERTIES OF LPG:-

- 1) Colorless
- 2) Odorless
- 3) Heavier than air.
- 4) Weight of LPG is half the weight of water.
- 5) Non-toxic
- 6) LPG expansion rate is high.
- 7) Highly flammable

VII. APPLICATIONS

- 1) Used in schools and colleges for drinking purpose.
- 2) used in industries like ice plants , refrigeration unit.
- 3) It is generally used for domestic purpose.
- 4) Used at railway stations ,air ports bus stands.
- 5) Used in hospitals and laboratories.
- 6) It is important in laboratories and chemistry labs.
- 7) It is also used in water purification appliances.
- 8) It is generally used in hotels, restaurants, various parties and marriage events. (The cooling of water take place simultaneously with cooking food) Chilled water will be provided to the guest with minimum cost.

VIII. MERITS AND DEMERITS

➤ MERITS

- 1) Time required for cooling is very less as compared to other water coolers.
- 2) Produce low noise and working is effective.
- 3) It does not creating hazardous situation.
- 4) Easy to use.
- 5) Eco-friendly cooling and working.
- 6) Reliability is much better.
- 7) By designing effectively we can use it for high capacity applications.
- 8) Eliminates the compressor and condenser
- 9) It saves electricity

➤ DEMERITS

- 1) LPG is explosive in nature
- 2) After the refrigeration process, the exhaust of LPG is burn into burner. Because of the exhausted vapor LPG cannot converted into liquid phase again, because the process is very costly.
- 3) The main disadvantage of the system is that, the process is not continuous. As, we switch off the burner whole cycle stops and no further cooling takes place. The system is applicable whenever there is use of burner.
- 4) Smell is pungent.

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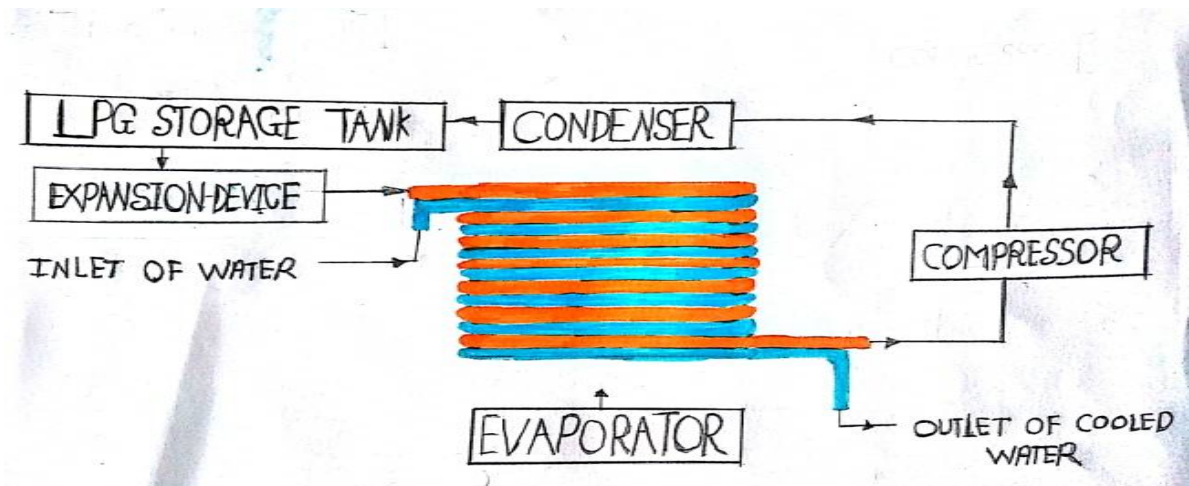
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IX. BUSINESS MODEL

If we want this process to be continuous in order to use this system for domestic purposes to support towards our environment from Ozone Depletion, then components to be added are compressor, condenser. still LPG can be used as refrigerant just by adding a small storage tank for LPG in the cycle in between condenser and throttling device. The compressor used for such purpose are of 50 to 60 Hz (AC). Now, the system will use electric energy as our domestic refrigerator uses but still, it will be eco-friendly, **Fig. (5)** and **(6)** shown below,



Fig(5):- Schematic Figure Using Compressor and Condenser

The **Fig no. (5)** gives complete idea about symbolic representation of all components used in system.



Fig(6):- Actual Setup Using Compressor and Condenser

The above **Fig no.(6)** shows actual setup of the components which can be used for industrial purposes for cooling effect.

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X. EXPERIMENTAL RESULT

| Time (in minutes) | Capillary inlet pressure (in bar) | Evaporator outlet pressure (in bars). | Evaporator temperature (in degree Celsius) |
|-----------------------|--|--|---|
| 5 | 10 | 3 | 27 |
| 15 | 10 | 3 | 21 |
| 25 | 10 | 3 | 5 |

The above Experimental table shows Decrease Evaporator Temperature with respect to time.

XI. FLOW CHARTS

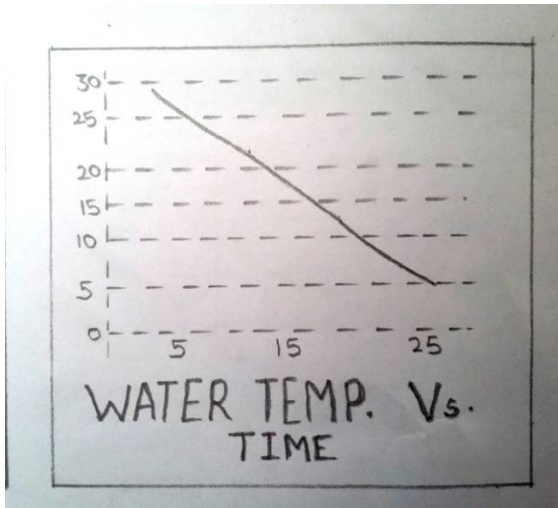


Chart-1: Water Temp. Vs. Time

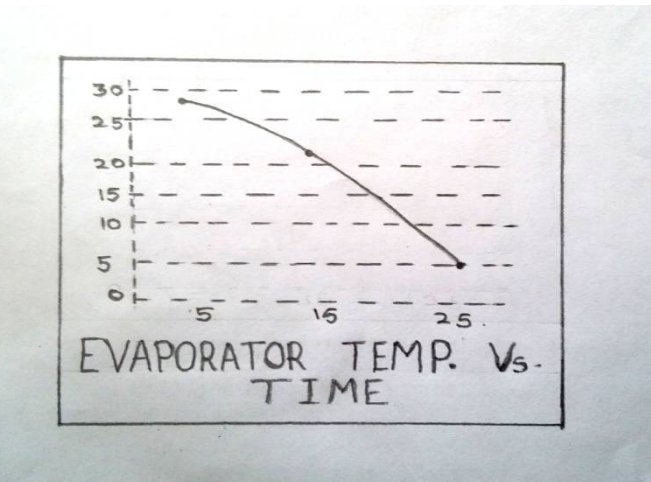


Chart-2: Evaporator Temp. Vs. Time

The Flow Charts shows Phenomenal Decrease in Water and Evaporator Temperature with respect to time.

XII. CONCLUSION

By fabricating this project of instantaneous water cooler, we conclude that the cooling of water in heat exchanger or evaporator is depend upon ,

- 1) Flow rate of incoming water in heat exchanger.
- 2) Flow of refrigerant through copper tube.
- 3) Super heating.
- 4) Quantity of water to be cooled.
- 5) Capacity and performance and efficiency of overall components.

By comparing other high water cooler withover instantaneous water cooler we observed and realized that water cooler is having excellent performance with good cooling of water and also have better efficiency. The temperature of outlet water obtain is in the range of 7-10°.

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REFERANCES

- 1) Shank K. Wang " Handbook of Air Conditioning and Refrigeration" page no. 11.14 chapter 11.
- 2) S.J. Cleg, "Thermodynamic Analysis of LPG as Refrigerant for Industrial Refrigeration and Transport", Institute of Transport studies, Universities of Leeds Working paper of 471,1996.
- 3) Dr. Iqbal Husain, " Analysis of VCR and VAR System using organic refrigerant", CRC press Taylor and Francis Group, USA ,2012.
- 4) Arora , " Refrigeration and Air Conditioning ", Capillary tube design (2010) page no. 311-317.
- 5) Wong, T.N. Ooi, K.T. "Adiabatic Capillary Tube Expansion Device: a comparison of the homogeneous flow and the separated flow models" Applied Thermal Eng. 16 (7) (1996) page no. 625-624.
- 6) Dr. Amir S.Dawood and Salim Ibrahim Hasan, "Numerical Study of Refrigeration Flows in Capillary tube using Refrigerant (R-134a), Journal(2011) page no. 1-19.
- 7) Mhasse M.S, Deshmukh T.S, Ankush D.D, Palkar S.M, Gaikvad V.S "performance evaluation of domestic refrigerator using LPG cylinder" International research journal of engineering and technology(IRJET), April 2016, volume 3 , page no. 2586-2591.
- 8) Heat Transfer by B.L. Singal, O.P. Misra, Tech-Max Publication , (2) page no. 16-18
- 9) "PCRA Energy Audit Report", HPCL LPG Bottling plant AsudaBahadurgarh (Haryana) Dec.2006.
- 10) Catalogue of Gas Authority of India on "Properties of Combustible Gases For industrial Purpose".
- 11) Zainalzakaria and Zuliaikhashahrum, "The Possibilities of Using LPG in Domestic Refrigeration System"(2011) page no. 347-354.
- 12) "Basic Statistics on Indian Petroleum and natural Gas" 2006-07.