CONSTRUCTION & PERFORMANCE TEST OF LOW COST REFRIGERATION SYSTEM USING LPG



SUBMITTED BY

Sujon Adhikari	ME2102024248
Bijoy Borman Apu	ME2102024221
Anik Chandra Datta	ME2102024222
Muha Alamin	ME2102024228
Sujit Hazra	ME2101023017

Supervisor By:

MD. Misbah Uddin

Lecturer

DEPARTMENT OF MECHANICAL ENGINEERING
SONARGAON UNIVERSITY (SU)
DHAKA, BANGLADESH

JANUARY 2025

STUDENT'S DECLARATION

We do hereby solemnly declare that, the work presented here in this project report has been carried out by us and has not been previously submitted to any University/ Organization forward of any degree or certificate. We further undertake to indemnify the university against any loss or damage arising from breach of the foregoing obligation.

Sujon Adhikari
Student ID.: ME2102024248

Bijoy Borman Apu
Student ID.: ME2102024221

Anik Chandra Datta
Student ID.: ME2102024222

Muha Alamin
Student ID.: ME2102024228

Sujit Hazra
Student ID.: ME2101023017

CERTIFICATE OF SUPERVISOR

This is to certify that the thesis work on **"Construction & Performance Test Low Cost Refrigeration System Using LPG"** by Sujon Adhikari - ME2102024248, Bijoy Borman Apu - ME2102024221, Anik Chandra Datta - ME2102024222, Muha Alamin - ME2102024228, Sujit Hazra - ME2101023017 under my supervision. The report or the information will not be used for any other purpose.

.....

MD. Misbah Uddin
Lecturer
Department Mechanical Engineering
SONARGAON UNIVERSITY (SU)

ACKNOWLEDGEMENT

The report titled as on "**Construction & Performance Test Low Cost Refrigeration System Using LPG**" has been prepared to fulfill the requirement of our practicum program. In the process of doing and preparing our practicum report, we would like to pay our gratitude to some persons for their enormous help and vast co-operation. At first, we would like to show our gratitude to the University authority to permit us to do our practicum. Specially, we would like to thank to our honorable teacher **Md. Misbah Uddin,** Lecturer, Department of Mechanical Engineering Sonargaon University, Dhaka, for his valuable and patient advice, sympathetic assistance, co-operation, contribution of new idea. Deep theoretical and hardware knowledge & keen interest of our supervisor in this field influenced us to carry out this project. His endless patience, scholarly guidance, continual encouragement, constant and energetic supervision, constructive criticism, valuable advice, reading many inferior draft and correcting them at all stage have made it possible to complete this project.

ABSTRACT

Refrigeration is the science of maintaining the temperature of a substance below the atmospheric temperature that is done by removing the heat from the substance that needs to be cooled. A general refrigeration system uses electricity and Chlorofluorocarbon to accomplish the task. Chlorofluorocarbon (CFC) is also contributed to the ozone depletion. As electricity is not abundant in our country, the need of an alternate to the existing system has arisen. In such case, LPG refrigeration system has proven to be an effective for remote areas such as research sites, mines, & deserts and also free of pollution. Many engineering analysis has been done in the recent years in LPG refrigeration system, but practical implication of such analysis is yet to be reported. We will investigate the performance parameters is the refrigeration effect in certain time. A LPG powered refrigeration system has been fabricated by using different components and measuring instruments. High pressure gas from LPG was regulated to low pressure and it is directly fed to the throttle valve where further drop of pressure and temperature occurs. This low temperature gas passes through the copper tube in the refrigerating chamber absorbs heat from the chamber and thus produce refrigerating effect.

TABLE OF CONTENTS

Name of the Contests **Page No.**

Thesis Top page			i
Student Declaration			ii
Certificate Of Supervisor			iii
Acknowledgement			iv
Abstract			v
Table of Contents			vi
List of Figures			vii
List of Tables			viii
Chapter 1		Introduction	1-2
	1.1	Introduction	1
	1.2	Proposed Method	2
	1.3	Objective	2
	1.4	Organization of book	2
Chapter 2		Literature Review	3-9
	2.1	History	3
	2.2	Block Diagram	3
	2.3	Components List	4
Chapter 3		Methodology	5-14
	3.1	Liquefied Petroleum Gas	5
	3.2	Flow Chart	5
	3.3	Methodology	12
	3.4	Complete Project Prototype Image	13
	3.5	Working Principle	13
	3.6	Cost Analysis	14
Chapter 4		Result, Comparison And Discussion	15-17
	4.1	Result	15
	4.2	Comparison	16
	4.3	Discussion	17
	4.4	Advantages	17
	4.5	Applications	17
Chapter 5		Conclusion	18
	5.1	Conclusion	18
	5.2	Future Work	18
REFERENCES ----------			19
APPENDIX ----------			20-21

LIST OF FIGURES

S/L	Figure Name	Page No.
Figure 2.1	Structural System Diagram	3
Figure 2.2	Block diagram	4
Figure 3.1	Flow chart of Proposed System	10
Figure 3.2	LPG Gas Cylinder	11
Figure 3.3	Copper Pipe	12
Figure 3.4	Pressure Gauge Meter	13
Figure 3.5	Evaporators	13
Figure 3.6	High Speed Regulator	14
Figure 3.7	PVC Fiber Gas Pipe	14
Figure 3.8	Stove	14
Figure 3.9	Node MCU	14
Figure 3.10	SMPS	14
Figure 3.11	LCD Display	14
Figure 3.12	DHT11 - Temperature Sensor	14
Figure 3.13	DS18B20 - Temperature Sensor	14
Figure 3.14	Capillary Tube	14
Figure 3.15	Complete Project Picture	14
Figure 4.1	Starting Cooling (C) Temp. & Normal (N) Temp.	15
Figure 4.2	After Getting Cold, Cooling (C) Temp. & Normal (N) Temp.	15

LIST OF TABLES

S/L	Table Name	Page No.
Table:3.1	Cost Analysis	17
Table:4.1	Result Analysis of this project	17

CHAPTER 01:INTRODUCTION

1.1 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 and domestic kitchens this project has the novelty of using LPG instead of electricity for refrigeration. 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. This refrigerating effect can be used for cooling purposes. So this work provides refrigeration for socially relevant needs as well as replaces global warming creator refrigerants. 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.

1.2 Proposed Method

Due to the huge demand of electricity over the world, we think of recovering the energy which is already spent but not being utilized further, to overcome this crisis with less 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 COST FREE Cooling Systems. 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 convenientfor refrigeration in regions having scares in electricity. 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. This refrigerating effect can be used for cooling purposes.

1.3 Objective

1) Compare the important characteristics between LPG Refrigeration system and traditional refrigeration system.

2) To distinguish between the current existing refrigerator Cost and estimated cost of LPG refrigerator.

3) The performance of existing refrigerator and LPG Refrigerator is to be compared.

4) To determine the cop of refrigerator using LPG as refrigerant.

1.4 Organization of book

The report has been organized into five chapters.

Chapter 1: Discusses introduction, Background and objectives.

Chapter 2 : Description about theoretical issues.

Chapter 3 : Description of circuit elements, such as Circuit diagram, Block Diagram, Flow Chart etc.

Chapter 4: Description of result, Advantages, Limitations, Applications & Discussion.

Chapter 5: Finally, we discussed here the Conclusion and future works.

CHAPTER 02: LITERATURE REVIEW

2.1 History

This chapter includes the total over view of the device. In this chapter we have followed-up the theory of LGP GAS, High Speed Regulator, Copper Pipe, Gauge Meter, Gas Pipe, Stove, Fridging Chamber, SMPS, Node MCU, LCD Display, DHT11, DS18B20, Vero board, and other components. Here we can know that the total system overview of the projects. And we will also know that how the equipment are working with each other.

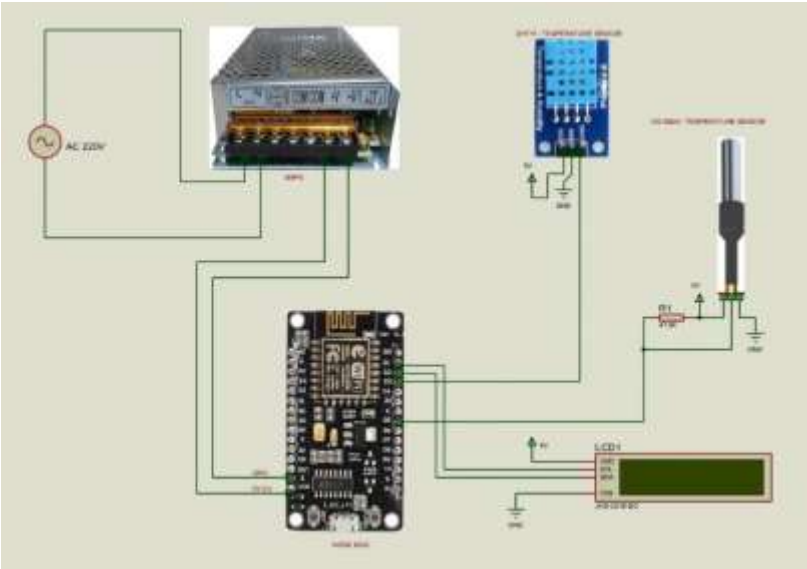


Figure 2.1: Structural System Diagram

2.2 Block Diagram:

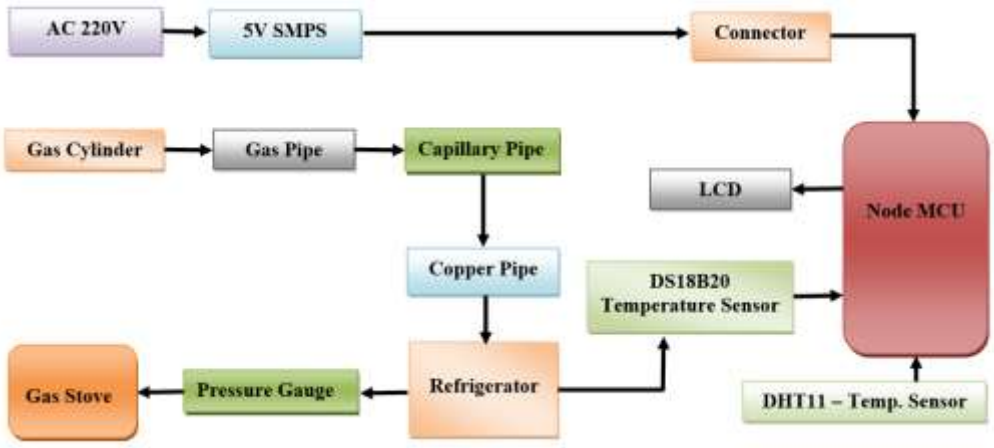


Figure 2.2: Block diagram

2.3 Components List

- Node MCU
- LCD + I2C
- DS18B20
- DHT11
- Gas Cylinder
- Plastic Pipe
- Copper Pipe
- SMPS
- Bridging Chamber
- High Speed Regulator
- Stove
- Color
- Capillary Pipe

CHAPTER 03: METHOLOGY

3.1 Liquefied Petroleum Gas

In this chapter fully cover with discuss design and fabrication of this project. Here we will discuss about developed block diagram and briefly describe about the circuit description and also learn about working principle. Total project flow chart is also available in this chapter. We use here a Node MCU as a microcontroller to read temperature value of this total system. Here We provide AC 220V power to SMPS and then it will be converted to 5V DC voltage output. This 5V DC power will be distributed to all components to run this system. we use here a DHT11 Temperature sensor to Read Normal Temperature and DS18B20 Water Proof Temperature Sensor to Read Inner Temperature of Refrigerator. LCD is used here to show all the operation output for manually monitoring. Here we use a gas cylinder to make sure gas supply to our system. This Gas Cylinder will supply LPG Gas to our Refrigerator by using a Copper Wire. Here we included a Capillary pipe on the way to flow gas to refrigerator part. This Copper wire will make resistance to flow gas very widely, then Gas will flow very fast and when it will passing the capillary pipe it will get again more space to flow in refrigeration chamber. then it will reduce the temperature of Refrigerator. after go out from refrigeration chamber this gas will flow to our Stove and You can burn that gas or use that gas for cooking anything.

3.2 Flow Chart

This is the Flue chart of our project. We use here a gas cylinder to make sure gas supply to our system. This Gas Cylinder will supply LPG Gas to our Refrigerator by using a Copper Wire.

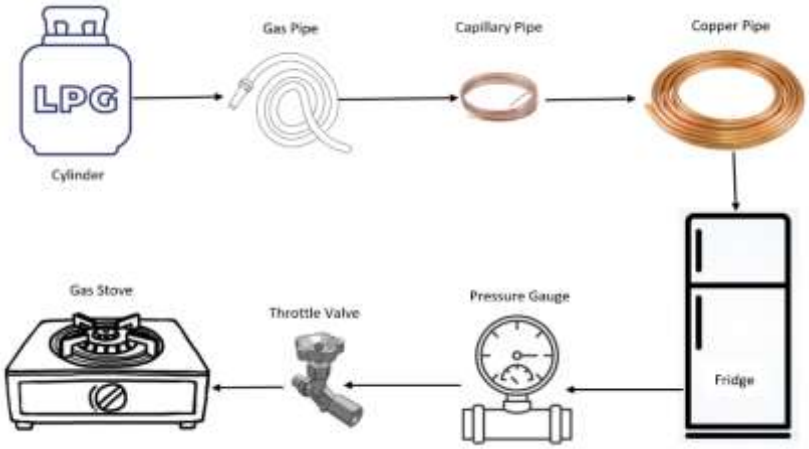


Figure 3.1: Flow chart of Proposed System

Here we included a Capillary pipe on the way to flow gas to refrigerator part. This Copper wire will make resistance to flow gas very widely, then Gas will flow very fast and when it will passing the capillary pipe it will get again more space to flow in refrigeration chamber. then it will reduce the temperature of Refrigerator. after go out from refrigeration chamber this gas will flow to our Stove and You can burn that gas or use that gas for cooking anything.

A) LPG Gas: Liquefied Petroleum Gas (LPG) is a flammable hydrocarbon gas that is used as fuel for heating appliances, cooking equipment, and vehicles. It is also used as a refrigerant in some air conditioning and refrigeration systems. Here's a detailed look at what LPG is, its composition, production, applications, and safety considerations.



Figure 3.2: LPG Gas Cylinder

B) Copper Pipe: Some of the most common ways to use a copper pipe nowadays is for construction industry for water supply lines and refrigerant line in heating, ventilation, and air-conditioning (HVAC) systems. Whilst this can mean AC, many don't realize that this copper tube system is what keeps our refrigerators and our freezers alive. While the majority of the copper tube applications lie in the residential sector, where they are used to convey potable water in homes and offices, refrigerator industries, firefighting systems, and medical and residential gas suppliers are also catching up.



Figure 3.3: Copper Pipe

C) Pressure Gauge Meter: Pressure gauges are used to measure the pressure of liquids, vapors, solids, and gases. It is used for the inspection of air brakes on trucks. Pressure gauges are used in chemical, petrochemical, sanitary, pharmaceutical, and process industries.



Figure 3.4: Pressure Gauge Meter

D) Evaporators: The Evaporation and vaporization are two processes in which simultaneous heat and mass transter process occurs resulting into separation of vapor from a solution. Evaporation and vaporization occur where molecules obtain enough energy to escape as vapour from a solution. The rate of escape of the surface molecules depends primarily upon the temperature of the liquid, the temperature of the surroundings, the pressure above the liquid, surface area and rate of heat propagation to product. The basic function of an evaporator in the refrigerator system is to remove the heat from the water, air, and other substances present in the refrigerator. The evaporators of refrigerator systems act as a heat exchange which helps in transferring the heat from the substance and make it cool by means of refrigerant. The refrigerant either boils as it flows

through a pipe, tube or other type of space so that liquid is continuously wetting all the inside surface or it boils in a shell around submerged tubes through which the fluid to be cooling is flowing. Various methods are used for evaporators, depending upon the refrigerant to be used and evaporator application, but iron, steel and copper predominate. Refrigerant evaporators should be of extended surface or finned tube type whatever practical. In order to keep the average surface temperature down, a good bond between the fin and tube is essential. Integral fins formed out of the tube itself are best in this respect and give the best heat transfer rate.



Figure 3.5: Evaporators

E) High Speed Regulator: High-pressure gas regulators are devices used to control and reduce the pressure of gases from a high-pressure source to a lower, more manageable level for safe and effective use in various applications. Here's a breakdown of their key aspects:

Function and Importance

- Pressure Control: They maintain the output pressure within a specified range despite fluctuations in the input pressure, ensuring safe and consistent delivery of gas.
- Safety: High-pressure gases can be dangerous. Regulators reduce the risk by controlling the pressure to safe levels for storage and use.
- Efficiency: They help optimize the performance of equipment by providing a stable pressure supply.



Figure 3.6: High Speed Regulator

F) PVC Fiber Gas Pipe: PVC is characterized by distinctive physical properties, and is resistant to corrosion. Important details about PVC Transparent Pipe manufacturing with acids, alkalis, salt solutions and many other chemicals. It is attacked, however, by polar solvents such as ketones and aromatics.



Figure 3.7: PVC Fiber Gas Pipe

G) Stove: A gas stove is a common household and commercial appliance used for cooking that operates by burning natural gas, propane, butane, or other flammable gases. It provides a reliable and efficient heat source for cooking food.



Figure 3.8: Stove

H) Node MCU: NodeMCU is an open-source firmware, hardware, and software development environment project developed initially for the Node MCU ESP8266 Wi-fi SoC chip based on LUA. The most spectacular features are: It is a low-cost, small, and powerful board.



Figure 3.9: Node MCU

I) SMPS: Switched-mode power supplies (SMPS), sometimes referred to as switch mode power supplies, have become the workhorse of efficient power conversion, taking a mains voltage AC input and converting it down to a low voltage DC output.



Figure 3.10: SMPS

J) LCD Display: The I2C LCD component is used in applications that require a visual or textual display. This component is also used where a character display is needed but seven consecutive GPIOs on a single GPIO port are not possible. In cases where the project already includes an I2C master, no additional GPIO pins are required.



Figure 3.11: LCD Display

K) DHT11: A The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin.



Figure 3.12: DHT11 - Temperature Sensor

L) Temperature Sensor: DS18B20 - Programmable Resolution 1-Wire Digital Thermometer. Page 1. General Description. The DS18B20 digital thermometer provides 9-bit to 12-bit Celsius temperature measurements and has an alarm function with nonvolatile user-programmable upper and lower trigger points.



Figure 3.13: DS18B20 - Temperature Sensor

M) Capillary Tube: A capillary tube is a type of metering device that is primarily used in refrigeration equipment and HVAC systems, designed to maintain the temperature of the system. It is installed between the condensing unit and the evaporator, and it supplies the refrigerant from the condenser to the evaporator in a regulated amount, depending on the fixed length of the tube and its diameter. It is an essential part of any HVAC system as its function is to control the flow of refrigerant.



Figure 3.14: Capilary Tube

3.3 Methodology

The methodology for this project involves a systematic approach to the design and construction of a low-cost refrigeration system utilizing LPG (liquefied petroleum gas) as the refrigerant. The step-by-step process is outlined below:

- Developing / creating an idea Fabrication of a low cost refrigeration using LPG as refrigerant.
- Drawing and listing of components/materials to know which components / materials need to construct it.
- Collecting the all components / materials for construct the refrigeration system.
- Finally, we constructed this system with maintaining all safety & checked it.
- We found that its works very well.

3.4 Compleate Project Prototype Image



Figure 3.15: Complete Project Picture

3.5 Working Principle

We use here a gas cylinder to make sure gas supply to our system. This Gas Cylinder will supply LPG Gas to our Refrigerator by using a Copper Wire. Here we included a Capillary pipe on the way to flow gas to refrigerator part. This Copper wire will make resistance to flow gas very widely, then Gas will flow very fast and when it will passing the capillary pipe it will get again more space to flow in refrigeration chamber. then it will reduce the temperature of Refrigerator. after go out from refrigeration chamber this gas will flow to our Stove and You can burn that gas or use that gas for cooking anything. we use here a Node MCU as a microcontroller to read temperature value of this total system. Here We provide AC 220V power to SMPS and then it will be converted to 5V DC voltage output. This 5V DC power will be distributed to all components to run this system. we use here a DHT11 Temperature sensor to Read Normal Temperature and DS18B20 Temperature Sensor to Read Inner Temperature of Refrigerator. LCD is used here to show all the operation output for manually monitoring.

3.6 Cost Analysis

SI	Particulars	Qty.	Unit Price	Total Price
1	Node MCU	1	450	450
2	LCD + I2C	1	350	350
3	DS18B20	1	270	270
4	DHT11	1	150	150
5	Gas Cylinder	1	1800	1800
6	Plastic Pipe	1	500	500
7	Copper Pipe	1	900	900
8	SMPS	1	550	550
9	Fridging Chamber	1	800	800
10	High Speed Regulator	1	1200	1200
11	Stove	1	1500	1500
13	Soldering Items	-	1300	1300
14	Capillary Pipe	1	400	400
15	Others	-	700	700
			Total	**10870/-**

Table:3.1: Cost Analysis

CHAPTER 04: RESULT, COMPARISON AND DISCUSSION

4.1 Result

Here we will try to show the results of our project. we record here primary temperature an after getting cold temperature of our system which showing here in bellow:



Figure 4.1: Starting Cooling (C) Temp. & Normal (N) Temp.



Figure 4.2: After Getting Cold, Cooling (C) Temp. & Normal (N) Temp.

Table 4.1: Result Analysis of this project:

Serial No.	Time	Starting Temp. (°c)	Cooling Temp. (°c)	Decrease Temp. (°c)	Cop
1	00 min.	25.92	25.92	0.00	1.65
2	05 min.	25.94	21.00	4.94	
3	10 min.	25.98	17.61	8.37	
4	15 min.	26.00	16.95	9.06	
5	20 min.	26.00	16.50	9.50	
6	30 min.	27.05	16.21	9.84	

Co-efficinet of Performance

$$\text{Cop}_{(r)} = \frac{T_2}{T_1 - T_2} = \frac{16.21}{25.92 - 16.21} = 1.65$$

T_1 = Higher Temperature
T_2= Lower Temperature

4.2 Comparison

Comparison between conventional refrigerators and LPG refrigerators:

Feature	Conventional Refrigerator	LPG Refrigerator
Refrigerant	Uses synthetic refrigerants like CFCs, HFCs	Uses LPG (propane, butane)
Environmental Impact	Higher Ozone Depletion Potential (ODP) and Global Warming Potential (GWP)	No ODP and lower GWP
Energy Efficiency	Generally less efficient	Higher Coefficient of Performance (COP)
Operating Cost	Higher electricity consumption	Lower operating cost due to use of LPG
Safety	Requires electrical power	Requires handling of pressurized gas
Maintenance	Standard maintenance	Requires regular checks for gas leaks
Availability	Widely available	Availability depends on LPG supply

Conventional refrigerators are widely used and rely on electricity to operate, using synthetic refrigerants that can be harmful to the environment. On the other hand, LPG refrigerators use LPG as a refrigerant, which is more environmentally friendly and can be more energy-efficient. However, they require handling of pressurized gas and regular maintenance to ensure safety.

4.3 Discussion

Here we complete our project work properly and we read starting and ending temperature of our system. We get a lower temperature in refrigeration chamber of our refrigerator. If we make sure continuous gas supply to our refrigeration chamber, then it will provide more efficient output from this Low cost refrigeration system using LPG.

4.4 Advantags

- Use of LPG as a refrigerant also improves the overall efficiency of by 10 to 20 %.
- The ozone depletion potential (ODP) of LPG is 0 and global warming potential (GWP) is 8 which is significantly negligible as compare to another refrigerant.
- A part from environment friendly, use of LPG also gives us lot of cost advantages.
- There is 60% reduction in weight of the system due to higher density of LPG.
- This fridge works when electricity is off.
- The parts are effectively silent in operation.
- Running cost is zero.
- Eliminates the compressor and condenser.

4.5 Applications

Here we included some applications of this proposed system in bellow:

- It can play an important role in restaurants where continuously cooling and heating is required.
- It can be useful in remote parts where electricity is not available.
- It can be used in refineries where consumption of LPG is high.
- The system can universally be used in industrial central cooling and domestic refrigeration and air conditioning as well.
- It can be used in automobiles running on LPG or other Gaseous fuels for air conditioning
- It can be used for zero cost air-conditioning of spaces like airports, shopping malls, etc. which have their own gas turbine power-plants.

CHAPTER 05: CONCLUSION

5.1 Conclusion

From the experiment we have conclude that the highpressure LPG gas stored in a cylinder at 12.41 bar with the weight of 14.5 kg equipped with a high-pressure regulator. when LPG gas released the pressure drop occurs and the weight decrease. With the help of capillary tube, the pressure will drop down to the 1 bar from the operational pressure 4.82 bar. Due to the pressure drop the refrigerating effect occurs in an evaporator. The refrigerating effect changes the properties of LPG before and after evaporator. Therefor a conclusion we can use LPG as a refrigerant in a refrigeration. LPG will not harm the environment and the eco system. The potential of ozone layer depletion and global warming will be reduced due to usage of current refrigerant in a domestic refrigerator. As per the experimental readings (Table:4.1) we conclude that the evaporator temperature reduces 25.92 ˚c to 16.21 ˚c at loading condition in just 10 mins. As per the above paragraph the cooling effect of LPG refrigeration varies with the load and pressure. So that the design of the refrigerator is different cooling load under the different pressure. From this temperature drop we can say that the refrigerating effect is higher than the other domestic refrigerator. Eliminates the Compressor and condenser we can conclude that the COP is higher than the other domestic refrigerator. Propane is an attractive and environmentally friendly alternative to CFCs used currently. Mass flow rate increases with increase in capillary inner diameter and 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. Cooling capacities were obtained order of about three- to four fold higher for LPG than those for R- 12. Capillary tube. COP of LPG refrigerator was higher than that of R134a by about 7.6%. LPG seems to be an appropriate long-term candidate to replace R134a in the existing refrigerator, 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.

5.2 Future Scope

Here we include some future work in bello:

- 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.
- This kind of system can be implemented on the food trucks as well where it can store in various quantities .
- To create workingmodel for LPGrefrigeration.

REFERENCES

[1] Gupta K, Shah H , Design of refrigeration system and comparative energy analysis with domestic refrigeration' IJESRT ISSN-2277-9655 July 2014

[2] Ibrahim Hussain Shah and Kundan Gupta “International Journal of Engineering Sciences and Research Technology” ISSN: 2277-9655, July 2014, Vol. 3(206- 213). 5. Khandare R. S. and Bhane A. B “International Journal of[4] Emerging Technology and Advanced Engineering” ISSN: 2250-2459, March 2015, Volume

[3] Vishwadipsingh J. Ghariya and Swastik R. Gajjar “International Journal for Scientific Research and Development” ISSN (online): 2321-0613, March 2014, Vol.2

[4] Zainal Zakaria and Zulaikha Shahrun “ The possibility of using liquefied petroleum gas in domestic refrigeration system” International Journal of Research and Reviews in Applied Science(IJRRAS), December 2011, Volume9

[5] Shank K. Wang, “Handbook of air conditioning and refrigeration” page no. 11.14 chapter 11.

[6] C.P. ARORA, “Hand book of Refrigeration and air conditioning”, by page no. 425

[7] W. F Stoecker., and J. W. Jones, “Refrigeration and Air conditioning”, TATA McGraw-Hill pub. Co. Ltd. pp. 264.

[8] Hermes CJL, “Conflation of e-Ntu and EGM design methods for heat exchangers with uniform wall Temperature”, Int. J. Heat and Mass Transfer, pp.3812- 3817, 2012.

[9] A. Bejan, “The thermodynamic design of heat and mass transfer processes and devices”, Heat and Fluid Flow pp.258-276, 1987

Appendix

C++ Programing Code:

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <OneWire.h>
#include <DallasTemperature.h>
#include <DHT.h>
LiquidCrystal_I2C lcd(0x27, 16, 2);
#define DHTPIN D3     // Digital pin connected to the DHT sensor
#define DHTTYPE DHT11 // DHT 11

#define ONE_WIRE_BUS D5
OneWire oneWire(ONE_WIRE_BUS);
DallasTemperature sensors(&oneWire);

DHT dht(DHTPIN, DHTTYPE);

void setup() {
  lcd.begin(16,2);
  lcd.init();   // initializing the LCD
  lcd.backlight(); // Enable or Turn On the backlight
  lcd.clear();
  Serial.begin(115200);
  dht.begin();
  sensors.begin();
  lcd.setCursor(3, 0);
  lcd.print("Low Cost Refrigeration");
  lcd.setCursor(0, 1);
  lcd.print("System usng LPG");
  delay(1000);  // Wait for 2 seconds
}
```

```
void loop() {
  delay(500); // Wait for 2 seconds between measurements

  float humidity = dht.readHumidity();
  float temperature = dht.readTemperature();

  if (isnan(humidity) || isnan(temperature)) {
    Serial.println("Failed to read from DHT sensor!");
    return;
  }
  sensors.requestTemperatures()

  float temperatureC = sensors.getTempCByIndex(0)+1.61;

  if (temperatureC == DEVICE_DISCONNECTED_C) {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Sensor error");
    return;
  }
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("C. Temp:");
  lcd.setCursor(10, 0);
  lcd.print(temperatureC);
  lcd.print(" C");
  lcd.setCursor(0, 1);
  lcd.print("N. Temp:");
  lcd.setCursor(10, 1);
  lcd.print(temperature);
  lcd.print(" C");
  delay(500);
}
```