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INVESTIGATION ON LIQUEFIED PETROLEUM GAS (LPG) AS REFRIGERANT FOR REFRIGERATOR

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ABSTRACT

Refrigerator and air conditioning consumes most of energy in industry or even at domestic or home applications. They also use refrigerant that harmful to the environment such as depletion of the ozone layer. This project is to fabricate a refrigerator that consume less energy and less harmful substances as refrigerant compare to the typical refrigerator. The size of the refrigerator is focused on mini sized fridge. The cooling method for this project is using the expansion of the liquefied petroleum gas (LPG) from the tank. The high pressure of LPG from the tank is expands by lowering the pressure using expansion device just like the vapor compression cycle in refrigerator and air conditioning. The project also has the same function as refrigerator and also have burner or stove for cooking as the final use of the LPG after the expansion. The result of the project is the project will have the same function as the domestic refrigerator that provides cooling to keep food in lower temperature. There are more ways and methods to save energy and using natural resources is one of the best method.

Keywords: liquefied petroleum gas (LPG), domestic, refrigerator, temperature.

INTRODUCTION

Nowadays, refrigerators usages have been essential in our daily life. The domestic refrigerators usually used for storage of foods, meats vegetables and ice maker. The temperature inside the refrigerator is maintained to the lowest possible from the cooling coil or evaporator. The refrigerant change phase, pressure and temperature before it could lower the temperature of the space in refrigerator. The cooling coil cooled by the content inside the pipe which is called refrigerant. In domestic usage, one of the highest consumption of electricity is air conditioning equipment and refrigerators. The current climate changes and global warming increase the demands of cooling system such as air conditioning and refrigerators [6]. Energy usage or power consumption in all sector such as industrial and domestic is recorded high. Many of research and works has been done to reduce the energy usage or even reuse the energy to avoid the waste of energy.

Refrigerator is one of the equipment in household that recorded highest consumption of electricity. The equipment may lead the high electricity bill. Connect4Climate, a website that discuss about energy has released an infographic shows the list of appliance in typical home in United States that use most energy. The air conditioners for heating and cooling shows the most of energy us up to 47% and the refrigerator alone use 4% of energy use [1]. Most of the energy used in these two appliances is for the moving of the main part which is compressor. Based on these data, the electricity also considered one of the most expenses for a typical The domestic refrigerator commonly use refrigerant that contain chlorofluorocarbon (CFC) and hydrofluorocarbon (HFC) which contribute to very high ozone layer depletion and global warming [7]. These two phenomenon can lead to other else disaster to the mother nature Earth such as the melting of ice in Antartica, the increase of sea level, increase of carbon dioxide in atmosphere, increase of global temperature and the list will be many and will not stop. The Montreal Protocol on substances that deplete the ozone layer has been agreed in 1987 designed to protect the ozone layer. The substances such CFCs are not be allowed to release to the atmosphere as the substance has the potential to deplete the ozone layer that shields the planet from UV radiation.

A technical report on the performance and safety on LPG refrigerants have done by [3]. They stated that the radiation properties that has in CFCs and their long lifespan in atmosphere have proved that CFCs are hazardous and worse than carbon dioxide. The LPG that are usually used for combustion will produce carbon dioxide. The effect of both radiation and combustion will just raise the temperature of global warming for entire cities and nations. Thus, reducing the global warming are the hot topic to discuss for restrictions of CFCs. Table below are comparison of each type of refrigerant [3].

Table-1. Different of each refrigerant properties.

Refrigerant	R12	R22	R134a	R600a
Class	CFC	HCFC	HFC	LPG
Atmospheric lifetime	130	15	16	<1
Ozone Depletion Potential	1.0	0.07	0	0
Global Warming Potential	7300	1500	1200	8

Liquefied Petroleum Gas (LPG) stored in a tank in high pressure and in liquefied state before it used for burning or cooking. The LPG stored in the tank is in high pressure, if it is expanded before the evaporator, it will become low pressure and low temperature then can be used to absorb heat. This working principle has been used in refrigeration system. In this case, the high pressure LPG can be used for cooling in refrigerator and then the expanded gas of LPG can be further used for cooking.

In this project, the high pressure from LPG is used for cooling the refrigerator by using mechanism of expansion device. The scope of this project will be focused for the household usage. The refrigerator size in this project will be almost the same as the domestic refrigerator size of the frozen part. Then, the LPG will be used straight from a 14.5 kg cylindrical tank storage

A. Work Scope

- The size of the refrigerator will be same as a mini fridge.
- The outlet pressure of LPG will be maintained by pressure gauge.
- The project will be held in the morning and the ambient temperature is recorded.

METHODOLOGY

The method and progress that undergo in this project is represented by a flowchart.

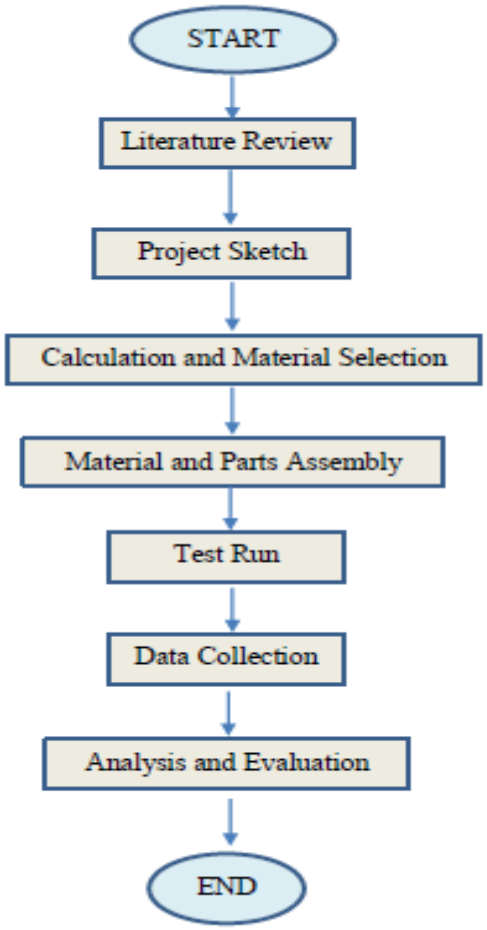


Figure-1. Flow chart for overall methodology.

A. System Design

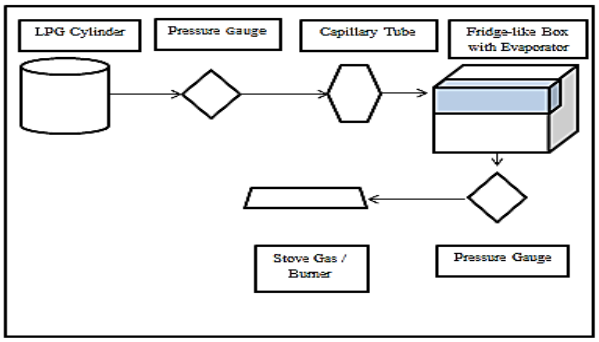


Figure-2. System Design.

The design of the project will be a one flow of the LPG. The LPG discharge from the tank then connected with a hose flow to the pressure gauge.

The pressure gauge is installed to monitor the pressure of LPG leaving the tank. Then, it flows in a copper pipe through a throttle valve or expansion device. This device is to regulate or lower the pressure of the LPG that initially high.

Then the lower pressure LPG will flow to the evaporator that installed in a fridge-like box. The box will have a thermal insulation to prevent the heat inside the box to release to the outside and keep the box in lower temperature. After that, the LPG will through a pressure gauge and lastly to the final usage which is to the stove. The stove will be used as final used of the LPG for combustion.

B. Material Selection

This part is essential in this project. The selection of the materials, components and parts for the project is important in order to achieve the objectives. This process also to make sure the project will operate smoothly after the assembly and ease the data collection. The materials that need to be consider and calculation is the size of the copper tube, the size of capillary tube and the size of the evaporator.

The size will be the key point in this project in order to achieve the LPG in lower pressure then provides low temperature in the box. Components that are need to be considered is copper tube, capillary tube, evaporator, fridge-like box and the LPG burner.

A tube or pipe is needed to allow fluid to travel from one part to another. The fluid that needs to be transfer in this case study is the LPG. Copper tube is preferred material as it has good heat transfer capacity, good resistance of corrosion and cheaper in cost. The choosing size of the copper tube can determine based on formula that used in American Society of Mechanical Engineers Code for Pressure Piping (ASME B31) [4]. There are many types of expansion device. But, for the project will be installed with capillary tube. Capillary tube has fixed restriction of flow compare to the variable restriction such as thermostatic expansion device. Capillary tube is easy to construct and cheaper in cost. Based on the previous research by [5], there will be two possibilities of evaporator to be used. One is the finned-tube evaporator and the other one is plate evaporator. These two evaporator have own disadvantages and advantages and different structure as well. But both evaporator is commonly used for refrigerator and have same working principle which is to absorb heat from a space and supply cold. The discussion is still on because the usage will be different due to availability from each of evaporator. The available evaporator is finned-tube type to be used for this project.

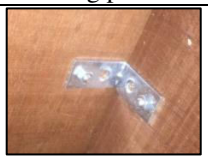
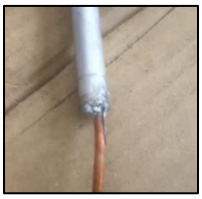
LPG burner is a device to produce flame to heat a product or food from a fuel such as natural gas, acetylene or propane. The burner is usually providing a spark to ignite the gas and change it to a flame state [2]. For household usage, the burners are called gas stove or cooking stove. There is numerous type of burners with different structure. For this project, there are two choices of burner which is single stove or single tube bunsen burner. A stove is likeable as it is cheaper and easy to obtain.

The space that needs to be cooled is a box made of wood. The inside of the box will be insulated with a thermal insulation to prevent the heat loss to the surrounding just like a refrigerator. The box has one access door. The evaporator will be inside of the box.

C. Fabrication Process

The fabrication process of the low energy refrigerator is explained in details in this section. The process is divided by two parts which is fabricating the piping system for the LPG and another part is fabricating the one-door fridge-like box. Table below shows the fabrication process.

Table-2. Fabrication process.

No.	Procedure	Figure
1	The plywood that need to be cut following the size needed was marked and then cut. Beware on hazard and risk during the cutting process using the wood cutter.	 Cutting process
2.	Portable drill was used to make holes for the screws and nuts at each edges of the plywood. The bracket was used to support the joint. The process done with cautions.	 The joint at the edges of the box
3.	Hinges is used for the opening part to work as the door. Drill was used to make holes and screws is used to joint.	 Hinge
4.	For the piping system, the copper pipe was expanded using flaring tools. Then, flare nut was used to connect the pipe to the pressure gauge. The flaring process was done carefully to avoid crack of the copper tube.	 Flared copper tube and flare nut
5.	To join the copper tube and the capillary tube, the copper tube need to clip until it fit to the size of capillary tube which the diameter is smaller. Then, the joint was secured with brazing process with additional copper rod as the filler. This process was done carefully as it involves fire and any safety procedure was followed.	 Joint of copper tube
6.	To join the capillary tube to the evaporator, extra careful is needed. Both of materials is different as capillary tube is made of copper and the evaporator is made of aluminium. The joint was using brazing process but with lower fire and made slowly to avoid the aluminium to melt. The aluminium is easier to melt than the copper. The aluminium rod was used to secure the joint. Extra careful and safety precaution was done during the process.	 Joint of the capillary tube and aluminium evaporator
7.	The joint of the hose was secured with hose clamp. White tape was used to secure the joint. This is to ensure there is no leakage of gas from the pipe.	 Joint using the hose clamp

RESULTS AND DISCUSSIONS

Fabrication Result

Figure-3. Inside the refrigerator.

Figure-4. Outside the refrigerator.

Analysis

The test run with safety precautions as it involves flammable material. All safety precaution is followed. The first test was run and the result is as followed:

Time (minutes)	Pressure outlet (psi)	Temperature (°C)
1	10	29.4
2	10	29.8
3	10	29.6
4	10	29.6
5	10	29.8
6	10	29.8
7	10	29.8
8	10	29.9
9	10	29.9
10	10	29.9

Figure-5. The first test run result.

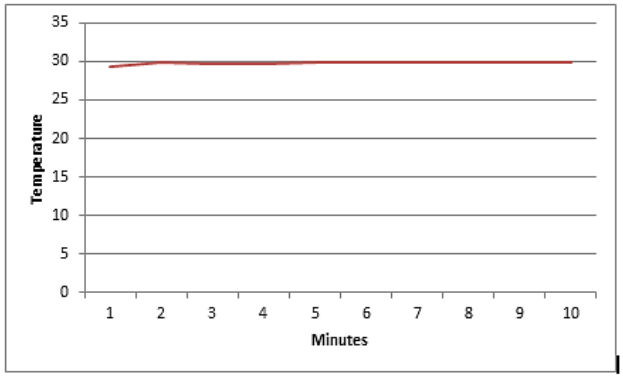


Figure-6. The first test run graph.

The first test run shows an unchanged of temperature inside the box. This is because the flow inside the system is in gas state of the LPG. The pressure of the gas can be decreased but not the temperature. So the second test run will flow the liquid state of LPG.

Time (minutes)	Pressure outlet (psi)	Temperature (°C)
1	10	28.4
2	10	20.0
3	10	17.6
4	10	17.8
5	10	15.8
6	6	18.4
7	5	15.4
8	4	17.5
9	2	18.7
10	1	21.0

Figure-7. The second test run result.

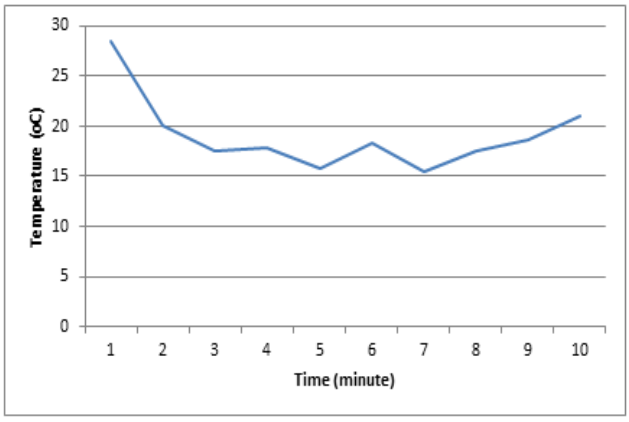


Figure-8. The second test run result.

Based on the second result, the graph shows the temperature drops drastically at the first 5 minutes until reached 15.0 ^{o}C and then start to shows a uniform reading until the tenth minute. This is because the pressure outlet is also decreased and can be caused by the capacity of LPG in the tank is about to finish. The temperature may be getting lower if the pressure could be maintained at 10 psi.

This refrigerator can achieve temperature same as the commercial mini-fridge if the correct expansion device sizing is used. This project consumes less electricity compare to commercial refrigerator.

CONCLUSIONS

Based on this project, the objective to fabricate low energy consumption refrigerator is achieved. The refrigerator used expansion of LPG pressure as a cooling medium. This project can achieve the same temperature as the commercial refrigerator.

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