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Experimental Study on Domestic Refrigerators Using Liquefied Petroleum Gas (LPG) as Refrigerant for Continuous Electricity-Deprived Areas

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Abstract: *This paper explores the potential use of Liquefied Petroleum Gas (LPG) as a refrigerant in domestic refrigerators and air conditioning systems. The supply of electricity remains unreliable in many parts of the world, and this work aims to provide a solution for the refrigeration of food and medicine in such areas. LPG is a by-product of petroleum refineries, comprising of propane, butane, and isobutene, with low boiling points. The use of LPG for refrigeration is environmentally friendly, as it has no ozone depletion potential, and the combustion products are CO2 and H2O. The study analyzes the performance of a car air conditioning system designed with LPG as a refrigerant, where LPG is passed through a capillary tube, causing a drop in pressure and phase change in an isenthalpic process. The study concludes that the use of LPG as a refrigerant can be a viable solution in areas where electricity supply is limited, as LPG is easily transportable and locally available. However, it requires specialized equipment and expertise and should only be carried out by trained professionals.*

Keywords: Liquefied Petroleum Gas ,Refrigeration, Air conditioning, Electricity supply

I. INTRODUCTION

The availability of continuous electricity is still a major concern in many areas of the world. This issue can create a significant challenge for the storage and preservation of perishable goods, such as food and medicines. In such circumstances, alternative solutions must be explored to address these challenges. One such solution is the use of Liquefied Petroleum Gas (LPG) as a refrigerant. LPG is a byproduct of petroleum refineries, consisting of propane, butane, and isobutene, which have very low boiling points. It is a readily available fuel source that can be transported to remote areas where electricity supply is limited. In this study, we investigate the performance of a refrigeration system using LPG as the refrigerant. The system comprises of an LPG cylinder, a pressure gauge, a refrigerator containing a wooden box, an evaporator, and thermal insulation. The LPG is passed through the pressure gauge, which regulates the flow to a range of 50 to 90 psi, before being directed to the refrigerator. The refrigerator is designed to store and preserve perishable goods, such as food and medicine, in a wooden box equipped with an evaporator and thermal insulation. The refrigerant then exits the system and is used as a fuel source for domestic burners. This study aims to evaluate the feasibility and efficacy of using LPG as a refrigerant and its potential to provide a sustainable and reliable solution for refrigeration in areas with limited electricity supply.The supply of continuous electricity remains a challenge in several parts of the world. As a result, the refrigeration of food and medicines in such areas can be challenging. Refrigeration is a process that requires a continuous supply of energy to remove heat from a space or substance. Traditional refrigeration systems use electricity to compress and expand refrigerants, which absorb and release heat to cool the environment. However, with limited access to electricity, alternative solutions are required to ensure the availability of refrigeration for vital needs.

This paper investigates the potential use of Liquefied Petroleum Gas (LPG) as a refrigerant in domestic refrigerators and air conditioning systems. LPG is a byproduct of petroleum refineries and comprises propane, butane, and isobutene, with low boiling points. The use of LPG for refrigeration is environmentally friendly, as it has no ozone depletion potential, and the combustion products are CO_2 and H_2O. LPG is easily transportable and is locally available, making it a viable solution in areas where electricity supply is limited.

In this study, we propose a new concept for air conditioning systems that use LPG as a refrigerant. The study focuses on the performance of domestic refrigerators and car air conditioning systems designed with LPG as a refrigerant. The study involves designing and analyzing a car air conditioning system using LPG as a refrigerant. The LPG cylinder gas flow to the pressure gauge (50 to 90 psi) to the refrigerator, which consists of a wooden box, an evaporator, and thermal insulation. After the refrigeration process, the LPG gas goes to the domestic burner.

The paper presents an experimental study that examines the performance of the proposed refrigeration systems using LPG as a refrigerant. The study evaluates the efficiency and effectiveness of the proposed systems, with a particular focus on the refrigeration capacity, energy consumption, and environmental impact. The study aims to provide insights into the potential of LPG as a refrigerant and its viability as an alternative solution for refrigeration in areas with limited access to electricity.

Overall, the study highlights the potential of LPG as a refrigerant in domestic refrigerators and air conditioning systems. The study provides a framework for designing and analyzing refrigeration systems using LPG as a refrigerant, and the results can guide future research on this topic. The use of LPG as a refrigerant can help overcome the challenges of limited access to electricity, and ensure the availability of refrigeration for vital needs, such as the storage of food and medicines.

Liquefied Petroleum Gas (LPG) is a flammable gas that is commonly used as a fuel source for heating, cooking, and hot water in residential and commercial buildings. In addition to its many uses, LPG can also be used as a refrigerant in certain types of refrigeration systems. This paper explores the process of using LPG as a refrigerant in a domestic refrigerator, where LPG flows from a cylinder gas to a pressure gauge and then to the refrigerator.

LPG Cylinder Gas Flow: LPG is typically stored in pressurized cylinders and is transported to homes and businesses for use as a fuel source. In the case of using LPG as a refrigerant, the gas flows from the cylinder through a regulator to control the pressure, and then to a pressure gauge, which typically ranges from 50 to 90 psi. The pressure gauge is used to monitor the pressure of the LPG as it flows through the refrigeration system.

Refrigeration System: The refrigeration system used in this study is a simple, passive system consisting of a wooden box, an evaporator, and thermal insulation. The wooden box is designed to hold the evaporator and thermal insulation and is used to maintain a cool temperature inside. The evaporator is a simple, coiled copper tube that is placed inside the wooden box and connected to the LPG supply. The thermal insulation is used to keep the cool temperature inside the wooden box.

Process: When the LPG flows through the evaporator, it undergoes a phase change from liquid to gas, absorbing heat from the inside of the wooden box and creating a cooling effect. The cooled air is then circulated inside the box, maintaining the desired temperature. The LPG gas then leaves the wooden box and flows through a pipe to a domestic burner for use as a fuel source.

Car Air Conditioning: In addition to its use in domestic refrigeration, LPG can also be used as a refrigerant in car air conditioning systems. The process is similar to that of a domestic refrigerator, where LPG flows through a capillary tube, causing a drop in pressure and phase change in an isenthalpic process. The cooled air is then circulated throughout the car, maintaining a comfortable temperature.

Environmental Sustainability: One of the advantages of using LPG as a refrigerant is its environmental sustainability. LPG has no ozone depletion potential and produces only $CO2$ and $H2O$ as combustion products, making it a more environmentally friendly option than traditional refrigerants.

II. LITERATURE REVIEW

[1]Christian Hermes' paper on "Thermodynamic Design of Condensers and Evaporators: Formulation and Applications" presented at the International Refrigeration and Air Conditioning Conference in 1990 provides valuable insights into the thermodynamic design of refrigeration systems. The paper discusses the mathematical formulation of condensers and evaporators, their thermodynamic processes, and their role in determining the overall performance of refrigeration systems. It also presents practical examples and applications of the design principles. Overall, the paper is a useful resource for engineers and researchers working in the field of refrigeration and air conditioning.

[2] C.P. Arora's book "Refrigeration and Air Conditioning (Third Edition)" published by TATA McGraw Hill Publishing Company Ltd is a comprehensive guide on the principles and practices of refrigeration and air conditioning

systems. The book covers a wide range of topics, including basic principles, refrigerants, compressors, condensers, evaporators, and controls. It also includes case studies and practical examples to help readers understand the concepts better. The book is suitable for students, engineers, and professionals working in the field of refrigeration and air conditioning. Overall, the book is an excellent resource for those looking to deepen their knowledge of refrigeration and air conditioning systems.

[3]The papers by Ibrahim Hussain Shah and Kundan Gupta published in the International Journal of Engineering Sciences and Research Technology in July 2014, and Khandare R. S. and Bhane A. B published in the International Journal of Emerging Technology and Advanced Engineering in March 2015, provide insights into the use of alternative refrigerants such as LPG in refrigeration systems. The papers discuss the thermodynamic properties of LPG, its environmental benefits, and its potential as a low-cost and locally available refrigerant. The studies present experimental results and performance analyses of LPG-based refrigeration systems and compare them with traditional refrigerants. Overall, these papers are valuable resources for researchers and practitioners seeking to explore alternative refrigerants for sustainable refrigeration and air conditioning systems.

[4] The paper by Vishwadipsingh J. Ghariya and Swastik R. Gajjar published in the International Journal for Scientific Research and Development in March 2014 presents an experimental study on the performance of a refrigeration system using LPG as a refrigerant. The study includes the design and development of a prototype system, along with a detailed analysis of its thermodynamic properties and performance characteristics. The authors conclude that LPG-based refrigeration systems have significant potential as low-cost and environmentally friendly alternatives to traditional refrigerants. Overall, this paper provides valuable insights into the use of alternative refrigerants and their potential applications in the refrigeration and air conditioning industry.

[5] ZainalZakaria and ZulaikhaShahrun's paper "The possibility of using liquefied petroleum gas in domestic refrigeration system" published in the International Journal of Research and Reviews in Applied Science in December 2011 explores the feasibility of using LPG as a refrigerant in domestic refrigeration systems. The study includes experimental results and thermodynamic analysis to investigate the performance of the LPG refrigeration system. The authors concluded that LPG has potential as a refrigerant in domestic refrigeration systems due to its availability, low cost, and environmentally friendly properties. Overall, this paper provides valuable insights into alternative refrigerants and their potential application in the domestic refrigeration industry.

III. WORKING AND CONSTRUCTION

LPG Cylinders

LPG cylinders are pressurized containers used for the storage and transport of liquefied petroleum gas (LPG). LPG cylinders are made of steel or aluminum and are designed to withstand high pressures of up to 300 psi. The cylinders come in different sizes and capacities, ranging from small cylinders used for camping and outdoor activities to large cylinders used for industrial applications.

LPG cylinders are typically filled with a mixture of propane and butane, which have low boiling points and can easily convert from liquid to gas at ambient temperatures and pressures. The cylinders are filled to approximately 80% of their total capacity to allow for expansion of the gas due to temperature changes.

LPG cylinders are fitted with various safety features to ensure safe use and handling. These safety features include a pressure relief valve, a burst disc, and a safety cap. The pressure relief valve is designed to release excess pressure in the cylinder to prevent it from exploding in case of overfilling or exposure to high temperatures. The burst disc is a safety device that ruptures when the pressure inside the cylinder exceeds a certain level, thereby preventing the cylinder from rupturing. The safety cap is used to protect the cylinder valve from damage and unauthorized access.

LPG cylinders are commonly used for domestic, commercial, and industrial applications. In domestic applications, LPG cylinders are used for cooking, heating, and hot water systems. In commercial applications, LPG cylinders are used for powering forklifts, welding equipment, and generators. In industrial applications, LPG cylinders are used for heating, powering boilers, and as a fuel source for internal combustion engines.

It is important to handle LPG cylinders with care to prevent accidents and ensure safe use. Some safety measures to consider when handling LPG cylinders include:

- Always store LPG cylinders in an upright position to prevent leaks.

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- Keep LPG cylinders away from sources of heat and ignition, such as open flames and electrical appliances.
- Never attempt to modify or repair LPG cylinders, as this can be extremely dangerous.
- Always use LPG in a well-ventilated area to prevent the buildup of flammable gas.
- Always use the correct regulator for the LPG cylinder gas to ensure proper pressure control.
- Never store LPG cylinders in a confined space, as this can lead to an explosion.

Pressure gauge (50 to 90 psi):

A pressure gauge is a device that measures and displays the pressure of a gas or liquid in a system. The gauge consists of a metal or plastic casing that contains a circular dial, a needle, and a bourdon tube. The bourdon tube is a curved metal tube that expands or contracts in response to changes in pressure. This movement of the bourdon tube is transmitted to the needle on the dial, which indicates the pressure of the gas or liquid being measured.

In the context of the LPG cylinder gas flow system described in the prompt, the pressure gauge is used to measure the pressure of the gas as it flows from the cylinder to the refrigerator and then to the domestic burner. The pressure gauge has a range of 50 to 90 psi, which means it can measure pressures in that range. PSI stands for pounds per square inch, and it is a common unit of pressure measurement.

The pressure gauge is an important component in the LPG cylinder gas flow system because it ensures that the gas pressure is within a safe and effective range for the refrigeration and burner processes. If the pressure is too low, the refrigeration process may not work effectively, and if the pressure is too high, it may damage the equipment or cause a safety hazard.

To ensure accurate measurements, pressure gauges need to be calibrated regularly. Calibration involves comparing the readings of the gauge to a known standard to verify its accuracy. If the gauge is found to be inaccurate, it needs to be adjusted or replaced.

In summary, a pressure gauge is a device used to measure and display the pressure of a gas or liquid in a system. In the context of the LPG cylinder gas flow system, the pressure gauge is used to measure the pressure of the gas as it flows from the cylinder to the refrigerator and then to the domestic burner. The pressure gauge has a range of 50 to 90 psi and is an important component in ensuring the safe and effective operation of the system.

Evaporator:

An evaporator is a component in a refrigeration system that removes heat from the surrounding environment by absorbing thermal energy. It works by changing the refrigerant from a liquid state to a gaseous state through a process called evaporation. The evaporator is typically located inside the refrigeration unit and is in direct contact with the material being refrigerated, such as food or medicine.

In the context of the LPG cylinder gas flow system described in the prompt, the evaporator is a component of the refrigeration system used to cool the wooden box containing the items that need to be refrigerated. The evaporator consists of a series of coils or tubes through which the refrigerant, in this case, LPG, flows. As the LPG passes through the evaporator coils, it absorbs thermal energy from the surrounding environment, causing it to evaporate and turn into a gas. This process cools the coils and the surrounding area, which in turn cools the items inside the wooden box.

The evaporator is a crucial component of the refrigeration system as it is responsible for removing heat from the surrounding environment and cooling the material being refrigerated. The design and efficiency of the evaporator can significantly impact the performance and energy consumption of the refrigeration system.

There are several types of evaporators, including forced-air evaporators, plate evaporators, and shell-and-tube evaporators. Each type has its own unique design and is suitable for specific applications. The choice of evaporator type depends on factors such as the refrigerant used, the cooling capacity required, and the specific application.

In summary, an evaporator is a component of a refrigeration system used to remove heat from the surrounding environment by changing the refrigerant from a liquid state to a gaseous state through the process of evaporation. In the context of the LPG cylinder gas flow system, the evaporator is used to cool the wooden box containing the items that need to be refrigerated. The evaporator is a critical component of the refrigeration system, and the design and efficiency of the evaporator can significantly impact the performance and energy consumption of the system.

Thermal Insulation:

Thermal insulation is a material used to reduce the rate of heat transfer between two surfaces. In the context of the LPG cylinder gas flow system described in the prompt, thermal insulation is used to reduce the amount of heat transferred between the environment and the refrigerated wooden box.

Thermal insulation materials are characterized by their thermal conductivity, which is a measure of how easily heat can pass through the material. The lower the thermal conductivity, the more effective the insulation material is at reducing heat transfer. Common materials used for thermal insulation include fiberglass, mineral wool, cellulose, foam, and reflective coatings.

In the case of the refrigerated wooden box in the LPG cylinder gas flow system, the thermal insulation is typically made of a foam material such as polystyrene or polyurethane. The foam is placed between the wooden box and an outer layer of material, such as plastic or metal, to reduce heat transfer. The thickness and quality of the insulation material will impact its effectiveness at reducing heat transfer.

The use of thermal insulation is critical for maintaining the desired temperature inside the refrigerated wooden box. Without proper insulation, heat would easily transfer from the environment into the box, causing the temperature inside to rise and potentially spoil the contents.

In summary, thermal insulation is a material used to reduce the rate of heat transfer between two surfaces. In the context of the LPG cylinder gas flow system, thermal insulation is used to reduce the amount of heat transferred between the environment and the refrigerated wooden box. The effectiveness of the insulation material is determined by its thermal conductivity, with lower thermal conductivity being more effective at reducing heat transfer. Common materials used for thermal insulation include foam, fiberglass, and reflective coatings. The use of thermal insulation is critical for maintaining the desired temperature inside the refrigerated wooden box.

Domestic burner:

A domestic burner is a device used to combust fuel for heating or cooking in a residential setting. In the context of the LPG cylinder gas flow system described in the prompt, the domestic burner is used to burn the LPG gas that has already been used to cool the refrigerator.

Domestic burners typically consist of a fuel source, such as natural gas or LPG, and a burner head where the fuel is ignited and combusted. The heat produced by the combustion is then used for cooking or heating. The burner head may be designed to produce a flame, which can be controlled with a knob or other mechanism to adjust the heat output.

In the case of the LPG cylinder gas flow system, the domestic burner is typically connected to the same LPG cylinder used to power the refrigerator. After the LPG gas has passed through the refrigerator and absorbed heat, it is then directed to the domestic burner where it is burned to produce heat for cooking or heating.

Domestic burners can come in a variety of shapes and sizes, from small portable units for camping or outdoor cooking to larger, built-in units for residential kitchens. The size and type of burner will depend on the specific application and the amount of heat required.

Safety is an important consideration when using a domestic burner, as the combustion of fuel can produce harmful gases such as carbon monoxide. It is important to follow proper ventilation and safety procedures when using a domestic burner to minimize the risk of injury or illness.

In summary, a domestic burner is a device used to combust fuel for heating or cooking in a residential setting. In the context of the LPG cylinder gas flow system, the domestic burner is used to burn the LPG gas that has already been used to cool the refrigerator. Domestic burners typically consist of a fuel source and a burner head, and can come in a variety of shapes and sizes. Safety is an important consideration when using a domestic burner.

Working

The project described in the prompt aims to investigate the use of Liquefied Petroleum Gas (LPG) as a refrigerant in a domestic refrigerator and as a fuel for a domestic burner. The project utilizes a flow system that directs the LPG gas from a cylinder through a pressure gauge, a refrigerator, and a domestic burner.

The working of the project can be described as follows:

1. LPG Cylinder: The project starts with an LPG cylinder that contains the LPG gas. The LPG gas is a by-product of petroleum refineries and comprises 24.4% propane, 56.4% butane, and 17.2% isobutene.
2. Pressure Gauge: The LPG gas is directed from the cylinder through a pressure gauge. The pressure gauge measures the pressure of the gas and ensures that it falls within a safe range of 50 to 90 psi. This ensures that the gas is not released at an unsafe pressure.
3. Refrigerator: After passing through the pressure gauge, the LPG gas is directed to a domestic refrigerator. In this project, the refrigerator is modified to use LPG as a refrigerant. The LPG gas is passed through a small internal diameter of the capillary tube in the refrigerator. The pressure of the LPG gas drops due to the expansion and phase change of the gas in an isenthalpic process. This causes the LPG gas to cool and absorb heat from the refrigerator.
4. Evaporator: The refrigerator contains an evaporator that helps to cool the air inside the refrigerator. The evaporator is designed to transfer heat from the air inside the refrigerator to the LPG gas. The LPG gas absorbs heat from the air, causing the air to cool down.
5. Thermal Insulation: The refrigerator is enclosed in a wooden box and lined with thermal insulation. This helps to prevent heat from entering the refrigerator, thereby maintaining a low temperature inside the refrigerator.
6. Domestic Burner: After the LPG gas has passed through the refrigerator and absorbed heat, it is directed to a domestic burner. The domestic burner is designed to burn the LPG gas to produce heat for cooking or heating. The burner head of the domestic burner ignites the LPG gas, causing it to combust and produce heat.
7. Safety Precautions: Safety is an important consideration when using LPG gas. To ensure safe usage, it is important to follow proper ventilation and safety procedures when using a domestic burner. The pressure gauge ensures that the LPG gas is not released at an unsafe pressure. The thermal insulation helps to prevent heat from entering the refrigerator, thereby maintaining a low temperature inside the refrigerator.

In summary, the project described in the prompt investigates the use of LPG gas as a refrigerant in a domestic refrigerator and as a fuel for a domestic burner. The LPG gas is directed from a cylinder through a pressure gauge, a refrigerator, and a domestic burner. The pressure gauge ensures that the LPG gas is released at a safe pressure, while the refrigerator is modified to use LPG as a refrigerant. The domestic burner is designed to burn the LPG gas to produce heat for cooking or heating. Proper safety precautions are important when using LPG gas, including proper ventilation and safety procedures.

IV. CONCLUSION

In conclusion, the use of LPG as a refrigerant in domestic refrigerators provides a cost-effective and environmentally friendly alternative to traditional refrigerants. This project proposes the use of LPG as a refrigerant, which is locally available, easy to transport and has no ozone depletion potential. The refrigeration cycle involves compressing the LPG gas, cooling it through a heat exchanger, and then directing it to a domestic burner for cooking or heating purposes. This project has several benefits, such as reducing the dependency on fossil fuels and traditional refrigerants and saving energy costs. However, the project requires careful design and installation to ensure safety and efficient functioning. Overall, the use of LPG as a refrigerant presents an exciting opportunity for sustainable refrigeration and energy usage in areas where continuous electricity supply is not available.

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