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Design And Analysis Performance of Liquid Petroleum Gases System in Residential Building; Review

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ABSTRACT

Liquefied petroleum gases (LPG) consist of hydrocarbons obtained by refining crude oil, either from propane or butane or a mixture of the two. There are often other components such as propylene, butylene or other hydrocarbons, but they are not the main component. The study aims to review previous studies dealing with designing an LPG system to deliver gas to residential campuses and buildings. LPG is extracted from natural gas NG by several processes, passing through fractionation towers and then pressuring into CNG storage tanks. Gas contains several problems, including gas leakage through the pipes and leads to fires or explosions in LPG storage and distribution tanks, so safety conditions were taken in the design and implementation. The major results are the gas leak detector showed that rapid response to gas leakage sense, so it is recommended to place the device at a distance of 0.6-2 meters from the gas source and at a distance of 0.2 to 1 meter above the ground, and the major conclusion is new techniques for using hardware and software components must be demonstrated again that can be applied to models to show fast and effective results.

Keywords: LPG, design, multi building, multi stories, LP gases.

تصميم وتحليل اداء نظام الغازات البترولية السائلة في المباني السكنية ؛ عرض

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الخلاصة

تتكون غازات البترول المسال (LPG) من الهيدروكربونات التي يتم الحصول عليها عن طريق تكرير النفط الخام ، إما من البروبان أو البوتان أو خليط من الاثنين ، وغالبًا ما توجد مكونات أخرى مثل البروبيلين والبيوتيلين أو الهيدروكربونات الأخرى ، ولكنها ليست المكون الرئيسي. الهدف من الدراسة هو استعراض البحوث السابقة التي تعاملت مع تصميم نظام غاز البترول المسال لتوصيل الغاز إلى المجمعات السكنية والمباني. يتم استخراج غاز البترول المسال من الغاز الطبيعي من خلال عدة عمليات ، ويمر عبر أبراج التجزئة ، ثم يتم ضغطه في صهاريج تخزين تسمى CNG. يحتوي الغاز على عدة مشاكل منها

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تسرب الغاز عبر الأنابيب ويؤدي إلى حرائق أو انفجارات في صهاريج تخزين وتوزيع غاز البترول المسال ، لذلك يتم أخذ شروط السلامة في التصميم والتنفيذ. النتائج الرئيسية هي أن كاشف تسرب الغاز يظهر استجابته السريعة لاستشعار تسرب الغاز ، لذلك يوصى بوضع الجهاز على مسافة 0.6 - 2 متر من مصدر الغاز وعلى مسافة 0.2 إلى 1 متر فوق سطح الأرض ، والنتيجة الرئيسية هي تقنيات جديدة لاستخدام مكونات الأجهزة والبرمجيات يجب إظهارها مرة أخرى والتي يمكن تطبيقها على النماذج لإظهار نتائج سريعة وفعالة.

الكلمات الرئيسية : غاز البترول المسال - تصميم - متعدد المباني - طوابق متعددة - غازات البترول المسال.

1. INTRODUCTION

Liquid petroleum gas (LPG) was used in homes by cylinders for easy movement and transportation. In multi-story buildings, cylinders could not be used due to the difficulty of carrying them. Therefore, there was a need to use a system that supplies buildings with liquefied gas through a network and transferred to the floors for use in cooking, water heating, and other uses. Liquefied petroleum gas (LPG) is considered suitable for home heating and cooking due to its economic characteristics and practical advantages clean combustion, no cumbersome prolonged purchase, and it is cleaner. One of its advantages is reducing air pollution because switching from using traditional coal or wood combustion to liquefied petroleum gas means that the health and environmental conditions are met (**Matthews and Zeissig, 2011**). One of the disadvantages or dangers of LPG is the gas leakage inside buildings or homes and lead to fires or explosions (**Mahalingam, et al., 2012**)

Liquefied petroleum gases consist of hydrocarbons obtained by refining crude oil, either from propane or butane or a mixture of the two. There are often other components such as propylene, butylene, or other hydrocarbons, but they are not the main component. It is considered among the range of delegations that are used in different applications such as agriculture, industry, civil engineering, economics, transportation, and household applications. This gas is produced from three main sources (from the removal of natural gas - oil refining - from the stability of oil in crude oil sites) (**Paczuski and Marchwiany, 2017**). One of the gas characteristics is not contain any odor, so some smells are added to it, such as ethanol, thiophene, or mercaptan, to distinguish the liquefied gas in the event of a leak (**Mahalingam et al., 2012**).

One of the designs related to the liquefied petroleum gas system in buildings is the design of a gas leak detector that helps people from the dangers of leakage. Therefore, a wireless leakage system was proposed in homes with an alarm device (**Mahalingam et al., 2012**). Another design of the LPG leak detector in the building uses the gas sensor models to send a message (SMS) to the user alerting the leak inside the apartment. The gas pumping to the apartment is not closed. (**Enalume and Silas, 2017**). A remote device was designed to measure the concentrations of gases in the surrounding atmosphere, such as Gas Liquid Petroleum (GLP) and CO. The device is linked to an online platform (**Flores et al., 2021**). Other designs are the design of compressed annular liquefied petroleum gas fuel tanks to determine the tank's optimal shape and give key indicators for the liquefied gas fuel tank (**Ṭālu, 2018**). As for household stoves that run on liquefied petroleum gas, devices were used to take measurements such as fuel consumption, time, and temperature (**Silva, et al., 2015**).

2. LPG, NG and CNG CONCEPT

The Global Liquefied Petroleum Gas Partnership (GLPGP) helps many countries that use LPG for cooking on a large scale, with the goal being to move one billion people around the world



to use clean energy LPG for home cooking by 2030 (Leeuwen et al., 2017). Liquefied petroleum gas is extracted from natural gas or is synthesized from petroleum refining as a by-product. LPG consists of propane and butane. Propane (C_3H_8) is a saturated hydrocarbon component with an energy value of 46 MJ/kg and a calorific value of 11,070 kJ/kg. Butane (C_4H_{10}) is an easily liquefied and highly flammable gas with an energy value of 45 MJ/kg and a calorific value of 10920 kJ/kg. LPG has an energy value of 45 MJ/kg and a density of 0.55 kg/m³. It is heavier than air as gases and lighter than water as a liquid, not poisonous, colorless, and odorless. Liquefied gas has its octane number from 106 to 110, so it is higher than the octane number of gasoline's (Synáka et al., 2019). There are many applications for LPG, and it can be used in three main areas, including air conditioning, hot water production, used in cooking, and pipeline networks (PRIF, 2016).

CNG contains about 4:1 H:C. NG and CNG require more expensive storage tanks due to extreme pressure or temperature requirements (Ryskamp, 2017). Natural gas may contain ethane, propane, or nitrogen, but in small quantities. Container parts for natural gas must be emphasized from the tank wall, bottom panels, roof panels, joint, handle, and compression rings. One of the specifications of natural gas tanks is that it has a capacity of 265 cubic meters or more and is placed at a distance of at least 0.7 from the diameter of the container, but not less than 30 meters. The distance between adjacent tanks for natural gas should be 1/4 of the sum of the diameters of each tank, (New Delhi, 2018).

3. OPERATIONAL LPG PROBLEM

A gas leak detector is essential to protect people from explosion hazards, so the implementation of a gas leak detector was studied through published papers. To detect the leak, the pressure in the pipeline must be calculated, which is usually at the ends. The sounds of gas leakage from cracks in the pipelines are analyzed, and a simulation program PROTEUS is used (Mahalingam et al., 2012). A sensor can be used that shows the leakage condition in ppm, as it sends signals to the GSM unit and the PIC18F2520 microcontroller receives it and converts it into a digital signal using the ADC and a digital result appears on the user's LCD screen (Enalume & Silas, 2017). There is also carbon monoxide (CO) and PLG sensors on electronic stations such as Amazon Web Services (AWS) to store data whose data can be accessed by a device connected to the Internet through a website (Flores et al., 2021). Another technique that detects gas leaks by sending a text message to the user and stopping the operation is considered from home safety and works through GSM by sending a message to the company that distributes the gas and to the user at the same time to stop the operation (Kumar et al., 2016).

To improve the compressed annular LPG tanks by using the variable section used in the automotive industry with the help of the Finite Elements Analysis (FEA) program for modeling of mechanical and thermal treatments and the optimal shape of the tank depending on design data such as maximum static hydraulic pressure, temperature between limits, symmetry on surfaces, the velocity of material and execution material for the tank, so the verification was carried out using AutoCAD Autodesk 2017 with SolidWorks 2017 analysis (Mihai and Ștefan, 2018). With the use of wood and coal for household needs such as cooking and others, so the national action plan aims to use liquefied petroleum gas and deliver it to homes. A survey was conducted for households in Ghana in 2016 and 2017 to use LPG cooking, and the results were analyzed using a program STATA (version 15.1) (Dalaba et al., 2018).



The efficiency of the gas leak detector depends on the sensitivity of the sensor, sensitivity output is measured in volt V_o , R_s (sensor resistance), and R_L (load resistor value in ohm) (10 k- 60k) from the LPG Gas Sensor (MQ-6) datasheet. The equations used are (1) and (2) (**Enalume and Silas, 2017**).

$$R_s = (V_c - V_o) \times \frac{R_L}{V_o} \tag{1}$$

R_s : Sensor resistance (in ohm) (10 k- 60k) from the MQ-6 datasheet

R_L : load resistor value (in ohm) about 20K Ω (10K Ω to 47K Ω) from the MQ-6 datasheet

V_o : Output voltage measured from the sensor

V_c : Circuit voltage (technical condition is 5V \pm 0.1)

to extract the concentration of LPG from the sensor readings, using eq (2)

$$\text{LPG (ppm)} = \left[\frac{R_s/R_o}{18.446} \right]^{\frac{-1}{0.421}} \tag{2}$$

R_o : Sensor resistance at 1000ppm of LPG in the clean air

R_s : Sensor resistance at various concentrations of gases.

4. DESIGN OF LPG SYSTEM

An LPG transport network was designed in one of the tourist accommodation complexes in Italy as an alternative fuel to electric energy, such as washing machines, refrigerators, and in kitchens, and the use of electricity was limited to limited consumption, such as lighting and television (**CUMO et al., 2015**). The first LPG storage station under Lake Nomyang in the western part of Korea was designed to facilitate gas storage under ownership limits. Confidential evaluation of geological data and numerical analyses was carried out. The new depth of the site was determined to determine pressure to obtain the largest capacity and continuous monitoring during the construction of caves and storage tunnels (**Park and Jeon, 2005**). Many studies were conducted on the design of an LPG tank suitable for moderate pressure according to ASME specification, and the results were compared with the design programs COMPRESS and PV ELLITE. The designed pressure for this type is between (1-206 bar). The tank contains a liquid and a partial vaporizer, and the pressure check is carried out due to the pressure loading and the head inside the tank. The PV ELLITE program is used to analyze the pressure inside the tank wall (**Salman et al., 2018**). Spherical tanks are widely used in Iraq for storing LPG. A design was carried out on the tanks using three artificial earthquakes according to the program SIMQKE_GR and the date and time analysis according to the code UBC97. The study was conducted in Maysan province because of frequent earthquakes. The STAAD Pro program was used to model the elements to know the response and stability of the tank structure. The used tank was empty and filled with 100% LPG (**Oda Dawood, 2019**).



5. RESULTS AND DISCUSSION

The design of the gas system in the data depends on the type of devices used, the pressure, the diameter of the pipe, and the detectors used to know the gas leakage, which are either tied to the user's mobile device or through an alarm to stop the system. There are also programs used in the design, including STAAD Pro, pipe flow, and for network system used EPANET, etc.

For analysis, some programs are used, including finite element, SPSS, Excel, and others. There is another method of analysis, including published papers for a survey.

There are different types of tanks, including horizontal and vertical. The common type used is horizontal tanks, but vertical ones are used in narrow spaces while providing safety conditions. One of the most common types in Iraq is spherical tanks.

6. CONCLUSIONS

The major conclusion from a review of LPG previous studies as:

- 1) The proposed design and implementation of LPG, a cost-effective gas leakage system, should be meet health and safety standards.
- 2) Determining the ideal annular tank with the minimum design variables using equations and considering the conditions.
- 3) The gas leak detector has been developed and used in home and industrial kitchens with reliability, as it works on electric current and battery.
- 4) New techniques using hardware and software components must be demonstrated and applied to models to show fast and effective results.
- 5) An LPG storage has been used like spherical tanks are widely used in Iraq to store LPG established with the assessment of ongoing hydrological and hydrological issues during operation.

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