LPG (Liquified Petroleum Gas) as a Fuel

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Abstract:-

This paper focuses mainly different properties of LPG (Liquefied petroleum gas) to exhibit its utility in different applications such as automobile and other areas which include cooking and refrigeration field also. It also highlights different safety and regulatory aspects of LPG uses in automobile area so that utility of LPG as a fuel can be further enhanced to maintain energy balance. Worldwide-liquefied petroleum gas (LPG) production is limited to about 10% of total gasoline and diesel fuel consumption is used to a great extent for domestic and industrial purposes. Since LPG burns cleaner with less carbon content, lesser oil contamination so engine wear is also reduced and the life of some components such as rings and bearings is much longer than with gasoline which ultimately increases life of the machine also. The high octane of LPG also minimizes wear from engine knock.

LPG has lower stoichiometric fuel air ratio and density compared to gasoline, and therefore it could reduce the specific fuel consumption and exhaust emissions. Moreover, when LPG is used in vehicular applications, carbon dioxide (CO₂) emission is reduced due to lower carbon molecules content compared to gasoline and diesel.

In terms of performance, a higher thermal efficiency and improved fuel economy is found out from internal combustion engines running on LPG. A higher octane rating for LPG makes it safe to run in higher compression ratio engine without the occurrence of detonation, and subsequently the thermal efficiency increases.

Keywords: - LPG-Liquefied petroleum gas, ASTM- American Society of Testing and Materials

1-Introduction:-

Liquefied petroleum gas or liquid petroleum gas (LPG), also referred to as simply propane or butane, are flammable mixtures of hydrocarbon gases used as fuel in heating appliances, cooking equipment, and vehicles. It is increasingly used as a propellant and a refrigerant, replacing chlorofluorocarbons in an effort to reduce damage to the ozone layer. When specifically used as a vehicle fuel it is often referred to as auto gas.

Varieties of LPG bought and sold include mixes that are mostly propane (C₃H₈), mostly butane (C₄H₁₀) and, most commonly, mixes including both propane and butane. In the northern hemisphere winter, the mixes contain more propane, while in summer, they contain more butane. In the United States, mainly two grades of LPG are sold: commercial propane and HD-5. These specifications are published by the Gas Processors Association (GPA) and the American Society of Testing and Materials (ASTM). Propane/butane blends are also listed in these specifications.

Propylene, butylenes and various other hydrocarbons are usually also present in small concentrations. HD-5 limits the amount of propylene that can be placed in LPG to 5%, and is utilized as an auto gas specification. A powerful odorant, ethanethiol, is added so that leaks can be detected easily. LPG is made during natural gas processing and oil refining. LPG is extracted

from heated crude oil using a distillation tower. This LPG can be used as is or separated into its three primary parts: propane, butane and isobutane. It is stored in a pressurized form, in liquid state in cylinders or tanks

2-Literature Survey:-

LPG is prepared by refining petroleum and is almost entirely derived from fossil fuel sources, being manufactured during the refining of petroleum (crude oil), or extracted from petroleum or natural gas streams as they emerge from the ground. It was first produced in 1910 by Dr. Walter Snelling, and the first commercial products appeared in 1912. It currently provides about 3% of all energy consumed, and burns relatively cleanly with no soot and very few sulfur emissions. As it is a gas, it does not pose ground or water pollution hazards, but it can cause air pollution. LPG has been used as a fuel for vehicles as early as 1912 but only at a limited scale. The fuel became more popular in the 1970s and the 1980s when territories such as the US and Canada tried to reduce their dependence on crude oil. In the 1990s, the increased demand of the fuel is driven by rising environmental concerns.

3-Properties:-

LPG has a typical specific calorific value of 46.1 MJ/kg compared with 42.5 MJ/kg for fuel oil and 43.5 MJ/kg for premium grade petrol (gasoline). However, its energy density per volume unit of 26 MJ/L is lower than either that of petrol or fuel oil, as its relative density is lower (about 0.5–0.58 kg/L, compared to 0.71–0.77 kg/L for gasoline). Its auto ignition temperature is 470 °C (878 °F) and its molecular weight is 44.097 kg/k mole.

As its boiling point is below room temperature, LPG will evaporate quickly at normal temperatures and pressures and is usually supplied in pressurized steel vessels. They are typically filled to 80–85% of their capacity to allow for thermal expansion of the contained liquid. The ratio between the volumes of the vaporized gas and the liquefied gas varies depending on composition, pressure, and temperature, but is typically around 250:1. The pressure at which LPG becomes liquid, called its vapour pressure, likewise varies depending on composition and temperature; for example, it is approximately 220 kilopascals (32 psi) for pure butane at 20 °C (68 °F), and approximately 2,200 kilopascals (320 psi) for pure propane at 55 °C (131 °F). LPG is heavier than air, unlike natural gas, and thus will flow along floors and tend to settle in low spots, such as basements. LPG gases are compressible into liquid at low pressures. Efficiency of device based on LPG fuel can be easily calculated by water heating application. It can be defined as the ratio of heat consumed by water evaporated to the heat liberated by fuel (LPG).

Efficiency of device based on LPG fuel in a heating device = $\frac{M_{ev}(hg-hf)}{M_f \cdot C_f}$

M_{ev} = mass of water evaporated, hg = Total heat absorbed by water (KJ/KG) or sensible heat plus latent heat of water

hf = Heat already present in water (KJ/KG) or sensible heat

M_f = mass of fuel (LPG) in KG

C_f = calorific value of fuel (LPG) KJ/KG

By taking into considerations of all the factors it is always beneficial to use LPG as a fuel because firstly it is a completely combustible fuel, leaving no harmful exhaust and having regulated flow control. There are two main dangers from this fuel. The first is a possible explosion if the mixture of LPG and air is within the explosive limits and there is an ignition source. The second is suffocation due to LPG displacing air, causing a decrease in oxygen concentration.

4-LPG vs Petrol :-

LPG, also known as propane and auto gas, is a by-product of crude oil extraction and the refining process. What is for certain is that LPG burns cleaner than petrol and therefore emissions of particulates are very low. Moreover, LPG is non-toxic, non-corrosive and free of tetra-ethyl lead and additives. It also has a high octane rating.

In terms of fuel costs, LPG costs a little more than half the price of petrol or diesel, but fuel economy is about 20-25% lower. In short the benefits of LPG vs. petrol fuel cars are significant, but only make economic sense if vehicles are running at high engine loads and doing at least 14,000 miles or more a year.

Comparison of Petrol with Liquefied Petroleum Gas (LPG) can be done in aspects like fuel consumption amount, octane rating, fuel odor, spark plug life by using fuel, octane number, etc. Fuel consumption in a petrol engine is 10 % less compared to Liquefied Petroleum Gas (LPG). Petrol has odour and 81 as a octane no whereas LPG has no odour and 110 octane no. Due to higher octane rating, the combustion of LPG is smoother and knocking is eliminated and the engine runs smoothly. When LPG leaks past the rings into the crankcase, it does not generate black carbon. Hence, the lubricating layer is not washed away; thereby the engine life is increased by 50%. Due to the absence of carbon deposits on the electrodes of the spark plugs, the life of the spark plugs is increased.

By comparing emissions in the exhaust gasses of the same engine powered by LPG and petrol, pollutants in LPG mode are reduced for

:•CO by 30% in urban cycle, HC by 30% in urban cycle ,NO_x by 41% in urban cycle ,•CO₂ by 10% in urban cycle

If 12% of emissions are produced by personal vehicles then reduction of emissions can be calculated by utilization of LPG fuel in driving. Based on the emission results it can be said, that the LPG represents a good fuel alternative for gasoline and therefore it must be taken into consideration in the future of personal transport.

5-Environmental effect:-

Vehicle emission is a major source of air pollution especially in the urban area. To reduce pollution, many governments would encourage the use of cleaner alternative fuel. LPG is one of the leading fuel in that sense.

LPG is cleaner than petrol and diesel because it is composed of predominantly simple hydrocarbon compounds. LPG is free of lead and most additives and contains very little sulphur. Compared with emissions from vehicles on petrol and diesel, emissions from LPG-driven vehicles contain lower levels of hydrocarbon compounds (HC), nitrogen oxides (NO_x), sulphur oxides, air toxics.

6-Safety Aspects:-

LPG tends to be more inflammable than both petrol and diesel because it has a wider flammability limit.

Accidents involving LPG sometimes result in fire or in explosion. Explosion happens when there are sufficient amounts of both air and LPG and they are ignited to generate a large amount of heat and rapid air movements in a very short period of time. If heat is released gradually, the burning of the fuel tends to lead to fire rather than explosion. This means that ventilation or air movement is important in safety in storage and transport of LPG.

LPG is dangerous when it is allowed to accumulate in enclosed areas such as garages. LPG is denser than air and tends to sink and accumulate. It evaporates quickly and expands 270 times its volume in liquid state. Sufficient quantity of LPG can cause unconsciousness due to the quick displacement of oxygen. Since LPG is colourless and odourless hence a peculiar smell is often added to it so that it can be easily detected in case of leakage.

There is no conclusive evidence to show that LPG is more dangerous or less dangerous than petrol or diesel. Human factor plays an important role in affecting the safety in using LPG. For example, advanced country such as Japan has not have any explosion or serious accidents in the past 30 years since it introduced various safety measures regulating the use of LPG.

Accidents falling in the human error category generally involve careless fuel handling and faulty workmanship such as poor sealing of bodywork around remote refuelling connectors. Accidents happened during refuelling in 25 cases or 31% of the total number of accidents, indicating the danger inherent in that operation.

7-Cost:-

Although Initial cost of LPG is lesser than other fuels but is subjected to change from time to time based on government policies.

7.1-Maintenance Cost:-

LPG-driven vehicles have a slightly lower maintenance cost than petrol- driven or diesel-driven vehicles. LPG as a gas does not wash lubricant from the cylinder walls of the engine as gasoline and diesel. This washing action is detrimental to any components that rely on the lubrication system for their proper functioning. The cleaner burning characteristics of LPG also reduce maintenance requirements and cost.

7.2-Fuel Cost:-

In automobile field switching to LPG means a certain amount of initial cost but the running cost of LPG-driven vehicles can be much lower than vehicles driven by petrol or diesel in many territories depending on government policy, especially that on fuel tax.

8-Safety issues in Automobile:-

To enhance safety in using LPG, regulations or codes of practice are introduced to regulate the safe handling of LPG, the use of LPG vehicles, the design and construction of LPG fuel tanks as well as to impose restrictions on LPG refueling stations and to impose requirements for regular inspection of LPG vehicles and proper training of personnel handling LPG.

8.1-Fuel System:-

The main purpose of the regulations governing the fuel system of LPG vehicles is to prevent leakage, minimize the possibility of accidents of man power and machine.

1-The regulations mainly require conversions to be done by authorized persons.

2-Regular inspections including a check of LPG leakage along the fuel system to be done by approved technicians.

3- Materials and thickness of fuel tanks should follow proper specification.

4- Various parts of the fuel tanks must follow specifications to include devices such as liquid level indicator, overfilling prevention device, safety relief valve and emergency shut-off valve.

5-LPG tanks should not be filled more than 80% in the US, 80% to 85% in the Netherlands and 85% in Japan.

6-LPG vehicles must pass barrier collision and fire tests.

8.2-Regulatory measures:-

There are other essential measures governing the operation of LPG refueling stations.

1-LPG equipment must be fitted with pressure gauges, and with mechanism which can immediately bring pressure down to the acceptable level.

2-Appropriate measures such as the display of labels guiding the appropriate use of valves and cocks must be taken.

3-Equipment providing backup electricity supply for equipment necessary for ensuring safety, such as automatic control equipment, sprinklers, fire-prevention equipment, cooling water pump, emergency lighting equipment, communication equipment, must be installed.

4-Equipment for the detection of gas leakage and sounding of warning must be installed; and storage tanks and their supports must be covered with non-inflammable heat insulating material, and fitted with effective cooling facilities.

9-Conclusion:-

LPG has a long history as an alternative fuel for vehicles in overseas territories. Successful and future application of the LPG fuel depends on a number of factors. The important ones are as follows: availability of the fuel; availability of LPG conversion kits or LPG dedicated vehicles; availability of re fuelling stations, safety, and competitive pricing. Considering the limited fossil fuel resources, energy conservation, environmental issues, increase in the demand on LPG in near future, it is a necessity to explore the ways to further improve the thermal efficiency and the emission characteristics of the existing LPG devices.

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