UNIT – III
GASEOUS FUELS

LIQUID PETROLEUM GAS (LPG)

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What are the additives added with LPG?

1. Hydrogen (H_2)
2. Methane (CH_4)
3. Methanol (CH_3 OH)
4. Carbon monoxide (CO)

What are the advantages of using LPG in engines?

Advantages LPG

1. Propane has low cold-start emissions due to its gaseous state.
2. Propane has lower peak pressure during combustion than conventional fuels, which generally reduces noise and improves durability.
3. LPG fuel systems are sealed and evaporative losses are negligible.
4. Propane is easily transportable and offers 'stand-alone' storage capability with simple and self-contained LPG dispensing facilities, with minimum support infrastructure.
5. LPG vehicles do not require special catalysts.
6. Propane contains negligible toxic components.

7. LPG has lower particulate emissions and lower noise levels relative to diesel, making propane attractive for urban areas. Noise levels can be less than 50% of equivalent engines using diesel.
8. Propane's emissions are low in greenhouse gases and low in NOx, thus they are low in ozone precursors.
9. Increases in future demand for LPG can be easily satisfied from both natural gas fields and oil refinery sources.
10. Emissions of PAH and aldehydes are much lower than those of diesel-fuelled vehicles.
11. It is cheaper than gasoline.
12. It gives better manifold distribution and mixes easily with air.
13. It is highly knock resistant.
14. Residue and oil contamination is small, as it burns cleanly.
15. Crankcase oil dilution is small, thereby resulting in increased engine life.

What are the limitations of using LPG as I.C. Engine fuel?

Although LPG has a relatively high energy content per unit mass, its energy content per unit volume is low which explains why LPG tanks take more space than diesel fuel tanks of the same energy storage capacity.

1. Propane tanks are pressure vessels and thus weigh more than the equivalent diesel tank.
2. Propane is heavier than air, which requires appropriate handling.
3. Propane vapor flammability limits in air are wider than those of petrol, which makes LPG, ignite more easily.
4. Propane has a high expansion coefficient so that tanks can only be filled to 80% of capacity.
5. Propane in liquid form can cause cold burns to the skin in case of inappropriate use.
6. Due to its faint odor, leakage cannot be easily detected.
7. LPG is advantageous only in engines working under high compression ratios.

What are the engines modifications required to be carried out for using LPG as fuel in existing diesel engines?

To run the existing diesel engine in LPG the diesel engine is to be fitted with the LPG conversion kit. The LPG conversion kit consists of a fuel cylinder, a solenoid valve, a regulator (also called vaporizer), and a gas carburetor.

In this system the pilot injection of diesel ignites the LPG air mixture to start the combustion.

What are the major constituents of LPG with range?

LPG (Liquefied Petroleum Gas) is predominantly propane with iso-butane and n-butane.

LPG fuel is mainly a mixture of propane and butane stored in steel cylinders in liquid form under a pressure of approximately 7 kg/cm^2.

State the important properties of LPG as engine fuel and the emissions from such engines. With a neat sketch explain LPG admission in an SI automotive engine.

As the octane number of LPG is ~100 to 104, LPG can be used as a petrol replacement in modern vehicles with no major engine modifications (except of course, the addition of LPG storage tanks and fuel metering systems etc). Retuning the engine and possibly advancing the timing is all that is needed.

The fuel system of the LPG engine consists of a fuel cylinder, a solenoid valve, a regulator (also called vaporizer), and a carburetor. LPG is stored in liquid form in the fuel cylinder, and the solenoid valve functions to prevent unwanted gas leaks. The solenoid valve opens only when the engine ignition switch is turned on to allow LPG to be supplied form the fuel cylinder to the regulator, wherein it is heated by air or hot water and vaporized LPG is then mixed uniformly with air in the carburetor before the mixture is induced to the combustion chamber.

LPG combustion implementation occurs with a neatly uniform fuel air mixture that reduces deposit of the products incomplete combustion, such as soot, on the combustion chamber walls. Furthermore, LPG does not cause fuel dilution of engine oil, which is often a problem with the gasoline engine.

LPG engines have the advantage of reduced cylinder wear and extended engine oil life. Advantage of the uniform mixture combustion realized by LPG is the reduced fuel consumption (by weight). The net calorific value of LPG ranges 11,080 -10,750 kcal/kg, as against approximately 10,500 kcal/kg of gasoline.

LPG consumption is as much as 10% less than gasoline. The reason for this is that LPG generates the maximum engine torque at a higher air fuel ratio, a leaner mixture condition, than gasoline. The stoichiometric air fuel ratio is 15.6 for propane and 14.7 for gasoline. LPG air fuel mixture more uniformly distributed in the combustion chamber compared to gasoline.

In the LPG engines the fuel is preheated and vaporized in a heat exchange pressure regulator before it is mixed with air in the carburetor, resulting high mixture temperature and a low mixture. And also the weight of the LPG fuel supplied to the combustion chamber is less than gasoline.

Further, it calorific value (885 kcal/m^3) is less than gasoline (928 kcal/m^3). So, lower power output is the result. By increasing the compression ratio the lower power problems can be overcome.

Emissions of hydrocarbons and carbon monoxide at idling and low loads are much less than from a gasoline vehicle. This is due to the fact that LPG forms a uniform mixture with air in the combustion chamber. Emissions of NO_x are slightly more than gasoline engines but can be sufficiently decreased by injecting water or water – methanol mixtures into LPG air mixtures.

What are the engines modifications required for using LPG in existing diesel engines? Discuss the performance characteristics of LPG diesel dual fuel engine.

In the case of using LPG as a diesel replacement, a difficulty arises as it has a low cetane number and thus the auto-ignition temperature is considerably higher than that of diesel. To achieve ignition temperatures, the compression ratio must be increased to impractically high levels (~25:1). To overcome this it is necessary to convert the engine to spark ignition which also requires decreasing the compression ratio to ~13:1, hence also reducing the thermal efficiency and increasing the greenhouse emissions as compared to a diesel only system.

Alternatively using a relatively complicated dual-fuel system in which a small quantity of diesel (~15% of the total fuel blend by volume) is injected into the cylinder to act as a source of ignition for the LPG. In this way the benefits of improved efficiency and reduced emissions from the higher compression ratios can be captured while using LPG.

Diesel engines can be converted to run partly on LPG, partly on diesel. This method uses the combustion of the diesel to ignite the LPG. The benefits include large increases in power and reduction in emissions, particularly the black smoke often associated with diesels. Typically a ratio of 30% LPG to 70% diesel is possible.

No adjustments are required to the diesel injection system and fuel savings come from the fact that throttle openings are lower due to the greatly increased power, which basically means you do not have to press the accelerator as hard to get the same performance. Fuel savings upwards of 30% are possible with the increased power levels seen as a major benefit to users.

Discuss the performance and emission characteristics of using LPG in engines.

Performance characteristics:

The air: fuel volumetric ratio affects the quantities of fuel and oxygen that independently enter the combustion chamber which in turn affects both the engine power output and the tailpipe emissions.

Under given conditions of atmospheric pressure, ambient temperature, engine speed etc, a modern vehicle engine designed to operate on petrol inducts air into the combustion chamber (cylinder) and the fuel is injected as a mist either into the inlet manifold or directly into the combustion chamber.

When the engine is converted to operate on LPG, the gas is normally metered into the inlet manifold which has two main effects.

Since the volume of gas is considerably larger than that of the liquid fuel otherwise injected, it will displace a significant proportion of the air volume and thus reduce the total air: fuel mixture resulting in a significant loss of power.

Improved mixing of the air: LPG mixture may lead to a slight improvement in combustion and hence engine efficiency.

Emission characteristics:

The main constituent of LPG is propane. Lower carbon-to-hydrogen ratio, higher octane rating and its ability to form a homogeneous mixture inside the combustion chamber enable it to produce lesser emissions compared to conventional fuels. Table gives a comparative emissions status from diesel and LPG fuel.

Pollutants	Euro-II Diesel + ULS/CRT	LPG	% Change
HC (g/km)	0.143	0.027	-81%
CO (g/km)	0.212	0.013	-94%
NOx/10 (g/km)	1.254	0.54	-57%
Particulates (g/km)	0.028	0.017	-39%
CO2/1000 (g/km)	1.344	1.309	-4%

THANK YOU