UNIT – III
GASEOUS FUELS

COMPRESSED NATURAL GAS (CNG)

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List down the major constituents of natural gas giving their ranges.

CNG (Compressed Natural Gas) is usually around 70-90% methane with 10-20% ethane, 2-8% propane's, and decreasing quantities of the higher HCs up to butane.

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

The major disadvantage of compressed gas is the reduced range. Vehicles may have between one to three cylinders (25 MPa, 90-120 liter capacity), and they usually represent about 50% of the gasoline range.

As natural gas pipelines do not go everywhere, most conversions are dual-fuel with gasoline. The ignition timing and stoichiometry are significantly different, but good conversions will provide about 85% of the gasoline power over the full operating range, with easy switching between the two fuels. Concerns about the safety of CNG have proved to be unfounded.

Illustrate the methods of using natural gas in C.I. engines.

Natural gas is used in diesel engines in two methods. In one method the diesel engine is made to work on dual fuel mode. In the other method it works in full natural gas mode.

In dual fuel mode the engine runs with diesel as well as natural gas. The engine starts and ideals as normal diesel engine. And after some speed and load the engine switches to dual fuel mode automatically.

In full natural gas mode the diesel engine is converted to a spark ignited engine. This requires replacement of diesel fuel system by spark ignition system, fitment of gas carburetor, and reduction in compression ratio. However, switch back to diesel operation is not possible.

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

To run existing diesel engines in natural gas some modifications to be done. They are:

1. Removal of Diesel fuel injection system.
2. Introduction of Spark ignition system.
3. Fitting spark plugs Instead of injectors.
4. Connecting Gas carburetor to engine.
5. Fitment of turbo charger.

What are the engines modifications required to be carried out for using natural gas as fuel in existing petrol engines?

To run existing petrol engines in natural gas some modifications to be done. The conversion kit is available in the market it consist of following items. They are:

1. CNG storage tank
2. Pressure regulator
3. Gas carburetor
4. Fuel selection switch
5. Gas filling valve
6. Petrol solenoid

Illustrate with a schematic the conversion kit that is required for the use of natural gas in C.I. engines. Also discuss its performance and emission characteristics.

Because of its characteristics, natural gas can be used in spark ignition engines, but in compression ignition engines a proportion of diesel fuel is usually required to trigger ignition. Alternatively, diesel engines can be converted to spark ignition for natural gas use.

For diesel engines, the conversion to a compression ignition dual (Mixed) fuel configuration involves use of a pilot supply of diesel to ignite the natural gas. This requires the addition of a gas fuel system alongside the existing diesel fuel system, together with a mechanism for regulating the proportion of diesel and gas for the engine speed and load conditions.

The engine efficiency for this configuration is about the same as that for a diesel engine. The efficiency of dual (mixed) fuel systems can be equal to or higher than for diesel at high loads, but lower at part loads. For this reason, the overall efficiency in service is lower than for diesel. This chapter deals with single fuel vehicles so that dual fuel vehicles have not been examined. It is to be expected, based on results of LPG dual fuel vehicles, that emissions reductions from dual fuel vehicles will not be as large as those from single fuel vehicles.

Conversion of diesel engines to spark ignition engines running solely on natural gas requires more extensive modification, in that the diesel fuel injectors in the cylinder head will be replaced by spark plugs, and an ignition system added to the engine. A compression ratio lower than that of the diesel is likely to be required. Also, a larger cylinder capacity than that required for a dual (mixed) fuel system may be needed, to provide the same energy content.

Most components of the kit are common for both CI and SI engines except that CI engine kit has a festo valve, rack limiter and airline are also added. The engine is started as a diesel engine and gradually, proportionally to the load, the engine starts using natural gas at a particular speed called change over speed. A small quantify of diesel fuel (pilot fuel) is used as ignition source. In order to achieve more power, the natural; gas addition to the intake air is increased. The gas is metered by the venture through a load regulator.

Conversion kits for the diesel engine to use dual fuel

I. **CNG Tank**: Cylindrical tanks designed for storage of CNG at a pressure of 200 bar. A typical tank capacity is 60 liters and 4 such tanks give a range of 200 km.

II. **Refueling Connection**: Multistage pressure regulator in which the gas pressure is reduced from the CNG filling station to the CNG tanks.

III. **CNG pressure regulator**: Multistage pressure regulator in which the gas pressure is reduced from the CNG tank pressure to a pressure just below the atmospheric pressure. Thus natural gas flow from this pressure regulator, when the engine is not running has overcome by its design.

IV. **Over speed limiter**: Pneumatically operated safety value which will close the gas supply to the engine if the engine speed reaches maximum allowable speed.

V. **Load Regulator**: Gas valve linked to the accelerator pedal which controls the gas flow as per engine load.

VI. **Diesel fuel limited**: Allows full load diesel flow up to a certain speed and reduces diesel flow to the pilot valve (about 30% of the full load) beyond the speed called changeover speed.

VII. **Venturi**: Gas air mixing and metering device located at the downstream of the engine air filter. This meters the gas flow proportionate to the engine speed.

VIII. **Change over switch**: Actuate the electrical circuits in the system to automatically change the mode of operation from diesel to pilot injection mode at the changeover speed of the engine.

Performance of CNG engine:

The efficiency of at full load is usually equal or better than that of the original diesel engine. At part load, the efficiency is lower, but still better than that of a spark ignited (Otto) engine. The use of 20% to 25% pilot diesel fuel is preferable to avoid poorer part load efficiency and overheating of injectors.

Illustrate with a schematic the conversion kit that is required for the use of natural gas in S.I. engines. Also discuss its performance and emission characteristics.

The CNG Kit

The kit required for the conversion from petrol generally contains various valves, connectors and gauges.

1. The Cylinder: The cylinder is used to store CNG at a working pressure of 200 bar. It is fitted with a shut-off valve and a safety burst disc. The cylinders are type approved by the Chief Controller of Explosives, Government of India

2. The Vapor Bag: Fitted onto the cylinder, the Vapor Bag is used to enclose the cylinder valve and the pipes connecting it and is vented out of the car

3. The High Pressure Pipe: This High Pressure Pipe connects the refueling valve to the CNG Cylinder and Pressure Regulator

4. The Refueling Valve: The Refueling Valve is used to refuel the CNG cylinder

5. The Pressure Regulator: The Pressure Regulator has a Solenoid Valve to shut-off gas supply to the engine. The CNG stored at a high pressure in the cylinder is reduced to just below atmospheric pressure by this unit. This negative pressure is also a safety feature that will not allow gas to pass through when the engine is not running

6. The Gas-Air Mixer: The Gas-Air Mixer is a unique component, specially designed to suit each engine model. It precisely meters gas fed into the engine

7. The Petrol-Solenoid Valve: The Petrol-Solenoid Valve is used to cut off petrol supply to the engine when it is run on CNG

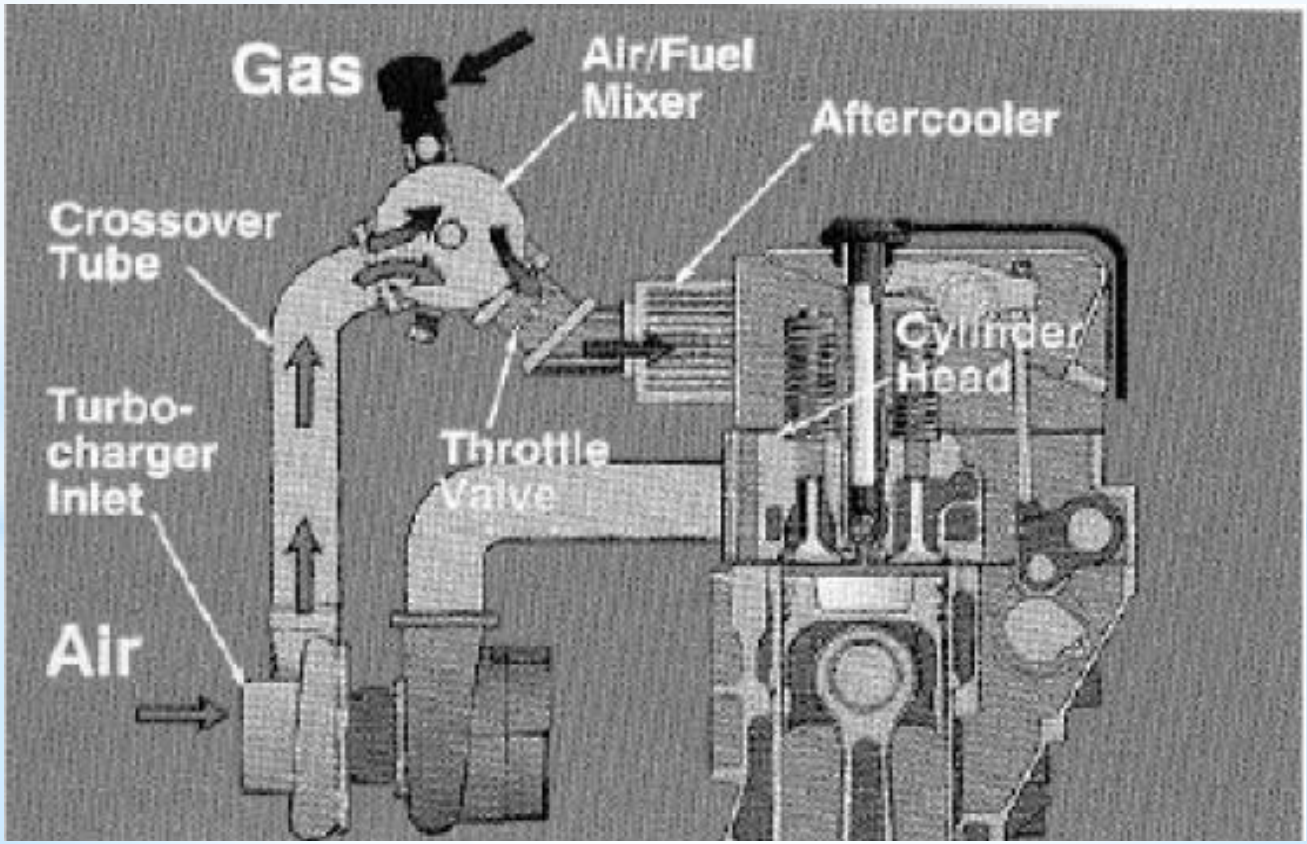
8. The Selector Switch: The Selector Switch is fitted at the dashboard, enabling the driver to choose either the CNG mode or the petrol mode of operation. The electronics built into this unit also ensures safety by switching off the gas solenoid whenever the engine is switched off. It also serves as a fuel indicator for the quantity of CNG available in the cylinder

Performance and Emission characteristics:

The brake power for the CNG operation is less at all speeds compared to petrol operation. The loss in power output is about 10% at all speeds. This may be attributed to the decrease in volumetric efficiency as a result of CNG being a light gaseous fuel, displaces air during operation and the temperature drop due to fuel vaporization as in the case of petrol is absent in the case of CNG.

The specific energy consumption is lower than that of petrol at particular speeds is possible due to complete combustion of the CNG fuel. Carbon monoxide, unburnt hydrocarbon and Oxides of Nitrogen emissions are found to be lower in the case of CNG operation. The low pollution characteristics of natural gas spark ignition engines are due in part to the controlled and uniform mixing of the fuel and air giving more complete combustion hence reduce hydrocarbons emissions.

Natural gas may have an octane rating too high for use in an unmodified petrol engine and hence would ideally require an increase in compression ratio. This will lead to a significantly higher thermal efficiency and thus either a petrol engine fully modified or a purpose built dedicated CNG engine with a high compression ratio will be able to take full advantage of the fuels higher octane rating. This would result in the higher reductions in emissions.



Compare the properties of natural gas with conventional fuels.

The auto ignition temperature of methane is about twice as high as that of gasoline, suggesting less chance o ignition due to contact with hot surfaces.

The flammability limits of methane are higher and wider than those of gasoline or diesel fuel.

The storichiometric ratio of methane is higher than gasoline or diesel fuel because methane has a higher percentage of hydrogen.

Methane flames are visible under all conditions, just like gasoline and diesel fuel flames, which make them easy to detect.

The octane number of methane is greater than 120.

THANK YOU