UNIT – III
GASEOUS FUELS

PRODUCER GAS AND BIOGAS

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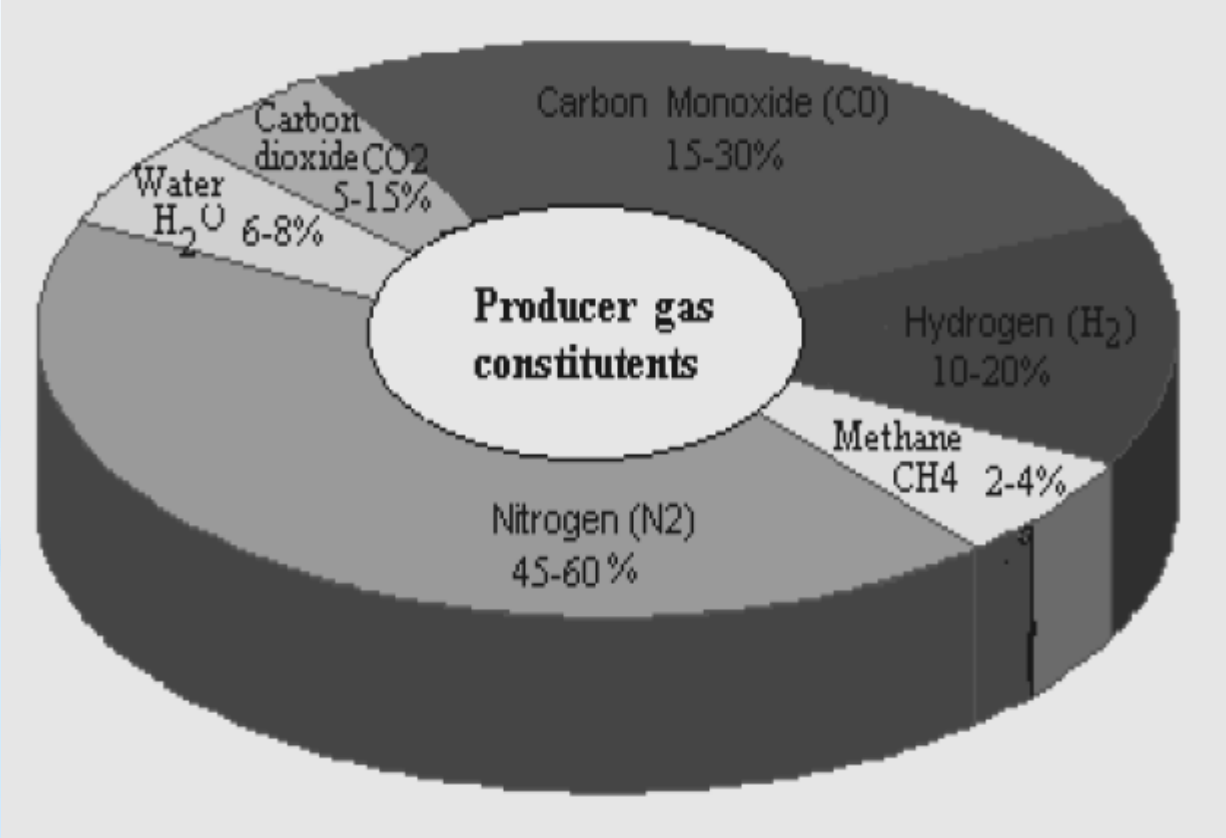
PRODUCER GAS AND ITS CONSTITUENTS

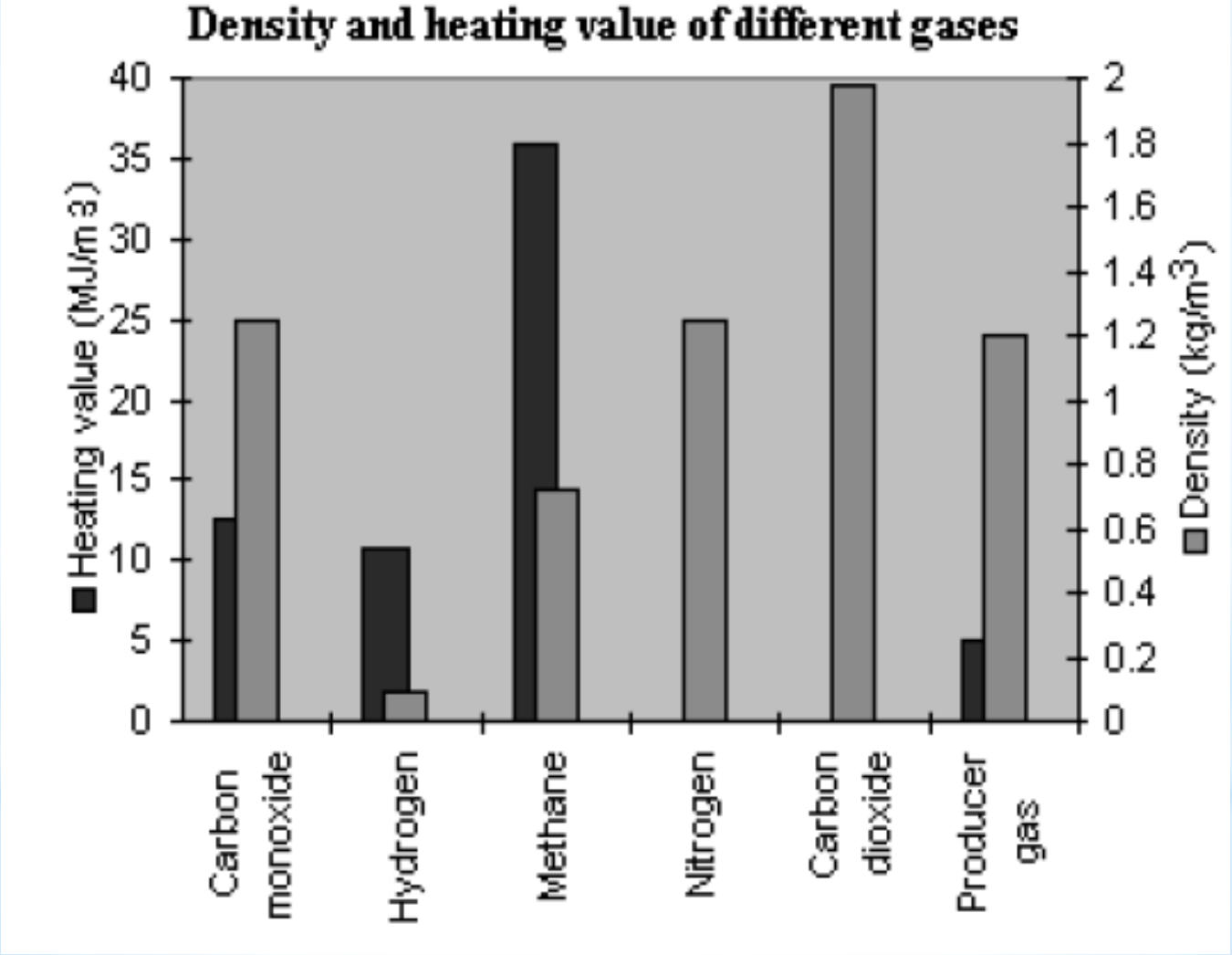
Producer gas is the mixture of combustible and non-combustible gases. The quantity of gases constituents of producer gas depends upon the type of fuel and operating condition.



PROPERTIES OF THE PRODUCER GAS

The heating value of producer gas varies from 4.5 to 6 MJ/m^3 depending upon the quantity of its constituents. Carbon monoxide is produced from the reduction of carbon dioxide and its quantity varies from 15 to 30 % by volume basis. Although carbon monoxide possesses higher octane number of 106, its ignition speed is low. This gas is toxic in nature. Hence, human operator need to careful while handling gas.

Hydrogen is also a product of reduction process in the gasifier. Hydrogen posses the octane number of 60-66 and it increases the ignition ability of producer gas. Methane and hydrogen are responsible for higher heating value of producer gas. Amount of methane present in producer gas is very less (up to 4 %). Carbon dioxide and nitrogen are non-combustible gases present in the producer gas. Compared to other gas constituents, producer gas contains highest amount (45-60 %) of nitrogen. The amount of carbon dioxide varies from 5 to 15 %. Higher percentage of carbon dioxide indicates incomplete reduction. Water vapor in the producer gas occurs due to moisture content of air introduced during oxidation process, injection of steam in gasifier or moisture content of biomass fuels.


Density and heating value of different gases
Heating value (MJ/m 3)
Density (kg/m3)
0
5
10
15
20
25
30
35
40
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Carbon monoxide
Hydrogen
Methane
Nitrogen
Carbon dioxide
Producer gas

Give the general composition of Bio Gas produced from farm wastes.

(Or) Indicate the various constituents of biogas.

Methane CH_4 = 55% to 70%

Carbon dioxide CO_2 = 27% to 44%

Hydrogen H_2 = 1%

Hydrogen Sulfide H_2S = 1% to 2 %

What do you understand by biomethanation?

Biomethanation is the process of conversion of organic matter in the waste (liquid or solid) to biogas and manure by microbial action in the absence of air.

Discuss any two important properties of Gober Gas with conventional fuels for use in I.C. engines.

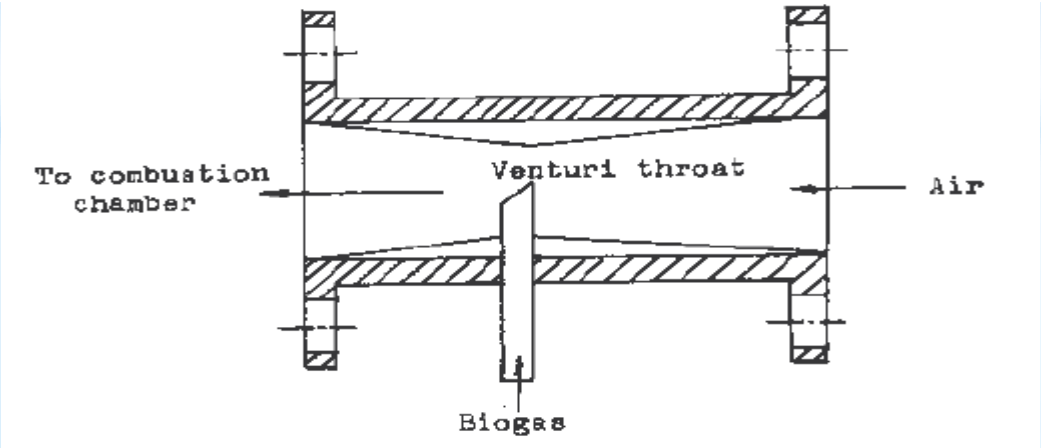
Biogas has a higher octane number (120) compared to 87 of gasoline. The auto ignition temperature (650° C) is higher than petrol (257 ° C) which makes it a safer fuel. Since calorific value of biogas (19550 kJ/kg) is lesser than gasoline (42000 kJ/kg), and has higher octane number it is possible to use higher compression ratio for same size of engine to generate same amount of power.

Also other properties of biogas are, its stoichiometric air / fuel ratio is 6.68:1 and Flammability limit is 5 to 15 % volume in air gas mixture. Density of biogas is 1.1 kg/m^3.

List down the various systems that are required for the use of biogas in engines.

Gas carburetor

A gas carburettor, especially designed for biogas, was used to mix the gas and the air. It contains a control valve and a T-tube with a venturi throat. Figure shows its schematic diagram. The amount of biogas was controlled by the throttle valve of the carburettor to improve the properties of biogas and air mixture. Figure presents a schematic diagram of the gas supply system. The gas carburettor was installed in the inlet manifold. In this way, the biogas was first mixed with air from air filter inside venturi throat of the gas carburettor. And then, the mixture of biogas and air was introduced to the combustion chamber of the engine.



Installing a spark ignition system

The original fuel injection system was eliminated. A spark plug was installed in the position of the original diesel injector orifice. The spark plug should be considerably chosen so that its electrodes could be located at a proper position of the combustion chamber.

Appending a biogas control apparatus

A conical valve was used in order to control the amount of biogas admitted to the gas carburettor. In addition, a linkage which connects the conical throttle of the gas carburettor and governor of the engine was mounted on the engine. Moreover, a main valve was used for controlling the flow of biogas. A gas flow meter was used for measuring the flow rate of biogas. And a U-shape manometer was used for measuring the pressure of biogas, and a pressure regulator for maintaining pressure of biogas was installed on the engine.

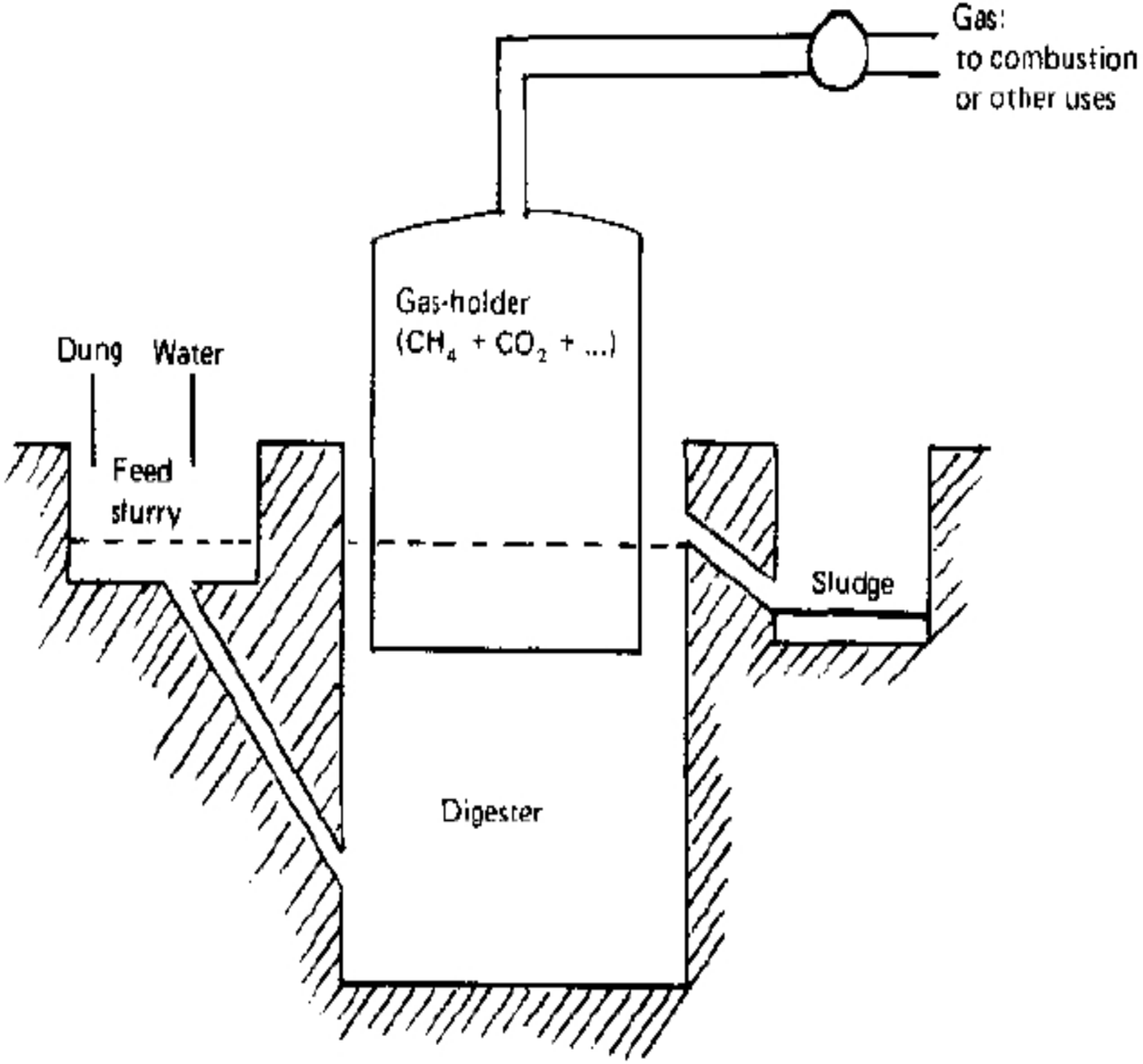
Explain typical Bio Gas Plant with neat sketch. (Or) Explain typical Gobar Gas Plant with neat sketch.

BIOGAS

Biogas is produced by the degradation of biological matter by the bacterial action (of anaerobic bacteria's) in the absence of free oxygen. Probably the cheapest and easily obtainable biogas is gobar gas (or dung gas), which is produced by the anaerobic fermentation of cattle dung. Biogas can also be produced from the sewage waste and other organic wastes.

GOBAR GAS:

The raw material for the gas is called dung, which is subjected to anaerobic fermentation (i.e., fermentation in the absence of free air, caused by fresh cattle dung and water, is poured. Anaerobic bacteria's (i.e., which can survive and function in the absence of free air), present in the dung, digest this slurry forming mainly methane and carbon dioxide. The optimum temperature for this fermentation is 34 – 48^{0}C. The gas generated is collected in a steel gas is holder, placed on the top of digestion tank. The average composition of gobar gas is: CH_4 = 55%; H_2 = 7.4%; CO_2 = 35.0%, N_2 = 2.6%; and traces of H_2S. Its average gross calorific value is 1200 kcal/m^3.


Gas:
to combustion
or other uses
Gas-holder
(CH_4 + CO_2 + ...)
Dung
Water
Feed
slurry
Sludge
Digester

Advantages:

1. It has been found that 4.25 kg of fresh cattle dung (or 1kg dry cattle dung) gives approximately 160 liters of gobar gas, which can supply 188 kcal of heat. On other hand, 1 kg of dry dung or direct burning gives only 23.4 kcal of effective heat. Thus, gobar gas production is highly economical.

2. The gas has all the advantages of gaseous fuel (such as flexibility, optimum utilization of waste, cleanliness of utensils and surrounding areas, absence of smoke, dust, dirt, etc.).

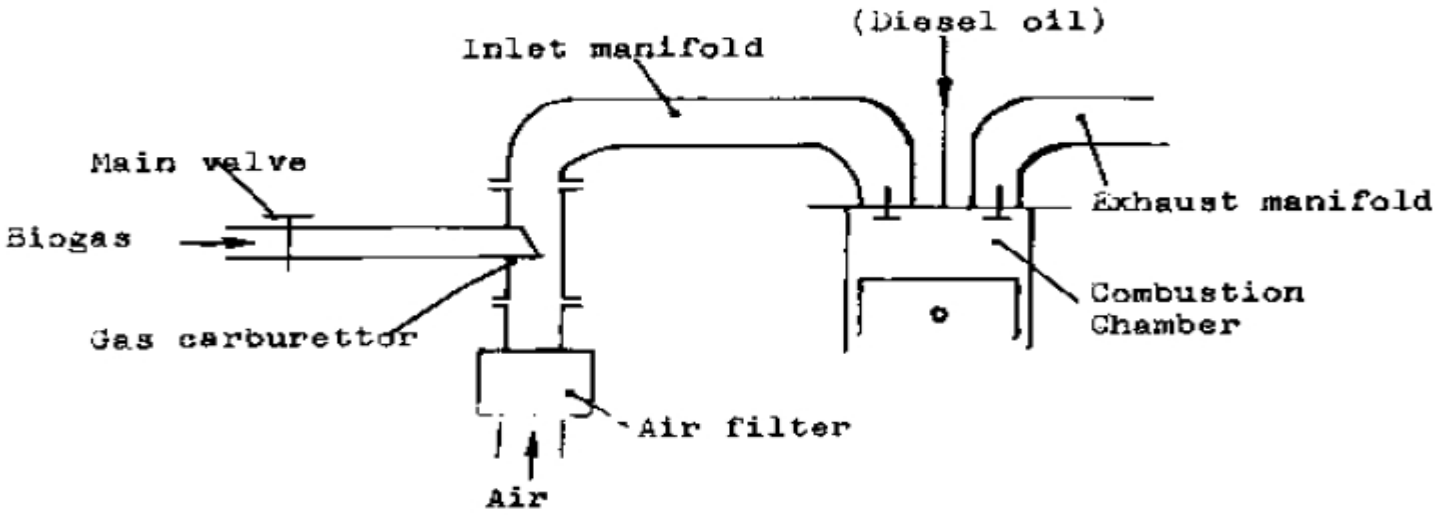
3. It does not contain the poisonous gas, carbon monoxide, as an ingredient.

4. It can provide the flame temperature of 540^{0}C, with proper burners.

5. Gobar gas also gives simultaneously excellent yield of good manure. The nitrogen content of the manure is 2% as against 0.75% in farm yard manure.

Explain how Bio Gas is used in diesel engines. Discuss the performance characteristics.

The biogas can be used in C.I engine as a dual fuel. The biogas can be introduced in the engine with air during suction stroke and compressed. A small quantity of diesel fuel (15 – 20%) is injected towards the end of compression, to initiate the combustion of biogas – air mixture. The diesel fuel ignites first and heat released by combustion leads to the combustion of biogas air mixture. The air flow rate is kept constant as in normal diesel engine and gas flow rate is regulated to achieve different outputs. Diesel fuel injected is always fixed amount. The gas flow rate is controlled by a throttle and diesel fuel flow rate by rack in the fuel pump. These two are linked together by an automatic governor.



In dual fuel C.I engine, biogas can substitute for about 80% of the normal diesel fuel consumption. Existing diesel engines in the rural areas like power pumping sets and small generators can be easily modified as biogas diesel dual fuel engines.

A small valve controlled pipe can introduce biogas into the inlet manifold of diesel engine. Initially the engine is started as a diesel engine and brought up to the required output. Then the gas valve slowly opened manually, allowing the gas to flow into inlet manifold and mix with air. If a speed governor is fitted in the engine, it automatically educes diesel flow rate. (If there is no speed governor, diesel flow is reduced manually) Gas flow rate can be gradually increased until diesel flow rate is just above minimum required.

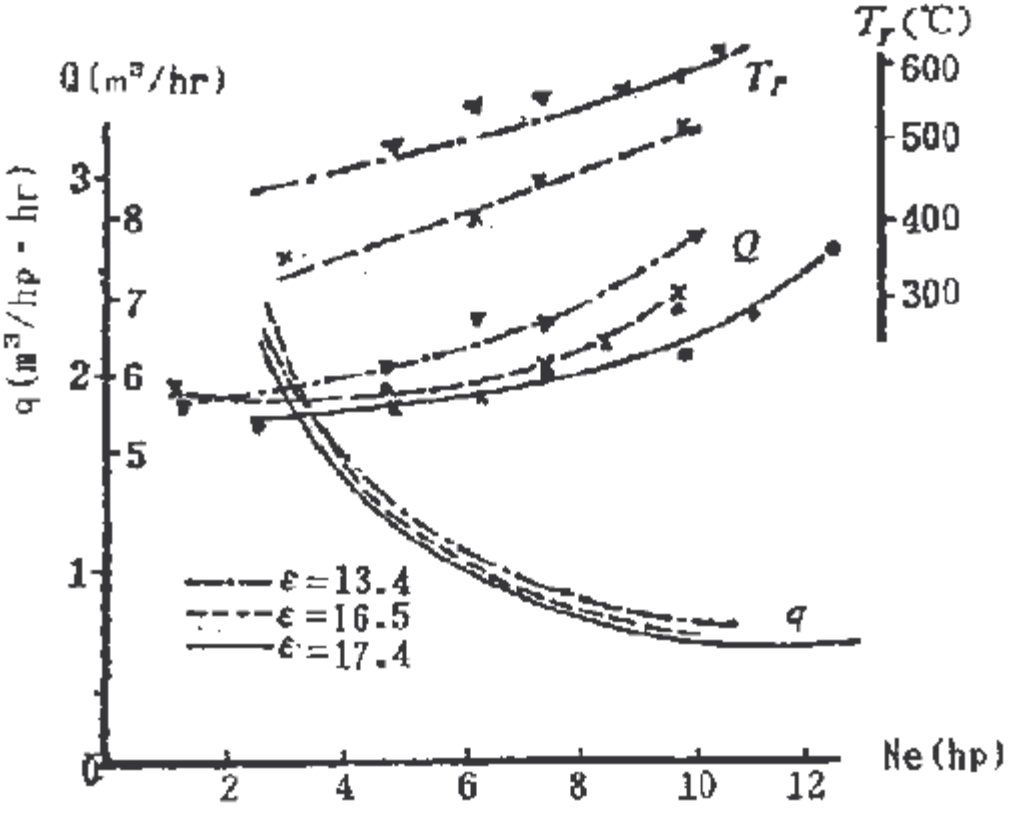
Before stopping engine, gas flow is gradually reduced and shut off and engine is run on diesel fuel alone for few minutes. This is to prevent gas from remaining in the inlet manifold.

Load Performance of the engine:

The load performances of the engine at three compression ratios were tested. The results are shown in Figure Specifically, when the engine using biogas alone operated at 2000 RPM with 39.2° rank angle of spark timing and compression ratio being 17.4: 1, its load performance data are shown in Table.

Force (kg)	Power (HP)	Biogas consumption (m^3/hr)	Specific biogas consumption ($m^3/hp \cdot hr$)
2	2.45	5.43	2.22
4	4.89	5.85	1.20
6	7.34	6.06	0.83
8	9.79	6.27	0.64
9	11.02	6.89	0.63
10	12.24	7.52	0.62

The load performance of diesel engine using biogas



The load performances of the engine at three compression ratios

THANK YOU