Experimental Study of Carbide as an Alternate Fuel Using in Internal Combustion Engine

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Abstract – The search for an alternative fuel is one of the needs for sustainable development, energy conservation, efficiency, management and environmental preservation. Therefore, any attempt to reduce the consumption of petrol and diesel possible alternative fuels is mostly preferable. Many research activities were developed in order to study the Internal Combustion Engines with alternative fuels. Acetylene is one of the tested fuels. The present project includes: providing a fuel comprising acetylene as a primary fuel and Alcohol as a Secondary fuel avoiding knocking for an internal combustion engine. The paper investigates working of SI engine on acetylene minor changes required to be done. Thus reducing the running cost and minimum pollutant emission, this makes it fit for use on economic and environment standard. It is more effective and eco-friendly alternative fuel option.

Index Terms – Internal Combustion Engine, Acetylene, Pollutant Emission, Alternative Fuel.

1. INTRODUCTION

1.1Facing effects of using other fuels

In the present context, the world is confronted with the twin crisis of fossil fuel depletion and environmental degradation. Conventional hydrocarbon fuels used by internal combustion engines, which continue to dominate many fields like transportation, agriculture, and power generation leads to pollutants like HC (hydrocarbons), Sox (sulphur oxides), and particulates which are highly harmful to human health. CO_2 from Greenhouse gas increases global warming. This crisis has stimulated active research interest in non-petroleum, a renewable and non-polluting fuel, which has to promise a harmonious correlation with sustainable development, energy conservation, efficiency, and environmental preservation. Promising alternate fuels for internal combustion engines are natural gas, liquefied petroleum gas (LPG), hydrogen, acetylene, producer gas, alcohols, and vegetable oils.

1.2 Alternate fuels

Among these fuels, there has been a considerable effort in the world to develop and introduce alternative gaseous fuels to replace conventional fuel by partial replacement or by total replacement. Many of the gaseous fuels can be obtained from renewable sources. They have a high self-ignition temperature; and hence are excellent spark ignition engine fuels. They cannot be used directly in petrol engines However, Petrol engines can be made to use a considerable amount of gaseous fuels in dual fuel mode without incorporating any major changes in engine construction. It is possible to trace the origin of the dual fuel engines to Rudolf Petrol, who patented an engine running on essentially the dual-fuel principle. Here gaseous fuel called primary fuel is either inducted along with air intake, or injected directly into the Cylinder and compressed, but does not auto-ignite due to its very high self-ignition temperature. Ignition of Homogeneous mixture of air and gas is achieved by timed injection of small quantity of petrol called pilot fuel near the end of the compression stroke. The pilot petrol fuel auto-ignites first and acts as a deliberate source of ignition for the primary fuel air mixture.

The combustion of gaseous fuel occurs by flame propagation similar to SI engine Combustion. Thus dual fuel engine combines the features of both SI and SI engine in a complex manner. The dual Fuel mode of operation leads to smoother operation; lower smoke emission and the thermal efficiency are almost comparable to the petrol version at medium and at high loads. However, major drawback with these engines are Higher NO_x emissions, poor part load performance, and higher ignition delay with certain gases like biogas and Rough engine operation near full load due to high rate of combustion.

Increasing industrialization, growing energy demands, limited reserves of fossil fuel and increasing environmental pollution have necessitated exploration of some alternatives of conventional petroleum fuels. Thermodynamic tests based on engine performance evolution have established the feasibility of using a variety of alternative fuels such as hydrogen, electric battery technologies, compressed natural gas (CNG), liquefied petroleum gas (LPG), acetylene, ethanol, methanol, biodiesel, vegetable oil and other biomass sources in internal combustion engines.

Alternative fuel should be easily available, environmentally friendly, renewable, cost effective and techno-economically competitive. Successful fuel should fulfill environmental and energy security needs without sacrificing engine performance. Gaseous fuels are the best suited for IC engines since their combustion delay is almost nil. However, as fuel displaces equivalent amount of air the engines may have poor volumetric efficiency.

1.3 Environmental Effects

- Global warming
- Ozone depletion
- Respiratory ailments
- Acid rain

Due to the noxious exhaust produced during the combustion during the combustion of this conventional hydrocarbon. But, due to a absence of a compatible and more eco-friendly fuel we are still depend on these hydrocarbon based fuel (Petrol, Diesel etc.). Acetylene which can be a better replacement for their fuels on environment and economic aspects still have certain obstacles which are dealt in this paper like:

- Production
- Storage
- Transfer
- Injection

The aim of this paper is to overcome the shortcomings which prevent the use of acetylene as a fuel in IC engine. The aim of this paper is to overcome the shortcomings which prevent the use of acetylene as a fuel in IC engine. Acetylene is produced by calcium carbide with water in following reaction:

Calcium carbide + water → acetylene +calcium hydroxide

Acetylene is produced by mixing calcium carbide with water in on-board tank. This acetylene on combustion burns to give carbon dioxide with water vapors. But as it has high ignition temperature certain engine modification are required.

2. LITERATURE SURVEY

G.Nagarajan,.Lakshamanan,(1998)[1], conducted experiments on a diesel engine aspirated acetylene along with air at Different flow rates without dual fuel mode. They carried out the experiment on a single cylinder, air cooled, direct injection(DI), compression ignition engine designed to develop the rated power output of 4.4 kW at 1500 rpm under variable load Condition. Acetylene aspiration results came with a lower thermal efficiency reduced Smoke, HC and CO emissions, when Compared with baseline diesel operation.

Ashok Kumar (2002) et .al [2], studied suitability of acetylene in SI engine along with EGR, and reported that emission got drastically reduced on par with hydrogen engine with marginal increase in thermal Efficiency.

Gunea, Razavi, and Karim,(1999)[3], conducted experiments on a four-stroke, single cylinder, direct injection diesel engine fueled With natural gas. Tests were conducted with diesel as the pilot fuel having different cetane numbers in order to find the Effects of pilot fuel quality on ignition delay. They concluded that ignition delay of a dual fuel engine mainly depends on Pilot fuel quantity and quality. High cetane number pilot fuels can be used to improve performance of engines using low Cetane value gaseous fuel.

Swami Nathan et al [4], conducted experiments on sole acetylene fuel in HCCI mode and shown the results with high Thermal efficiencies in a wide range of BMEP. The thermal efficiencies were comparable to the base diesel engine and a Slight increase in brake thermal efficiency was observed with optimized EGR operation. The intake charge temperature and Amount of EGR have to be controlled based on the output of engine and at high BMEPs hot EGR leads to knock.

John W.H. Price,(1993) [5], described the explosion of an acetylene gas cylinder, which occurred in 1993 in Sydney. The failure Caused severe fragmentation of the cylinder and resulted in a fatality and property damage. He examined the nature of the Explosion which occurred and sought an explanation of the events. He gave more information to prevent accidents Regarding while using acetylene and the reactions take place in combustion and safety precautions.

M. Senthil Kumar(2005) [06], concluded that hydrogen can be inducted along with air to improve the performance and reduce Hydrocarbons and smoke emissions of a Jatropha oil fuelled compression ignition engine with cleared dual fuel mode Concept. The most significant environmental penalty will be an increase of NO emission. The amount of hydrogen that can Be added depends on the output. At full load 7% of the total mass of fuel admitted has to be hydrogen for optimal Performance. At low outputs it is not advantages to use hydrogen induction.

Das,et .al (2005) [07], suggested that hydrogen could be used in both SI engine and CI engine without any major modification in the Existing system. He studied different modes of hydrogen induction by carburetion, continuous manifold injection (CMI),Timed manifold injection (TMI), low pressure direct injection (LPDI), and high pressure direct injection (HPDI); and Suggested to use manifold injection method for induction of gases to avoid undesirable combustion phenomenon (back fire)And rapid rate of pressure rise. The available research material on acetylene combustion and use of alternative fuels in IC engine is extensive. It is actually started related to the present work.

Sharma P.K.(2010)et al. [8] ,Explained the method to employ acetylene as an alternative energy source IC engines. They have conducted experiments on SI engine using acetylene as a primary and alcohol as a secondary fuel. Final results showed that alcohol can be introduced so as to reduce the in cylinder temperatures of the engine. Nagarajan G and Lakshamanan, studied about the performance and also the emission quality of a compression ignition engine suitable for multi fuel operation, by timed manifold injection to induct acetylene at different flow rates. Results show that best possible condition as manifold injection with 10° ATDC with the injection interval of 90crank angle.

It is experimentally proved that the emissions of such engines are quite encouraging since the smoke, hydrocarbon and carbon monoxide levels are noticed to be lower. However the efficiency of the engine is sacrificed in such case.

Mahla S.K. et. al[9], Experimented on diesel engine with acetylene aspiration and blended it with diethyl ether at a rate of 12L/m into the inlet manifold. In search engine the source of ignition was diesel, which was the primary fuel. The functioning of the diesel engine which used pilot fuel and Di Ethyl Ether (DEE) showed better thermal efficiency and hence the performance was better compared to the standard diesel engine.

Acetylene as a sole fuel in HCCI mode resulted in higher thermal efficiencies, and it is also better suited for a wide spectrum of brake mean effective pressure. If the inlet charge temperature is increased the brake thermal efficiency reaches its maximum at certain exhaust gas recirculation condition in addition to the temperatures of the inlet air. At higher brake mean effective pressures the re-circulated exhaust gas is normally at higher temperatures, and that in turn causes uncontrolled combustion or detonation. Therefore the amount of EGR is controlled accordingly.

Gunea, Razavi and Karim et.al [9], has been verified experimentally. Another important case is the nature of the pilot fuel system and its importance on the delay period of engine. This was also investigated for wide ranges of cetane numbers. The ignition delay time, mainly depends on fuel quality and quantity of the pilot fuel in the engine. If high cetane number fuels are used, then the performance of the engine improves.

John W.H. Price (2014), [10], described the explosion of a cylinder containing acetylene gas, which occurred in 1993 in Sydney. In this paper, he describes the failure and the conditions that affected with it. The assessment says that the explosion, which occurred, needs an explanation of the events.

3. PREPARATION OF ACETYLENE GAS

3.1 Acetylene Gas

Acetylene (C_2H_2) is a synthesis gas but not an air gas, but generally produced from the reaction of calcium carbide with water. It was burnt for many applications such as to light homes and mining tunnels in the 19th century. A gaseous hydrocarbon is unstable, colour less, has a strong preparation garlic odor, is highly combustible, and produces a very hot flame (over 5400°F or 3000°C)when combined with oxygen.

Acetylene is generally produced by reacting calcium carbide with water. The reaction is carried out spontaneously and can be conducted without any sophisticated equipment or apparatus. Such produced acetylene has been utilized for street vendors, lighting in mine areas etc. In most such application, acetylene is generally handled in solution form such as acetone.

Acetylene is a colourless and highly combustible gas with a pungent odour. If it is compressed, heated or mixed with air, it becomes highly explosive. It is produced by a straightforward chemical process in which calcium carbide reacts with water and generates acetylene gas and slurry of calcium carbonate.

3.1.1Properties of acetylene gas

Acetylene is chosen as an alternative fuel in the present study. Since it is renewable in nature, it seems to posses similar properties of hydrogen (table 1) and can be used as an alternative fuel in internal combustion engines in competition with hydrogen fuel.

Acetylene was discovered in 1836 in England by E.Davy. It is a colorless gas with a garlic smell produced from calcium carbonate (lime stone), which is abundant and renewable in nature in a lime kiln at 825^{o}C which yields calcium oxide (lime) by liberating $CO_{2.}$ Calcium oxide is heated along with coke in electric furnace to produce calcium carbide.

Finally calcium carbide is hydrolyzed to liberate acetylene. Acetylene has a very wide flammability range, and minimum ignition energy is required for ignition.

3.1.2Acetylene gas compare with other fuel properties

Properties	**Acetylene**	**H_2**	**CNG**	**Petrol**
Composition	C_2H_2	H_2	CH_4: 86.4-90%; C2H6 : 3-6% ,	C8H18

			C3H8 : 0.35-2%	
Density kg/m3,(At 1 atm&20 o C)	1.092	0.08	0.72	800
Auto ignition temperature (oC)	305	572	450	246
Stoichiometeric air fuel ratio, kg/kg)	13.2	34.3	17.3	14.7
Flammability Limits ,(Volume %)	2.5 –81	4 – 74.5	5.3 – 15	1.2-8
Flammability Limits,(Equivalent ratio)	0.3-9.6	0.1 – 6.9	0.4-1.6	-------
Lower Calorific Value (kJ/kg)	48,225	1,20,00	45800	44500
Lower Calorific Value (kJ/m^3)	50,636	9600	-------	-------
Max deflagration speed (m/sec)	1.5	3.5	--------	-------

Acetylene gas is having high auto ignition temperature, very little ignition energy and low density which are close to that of hydrogen. The calorific value of acetylene gas is more than diesel fuel and having sufficient flammability limits. So acetylene gas can be preferred as an alternative fuel for SI engine.

Acetylene (C_2H_2) is not only an air gas but also a synthesis gas generally produced from the reaction of calcium carbide with water. It was burnt in "acetylene lamps" to light homes and mining tunnels in the 19th century. A gaseous hydrocarbon, has a strong garlic odour, it is colourless, is unstable, highly combustible, and produces a very hot flame (over 5400°F or 3000°C)when combined with oxygen. Acetylene is generally produced by reacting calcium carbide with water. The reaction is continuously occurring and can be conducted without any sophisticated equipment or apparatus. Such produced acetylene has been utilized for lighting by street vendors, in mine areas etc. People often call such lighting sources “carbide lamps” or “carbide light” Industrial uses of acetylene as a fuel for motors or lighting sources, however, have been nearly nonexistent. In modern times, the use of acetylene as a fuel has been largely limited to welding-related applications or acetylene torches for welding.

3.2 Procedure of production

The aim of this paper is to overcome the short comings which prevent the use of acetylene as a fuel in IC engine. Acetylene is produced by calcium carbide with water in following reaction:

Calcium carbide + water acetylene +calcium hydroxide

Acetylene is produced by mixing calcium carbide with water in on-board tank. This acetylene on combustion burns to give carbon dioxide with water vapours. But as it has high ignition temperature certain engine modification are required.

Step 1:

The first step involves the production of acetylene gas through the Calcium Carbide reacting with water in the reaction tank.

$CaC_2+2H_2O\ C_2H_2+Ca\ (OH)^2$

The reaction tank constitutes two chambers:

• In first (upper) chamber the water is kept.

• In second (lower) chamber the calcium carbide is kept.

The water from the first chamber is released in such away to proceed the reaction spontaneously. The water is passed through the control valve. In the second chamber the calcium carbide is kept in desirable amount to react with water. Through second chamber a valve is connected to the storage tank where the gas produced during reaction is stored.

Step 2:

In this step the acetylene gas is stored in the storage tank and the pressure is measured by the pressure gauge in this step the produced gas is stored and is passed through the pipes. Here the gas is stored to avoid moisture and the gas stored in storage tank is provided pressure through pressure gauge so the gas is of high concentration .sophisticated manner and then pipe is joined in the carburet or fitted with the filter, this then filters the air and then combines with petrol as secondary fuel which is added in very few amount (in about 10 to 15%) to prevent knocking for smooth operation of an engine. Then the mixture is passed in the engine. We can illustrate that introduction of secondary fuel is an essential part of this project as flame temperature in the combustion process which leads to avoid the auto ignition and knocking.

3.3 Calcium carbide manufacturing

Calcium carbide (CaC_2) is manufactured by heating a lime and carbon mixture to 2000 to 2100°C (3632 to 3812°F) in an electric arc furnace. At those temperatures, the lime is reduced by carbon to calcium carbide and carbon monoxide (CO), according to the following reaction:

$CaO + 3C \rightarrow CaC_2 + CO$

Lime for the reaction is usually made by calcimine limestone in a kiln at the plant site. The sources of carbon for the reaction are petroleum coke, metallurgical coke, and anthracite coal. Because impurities in the furnace charge remain in the calcium carbide product, the lime should contain no more than 0.5 percent each of magnesium oxide, aluminum oxide, and iron oxide, and 0.004 percent phosphorus. Also, the coke charge should be low in ash and sulfur. Analyses indicate that 0.2 to 1.0 percent ash and 5 to 6 percent sulfur are typical in petroleum coke. About 991 kilograms (kg) (2,185 pounds [lb]) of lime, 683 kg (1,506 lb) of coke, and 17 to 20 kg (37 to 44 lb) of electrode paste are required to produce 1 mega gram (Mg) (2,205 lb) of calcium carbide. The process for manufacturing calcium carbide is illustrated in Figure 11.4-1. Moisture is removed from coke in a coke dryer, while limestone is converted to lime in a lime kiln. Fines from coke drying and lime operations are removed and may be recycled. The two charge materials are then conveyed to an electric arc furnace, the primary piece of equipment used to produce calcium carbide.

There are three basic types of electric arc furnaces: the open furnace, in which the CO burns to carbon dioxide (CO_2) when it contacts the air above the charge; the closed furnace, in which the gas is collected from the furnace and is either used as fuel for other processes or flared; and the semi-covered furnace, in which mix is fed around the electrode openings in the primary furnace cover resulting in mix seals. To prevent explosion hazards from acetylene generated by the reaction of calcium carbide with ambient moisture, crushing and screening operations may be performed in either an air-swept environment before the calcium carbide has completely cooled, or in an inert atmosphere. The calcium carbide product is used primarily in generating acetylene and in desulfurizing iron.

3.4 ENGINE & WORKING PRINCIPLES

A heat engine is a machine, which converts heat energy into mechanical energy. The combustion of fuel such as coal, petrol, and diesel generates heat. This heat is supplied to a working substance at high temperature. By the expansion of this substance in suitable machines, heat energy is converted into useful work. Heat engines can be further divided into, Two types:

(i) External combustion and

(ii) Internal combustion.

In a steam engine the combustion of fuel takes place outside the engine and the steam

Thus formed is used to run the engine. Thus, it is known as external combustion engine. In the case of internal combustion engine, the combustion of fuel takes place inside the engine cylinder itself.

The IC engine can be further classified as:

(i) stationary or mobile,

(ii) horizontal or vertical and

(iii) low, medium or high speed. The two distinct types of IC engines used for either mobile or stationary operations are:

(i) diesel and

(ii) carburettor

3.4.1 Spark Ignition (Carburetor Type) IC Engine

In this engine liquid fuel is atomized, vaporized and mixed with air in correct proportion before being taken to the engine cylinder through the intake manifolds. The ignition of the mixture is caused by an electric spark and is known as spark ignition.

3.4.2Compression Ignition (Diesel Type) IC Engine

In this only the liquid fuel is injected in the cylinder under high pressure.

3.5 CONSTRUCTIONAL FEATURES OF IC ENGINE:

The cross section of IC engine.A brief description of these parts is given below.

3.5.1 Cylinder

The cylinder of an IC engine constitutes the basic and supporting portion of the engine power unit. Its major function is to provide space in which the piston can operate to draw in the fuel mixture or air (depending upon spark ignition or compression ignition), compress it, allow it to expand and thus generate power. The cylinder is usually made of high-grade cast iron. In some cases, to give greater strength and wear resistance with less weight, chromium, nickel and molybdenum are added to the cast iron.

3.5.2 Piston

The piston of an engine is the first part to begin movement and to transmit power to the crankshaft as a result of the pressure and energy generated by the combustion of the fuel. The piston is closed at one end and open on the other end to permit direct attachment of the connecting rod and its free action. The materials used for pistons are grey cast iron, cast steel and aluminium alloy. However, the modern trend is to use only aluminum alloy pistons in the tractor engine.

3.5.3 Piston Rings

These are made of cast iron on account of their ability to retain bearing qualities and elasticity indefinitely. The primary function of the piston rings is to retain compression and at the same time reduce the cylinder wall and piston wall contact area to a minimum, thus reducing friction losses and excessive wear. The other important functions of piston rings are the control of the lubricating oil, cylinder lubrication, and transmission of heat away from the piston and from the cylinder walls.

Piston rings are classed as compression rings and oil rings depending on their function and location on the piston. Compression rings are usually plain one-piece rings and are always placed in the grooves nearest the piston head. Oil rings are grooved or slotted and are located either in the lowest groove above the piston pin or in a groove near the piston skirt. Their function is to control the distribution of the lubricating oil to the cylinder and piston surface in order to prevent unnecessary or excessive oil consumption ion.The materials used for pistons are grey cast iron, cast steel and aluminium alloy. However, the modern trend is to use only aluminium alloy pistons in the tractor engine.

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3.5.5 Piston Pin

The connecting rod is connected to the piston through the piston pin. It is made of casehardened alloy steel with precision finish. There are three different methods to connect the piston to the connecting rod.

3.5.6Connecting Rod

This is the connection between the piston and crankshaft. The end connecting the piston is known as small end and the other end is known as big end. The big end has two halves of a bearing bolted together. The connecting rod is made of drop forged steel and the section is of the I-beam type.

3.5.7 Crankshaft

This is connected to the piston through the connecting rod and converts the linear motion of the piston into the rotational motion of the flywheel. The journals of the crankshaft are supported on main bearings, housed in the crankcase. Counter-weights and the flywheel bolted to the crankshaft help in the smooth running of the engine.

3.5.8 Engine Bearings

The crankshaft and camshaft are supported on anti-friction bearings. These bearings must be capable of withstanding the high speed, heavy load and high temperatures. Normally cadmium, silver or copper lead is coated on a steel back to give the above characteristics. For single cylinder vertical/horizontal engines, the present trend is to use ball bearings in place of main bearings of the thin shell type.

3.5.9 Valves

To allow the air to entering to the cylinder or the exhaust, gases to escape from the cylinder, valves are provided, known as inlet and exhaust valves respectively. The valves are mounted either on the cylinder head or on the cylinder block.

3.5.10 Camshaft

The valves are operated by the action of the camshaft, which has separate cams for the inlet, and exhaust valves. The cam lifts the valve against the pressure of the spring and as soon as it changes position the spring closes the valve. The cam gets drive through either the gear or sprocket and chain system from the crankshaft. It rotates at half the speed of the camshaft.

3.5.11 Flywheel

This is usually made of cast iron and its primary function is to maintain uniform engine speed by carrying the crankshaft through the intervals when it is not receiving power from a piston. The size of the flywheel varies with the number of cylinders and the type and size of the engine. It also helps in balancing rotating masses.

3.5.12 Materials used for engine parts

S. No.	**Name of the Parts**	**Materials of Construction**
1	Cylinder head	Cast iron, Cast Aluminium
2	Cylinder liner	Cast steel, Cast iron
3	Engine block Cast iro	Cast aluminum, Welded steel
4	Piston	Cast iron, Aluminium alloy
5	Piston pin	Forged steel Casehardened steel
6	Connecting rod	Forged steel Aluminium alloy.
7	Piston rings	Cast iron, Pressed steel alloy
8	Connecting rod	bearings Bronze, White metal.
9	Main bearings	White metal, Steel backed Babbitt
10	Crankshaft	Forged steel, Cast steel
11	Camshaft	Forged steel, Cast iron, cast steel,
12	Timing gears	Cast iron, Fiber, Steel forging

13	Push rods	Forged steel.
14	Engine valves	Forged steel, Steel, alloy.
15	Valve springs	Carbon spring steel.
16	Manifolds	Cast iron, Cast aluminium.
17	Crankcase	Cast iron, Welded steel
18	Flywheel	Cast iron.
19	Studs and bolts	Carbon steel.
20	Gaskets Cork	Copper, Asbestos.

4.1 PRINCIPLES OPERATION OF IC ENGINES

4.1.1 four-stroke cycle diesel engine

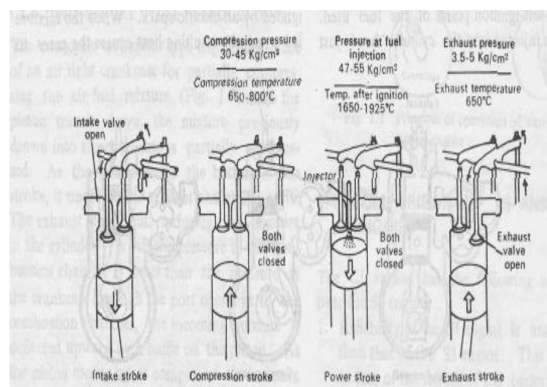
In four-stroke cycle engines there are four strokes completing two revolutions of the crankshaft. These are respectively, the suction, compression, power and exhaust strokes. In Fig. 3, the piston is shown descending on its suction stroke. Only pure air is drawn into the cylinder during this stroke through the inlet valve, whereas, the exhaust valve is closed. These valves can be operated by the cam, push rod and rocker arm. The next stroke is the compression stroke in which the piston moves up with both the valves remaining closed air, which has been drawn into the cylinder during the suction stroke, is progressively compressed as the piston ascends. The compression ratio usually varies from 14:1 to 22:1. The pressure at the end of the compression stroke ranges from 30 to 45 kg/cm^2. As the air is progressively compressed in the cylinder, its temperature increases, until when near the end of the compression stroke, it becomes sufficiently high (650-80O°C) to instantly ignite any fuel that is injected into the cylinder.

When the piston is near the top of its compression stroke, a liquid hydrocarbon fuel, such as diesel oil, is sprayed into the combustion chamber under high pressure (140-160 kg/cm2), higher than that existing in the cylinder itself. This fuel then ignites, being burnt with the oxygen of the highly compressed air. During the fuel injection period, the piston reaches the end of its compression stroke and commences to return on its third consecutive stroke, viz., power stroke. During this stroke the hot products of combustion consisting chiefly of carbon dioxide, together with then it nitrogen left from the compressed air expand, thus forcing the piston downward. This is only the working stroke of the cylinder. During the power stroke the pressure falls from its maximum combustion value (47-55kg/cm2),which is usually higher than the greater value of the compression pressure (45kg/cm2), to about 3.5-5 kg/cm2near the end of the stroke. The exhaust valve then opens, usually a little earlier than when the piston reaches its lowest point of travel. The exhaust gases are swept out on the following upward stroke of the piston. The exhaust valve remains open throughout the whole stroke and closes at the top of the stroke. The reciprocating motion of the piston is converted into the rotary motion of the crank shaft by means of a connecting rod and crankshaft. The crankshaft rotates in the main bearings, which are set in the crankcase. The flywheel is fitted on the crankshaft in order to smoothen out the uneven torque that is generated in the reciprocating engine.

4.1.2 Two-stroke cycle diesel engine:

The cycle of the four-stroke of the piston (the suction, compression, power and exhaust strokes) is completed only in two strokes in the case of a two-stroke engine. The air is drawn into the crankcase due to the suction created by the upward stroke of the piston. On the down stroke of the piston it is compressed in the crankcase, The compression pressure is usually very low, being just sufficient to enable the air to flow into the cylinder through the transfer port when the piston reaches near the bottom of its down stroke.

The air thus flows into the cylinder, where the piston compresses it as it ascends, till the piston is nearly at the top of its stroke. The compression pressure is increased sufficiently.



4.1.2 Principle of four-stroke engine

4.1.3 Two-stroke cycle diesel engine:

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The air thus flows into the cylinder, where the piston compresses it as it ascends, till the piston is nearly at the top of its stroke. The compression pressure is increased sufficiently high to raise the temperature of the air above the self-ignition point of the fuel used. The fuel is injected into the cylinder head just before the completion of the compression stroke and only for a short period. The burnt gases expand during the next downward stroke of the piston. These gases escape into the exhaust pipe to the atmosphere through the piston uncovering the exhaust port.

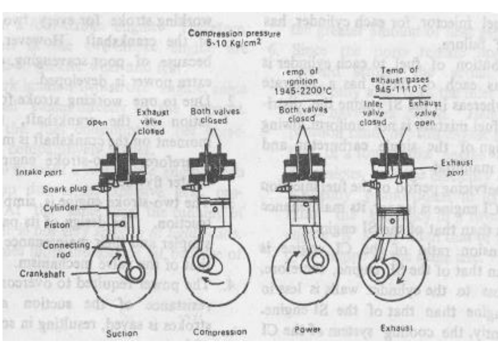
4.1.4 Modern Two-Stroke Cycle Diesel Engine

The crankcase method of air compression is unsatisfactory, as the exhaust gases do not escape the cylinder during port opening. Also there is a loss of air through the exhaust ports during the cylinder charging process. To overcome these disadvantages blowers are used to pre compress the air. This pre-compressed air enters the cylinder through the port. An exhaust valve is also provided which opens mechanically just before the opening of the inlet ports.

4.1.5 Four-stroke spark ignition engine

In this gasoline is mixed with air, broken up into a mist and partially vaporized in a carburetor (Fig. 5). The mixture is then sucked into the cylinder. There it is compressed by the upward movement of the piston and is ignited by an electric spark. When the mixture is burned, the resulting heat causes the gases to expand.

The expanding gases exert a pressure on the piston (power stroke). The exhaust gases escape in the next upward movement of the piston. The strokes are similar to those discussed under four-stroke diesel engines. The various temperatures and pressures are shown in Fig. 6. The compression ratio varies from4:1 to 8:1 and the air-fuel mixture from 10:1 to 20:1.



4.1.5Principle of operation of four-stroke petrol engine

4.1.6 Two-stroke cycle petrol engine

The two-cycle carburetor type engine makes use of an airtight crankcase for partially compressing the air-fuel mixture (Fig. 6). As the piston travels down, the mixture previously drawn into the crankcase is partially compressed. As the piston nears the bottom of the stroke, it uncovers the exhaust and intake ports. The exhaust flows out, reducing the pressure in the cylinder. When the pressure in the combustion chamber is lower than the pressure in the crankcase through the port openings to the combustion chamber, the incoming mixture deflected upward by a baffle on the piston. As the piston moves up, it compresses the mixture above and draws into the crankcase below a new air-fuel mixture. The, two-stroke cycle engine can be easily identified by the air-fuel mixture valve attached to the crankcase and the exhaust Port located at the bottom of the cylinder.

4.1.7 Comparison of CI and SI engines

The CI engine has the following advantages over the SI engine.

1. Reliability of the CI engine is much higher than that of the SI engine. This is because in case of the failure of the battery, ignition or carburettor system, the SI engine cannot operate, whereas the CI engine, with a separate fuel injector for each cylinder, has less risk of failure.
2. The distribution of fuel to each cylinder is uniform as each of them has a separate injector, whereas in the SI engine the distribution of fuel mixture is not uniform, owing to the design of the single carburettor and the intake manifold.
3. Since the servicing period of the fuel injection system of CI engine is longer, its maintenance cost is less than that of the SI engine.
4. The expansion ratio of the CI engine is higher than that of the SI engine; therefore, the heat loss to the cylinder walls is less in the CI engine than that of the SI engine Consequently, the cooling system of the CI engine can be of smaller dimensions.
5. The torque characteristics of the CI engine are more uniform which results in better top gear performance.
6. The CI engine can be switched over from part load to full load soon after starting from cold, whereas the SI engine requires warming up.
7. The fuel (diesel) for the CI engine is cheaper than the fuel (petrol) for SI engine.
8. The fire risk in the CI engine is minimised due to the absence of the ignition system.
9. On part load, the specific fuel consumption of the CI engine is low.

4.2 Advantages and disadvantages of two-stroke cycle over four-stroke cycle engines

4.2.1Advantages

1. The two-stroke cycle engine gives one working stroke for each revolution of the crankshaft. Hence theoretically the power developed for the same engine speed and cylinder volume is twice that of the four-stroke cycle engine, which gives only one working stroke for every two revolutions of the

crankshaft. However, in practice, because of poor scavenging, only 50-60% extra power is developed.

2.Due to one working stroke for each revolution of the crankshaft, the turning moment on the crankshaft is more uniform. Therefore, a two-stroke engine requires a lighter flywheel.

3.The two-stroke engine is simpler in construction. The design of its ports is much simpler and their maintenance easier than that of the valve mechanism.

4.The power required to overcome frictional resistance of the suction and exhaust strokes is saved, resulting in some economy of fuel.

5.Owing to the absence of the cam, camshaft, rockers, etc. of the valve mechanism, the mechanical efficiency is higher.

4.3 Present work of our project

The present work, acetylene gas was aspirated in the intake manifold in SI engine with petrol being the ignition source. The performance and emission characteristics are compared with baseline petrol. The variation of brake thermal efficiency with brake power .The brake thermal efficiency in induction technique is found to be 11.23% lower, when compared with neat petrol fuel of 28.84% efficiency at full load. In general, it may be noted that in the dual-fuel engines, the thermal efficiency decreases at low loads and in the cycle and higher flame speed. Cylinder pressure diagram confirmed this, in which maximum pressure was observed to occur earlier in the cycle when acetylene was introduced along with the intake air.

Then with heterogeneous mixtures, most of the smoke is formed in the diffusion flame. The amount of smoke present in the exhaust gas depends on the mode of mixture formation. The combustion processes and quantity of fuel injected occur before ignition The smoke level increases with increase in petrol flow rate, and at full load it is 7 BSU in case of petrol fuel operation. Dual-fuel operation with any gaseous fuel proved to be a potential way of reducing the smoke density as compared to petrol operation. A reduction in smoke level is noticed. The smoke level is reduced by 14% in induction technique at full load when compared to baseline petrol operation.

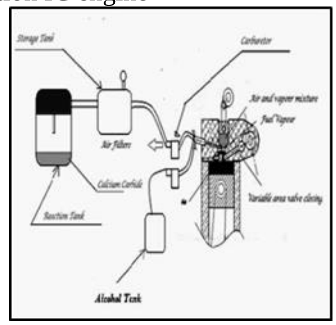
4.3.1 Experimental setup

The acetylene gas working at spark ignition in internal combustion engine model experimental setup are the given below;

4.3.2Parts of experimental setup

1. Reaction tank(calcium carbide with water)
2. Air filter
3. Carburetor

Spark ignition IC engine



4.3.2 Parts of experimental setup

4.3.3Working of acetylene gas in IC engine

When the calcium carbide taken the storage tank .then mixing the calcium carbide and the water at that time acetylene gas will be form in the storage tank. The formed acetylene gas is stored the other storage tank by through the gas tube. The gas pressure is measure by using of the pressure gauge. When the gases passed through the carburetor and gas open and close are the controlled by thee gas regulator. Then the carburetor mixing the air and the gas is passed at spark ignition (SI) in internal combustion(IC) engine. Actually running the engine by using fuel is acetylene gas.

5 RESULTS AND DISCUSSION

In the present work, acetylene gas was aspirated in the intake manifold in SI engine with petrol being the ignition source. The performance and emission characteristics are compared with baseline petrol operation.

5.1Brake Thermal Efficiency

1. The variation of brake thermal efficiency with brake power is shown in figure
2. The brake thermal efficiency in induction technique is found to be 11.23% lower, when compared with neat petrol fuel of 28.84% efficiency at full load. In general, it may be noted that in the dual-fuel engines, the thermal efficiency decreases at low loads and increases above the base line at full load operation with addition of inducted fuels like LPG, CNG etc.
3. However, acetylene, because of its wide flammability limit and high combustion rate, is an exception where efficiency is lower throughout the load spectrum. With high loads, the brake thermal efficiency falls because of high diffusion rate and faster energy release .This confirms that faster energy release occurs with acetylene introduction; and is also supported by the observed increase in maximum cycle pressure.

5.2. Exhaust Gas Temperature

The exhaust gas temperature at full load, depicted in figure 3, reaches 368ºC in acetylene induction technique and 444ºC in the case of base line petrol operation. Acetylene induct ion decreased the exhaust gas temperature at all loads, indicating the advancement of energy release in the cycle and higher flame speed. Cylinder pressure diagram confirmed this, in which maximum pressure was observed to occur earlier in the cycle when acetylene was introduced along with the intake air.

5.3 Oxides of Nitrogen (NOx)

It can be observed from figure 4 that NO*x* emission is 1866 ppm at maximum output with neat petrol fuel operation. In dual fuel operation with acetylene induction, NO*x* emission is increased by 17%when compared to baseline petrol operation. According to zeldovich mechanism model, the formation of NO*x* is attributed to the reaction temperature, reaction duration, and the availability of oxygen [1]. When acetylene is inducted, increase in NO*x* may be attributed to the increased peak cycle temperature level because of faster energy release, which is confirmed by increased peak cycle pressure.

5.4 Smoke

The variation of smoke level with brake power. The exact mechanism of smoke formation is still unknown. Generally speaking, smoke is formed by the pyrolysis of HC in the fuel rich zone, mainly under load conditions. In petrol engines operated with heterogeneous mixtures, most of the smoke is formed in the diffusion flame. The amount of smoke present in the exhaust gas depends on the mode of mixture formation. The combustion processes and quantity of fuel injected occur before ignition [2]. The smoke level increases with increase in petrol flow rate, and at full load it is 7 BSU incase of petrol fuel operation. Dual-fuel operation with any gaseous fuel proved to be a potential way of reducing the smoke density as compared to petrol operation. A reduction in smoke level is noticed. The smoke level is reduced by14% in induction technique at full load when compared to baseline petrol operation. This may be attributed to the fact that combustion of acetylene-petrol fuel is faster, contributing to complete combustion, and is also due to triple bond in acetylene which is unstable.

5.5 Hydrocarbon Emissions

Depicts the variation of hydrocarbon emissions with load. The HC emissions are 25ppm in baseline petrol operation and 23ppm when acetylene is aspirated at full load in induction technique. The reduction in HC emission in the case of dual fuel mode is due to the higher burning velocity of acetylene which enhances the burning rate.

5.6 Carbon Monoxide Emissions

The variation of carbon monoxide emissions with load exhibits similar trend of HC. This is shown in figure 7. The CO emissions are lower compared to the base line petrol operation. The maximum is 0.01% by volume in induction technique followed by base line petrol of 0.02% at full load. The CO emissions are lower due to the complete burning of the fuel, and is also due to the reduction in the overall C/H ratio of total fuel inducted into the engine.

5.7 Carbon Dioxide Emissions

The CO2emissions are lower compared to the base line petrol, the minimum being8.7% by volume at full load in acetylene induction technique followed by 9.0% by volume in baseline petrol operation, as shown in figure 8. The CO2emission of acetylene is lowered because of lower hydrogen to carbon ratio.

5.8 Pressure Crank Angle Diagram

Portrays the variation of cylinder pressure with crank angle. The peak pressure is about 72.1 bar at maximum power with base line petrol operation. Peak pressure is further increased indual fuel operation with acetylene induction at maximum load. In dual fuel engine, the trend of increase in peak pressure is due to increased ignition delay and rapidity of combustion. There is an increase to about 3. bar when acetylene is inducted. The peak pressure for acetylene inducted dual fuel engine is advanced by 5°C.A compared to peak pressure of petrol at full load. The advance in peak pressure for acetylene combustion is perhaps due to instantaneous combustion of acetylene as compared to petrol. The rate of pressure rise is also high for acetylene operated dual fuel engine, compared to petrol operated engine due to instantaneous combustion of acetylene fuel.

5.9 Heat Release Rate

Indicates the rate of heat release for acetylene operated dual fuel engine at 31pm flow rate, and petrol engine at full load as well. The burning rate diagram can be divided into three distinct phase, namely ignition delay, premixed combustion phase, mixing controlled combustion phase, and late combustion phase [1].The heat release rate for acetylene aspiration shows distinct characteristics of explosive, premixed type combustion followed by a brief second phase dip in burning rate and then a rapid increase during the third phase of combustion of the gas mostly diffusion type of combustion.

5.10 Problem Definition

We have taken the performance test on petrol as well as on acetylene gas. We are taken the following different reading for the petrol as well as acetylene.

1. Load (Kg)
2. Speed (rpm)
3. Time for 10 ml of fuel consumption of petrol (Sec)
4. Mass of fuel for acetylene gas (Kg/Sec)

On the basis of above parameters following different results are calculated for various reading.

1. Break power (KW)
2. Break specific fuel consumption (Kg/KW.hr)
3. Break thermal efficiency (%).

Different graphs were plotted on above results are as follows.

1. Break power Vs BSFC
2. Load Vs Break thermal efficiency
3. Load Vs BSFC
4. Specific fuel consumption Vs Break power

Table 5.1Specifications of engine

Type	Air cooled engine
Stroke (2/4)	4 stroke
No. of cylinders	Single cylinder
Bore x stroke	50 mm x 50.6 mm
Displacement	99.35 cc
Battery	12 Volt

5.10.1Calculation procedure for performance testing:

1. Brake power (kw) :-

BP = (W*N)/K

Where W = load in kg

N = dynamometer rpm

K=2719.2 = constant of dynamometer

2. Fuel consumption:-

Burette is provided for fuel measurement range of burette is 0-100 cc.

Rate of fuel consumption=(cc/sec)*(sp.gravity*1000)

= (kg/sec)

3. Brake specific fuel consumption (kg/KW-hr,Brake power

4. Heat supplied by fuel (kJ/hr):-

=calorific value of fuel *fuel consumption

= (kJ/hr)

5. Brake thermal efficiency:-

$$\eta bth = \frac{\text{Heat equivalent of bp/hr}}{\text{Heat supplied by fuel /hr}}$$

5.10.2 Observations

Measurement and result got by conducting trial using petrol, acetylene gas with the help of various apparatus are represented are represented in following table.

Table 5.10.2 Observation of petrol

Sr. No.	**Load (kg)**	**Speed Rpm**	**Time for 10ml Fuel(sec)**
1	1	800	75
2	2	800	65
3	3	800	50
4	4	800	47
5	5	800	45
6	6	800	41
7	7	800	38
8	8	800	35
9	9	800	30
10	10	800	26
11	11	800	23
12	12	800	20
13	13	800	18

Table 5.10.3 Observation of petrol

S No	Load (kg)	Speed (rpm)	Time for 10ml Fuel (sec)	Brake Power (kW)	BSFC (Kg/kW-hr)	Brake thermal eff. ηbth (%)
1	1	800	75	0.2942	1.3051	6.19
2	2	800	65	0.5884	0.753	10.74
3	3	800	50	0.88261	0.6526	12.39
4	4	800	47	1.1768	0.5206	15.53

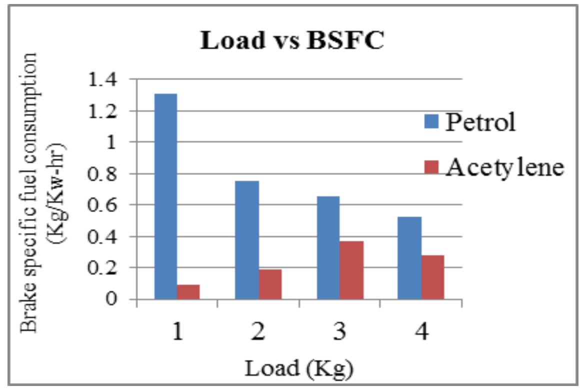
Table 5.10.4 Observation of acetylene gas

Sr.no	Load (kg)	Speed (Rpm)	Mass of fuel x 10^-4 (kg/sec)
1	1	800	0.89285
2	2	800	0.89435
3	3	800	0.89435
4	4	800	0.89885
5	5	800	0.89885
6	6	800	0.89885
7	7	800	0.90942
8	8	800	0.91400
9	9	800	1.09385

Table 5.10.5 Result of acetylene gas

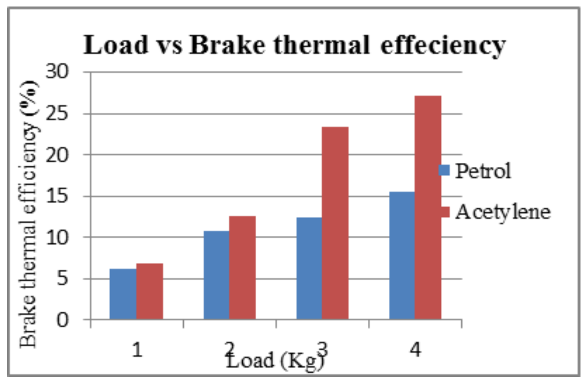
Sr. No	Load (kg)	Speed (rpm)	Mass of fuel (Kg/sec) x 10^{-4}	Brake Power (kW)	BSFC (Kg/kW-hr)	Brake thermal eff. ηbth(%)
1	1	800	0.89285	0.2942	0.09456	6.83
2	2	800	0.89435	0.5884	0.1894	12.64
3	3	800	0.89635	0.88261	0.3656	23.41
4	4	800	0.89885	1.1768	0.275	27.14

BRAKE SPECIFIC FUEL CONSUMPTION:



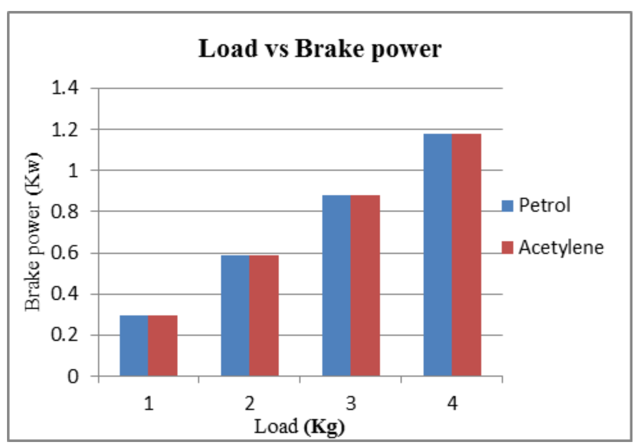
Graph 5.1 Load vs BSFC

The above graph shows the variation between load and brake specific fuel consumption. From the graph it can be observed that the brake specific fuel consumption of acetylene gas is lower than petrol.



Graph 5.2 Load vs Brake thermal efficiency

The above graph shows the variation between load and Brake thermal efficiency. From the graph it can be observed that the Brake thermal efficiency of acetylene gas is higher than petrol.



Graph 5.3 Load vs Brake power

The above graph shows the variation between load and Brake power. From the graph it can be observed that the Brake power of acetylene gas is equal the petrol.

6 CONCLUSION

Experiments were conducted to study the performance and emission characteristics of SI petrol engine in dual fuel mode of operation by aspirating acetylene gas in the inlet manifold for various loads, with petrol as an ignition source. The following conclusion has been arrived at, based on the experimental results: Brake thermal efficiency in dual fuel mode is lower than petrol operation at full load, as a result of continuous induction of acetylene in the intake. There is an increase in the peak cylinder pressure and rate of pressure rise, when gas is inducted. On the whole, it is concluded that acetylene induction resulted in a slight decrease in thermal efficiency, when compared to base line petrol operation. Exhaust temperature, HC, CO, CO2and smoke emissions were less than baseline petrol operation. However, a significant increase in the NO*x* emission is observed in the exhaust. To conclude, we state that acetylene would compete with hydrogen in near future for use of alternative fuel in internal combustion engine. By applying certain techniques like TMI, TPI of gas to get increased efficiency and reduced NOx emissions level .Dual fuel operation of acetylene exhibits lower exhaust gas temperature of about 76°C as compared to petrol operation.• There is a an appreciable reduction in smoke level. It dropped from 7 to 6.50 BSU when compared to neat petrol operation.A perceivable reduction in HC, CO and CO2 emissions was observed with acetylene operated dual fuel mode. There reduction in HC and CO2 emissions at maximum load is of 8 % and 3% respectively.

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