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Acetylene as Alternative Fuel in I.C Engine

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Abstract— Studies reveal that Acetylene gas produced from calcium carbide (CaC2) is renewable in nature and exhibits similar properties to those of hydrogen. An experimental investigation has been carried out on a single cylinder, Spark ignition (SI) engine tested with pure petrol and petrol- Acetylene dual fuel mode with diethyl ether as oxygenated additive. Experiments were conducted to study the performance characteristics of petrol engine in dual fuel mode by aspirating Acetylene gas in the inlet manifold, with petrol- diethyl ether blends as an ignition source. Fixed quantity of Acetylene gas was aspirated and Blend of diethyl ether with petrol was taken and then readings were taken at various loads. From the detailed study it has been concluded that the acetylene gas give gives less emission than petrol. Dual fuel operation along with addition of diethyl ether resulted in higher thermal efficiency when compared to neat petrol operation Acetylene aspiration reduces smoke and exhaust temperature.

Index Terms— Acetylene Gas, Internal Combustion Engine, Water, Calcium Carbide,Spark Ignition,renewable energy,dual fuel.

1 INTRODUCTION

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. 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. [3]

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 Knox 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. In the present statuesque where fossil fuel is on the verge to exhaust, the need of the hour is to search for an alternative fuel and we have many choices like LPG, CNG with their drawbacks. Due to which it is complicated to use them among various options acetylene gas is a very good fuel for automobiles but it also has many shortcomings which are needed to be studied before using. The paper investigates the changes required to be done for running a IC engine on acetylene produced on-board by a decomposition reaction of calcium carbide with water in presence of aluminium powder. Thus reducing the running cost and minimum pollutant emission, which makes it fit for use on economic and environment standard? It is more eco- friendly fuel option. [7]

Among the internal combustion engines, compression ignition (CI) engines are widely used. These engines give superior power output and consistent performance at all loads. Diesel is the prime fuel for CI engines. In the search of alternative fuels for diesel engines many fuels were experimented and successfully replaced, but at the sake of performance and emissions. The self-ignition temperature of acetylene which is actually drawn from the energy sources that are renewable is really exceptional and therefore more explicitly suitable for spark ignition engines. But in case of compression ignition engines they are not generally designed for gaseous fuels. Nevertheless, duel fuel suitability and design modifications are being done and implemented successfully. The Engines were also designed and used with gaseous fuels in dual fuel mode but were not successful. Emergent industrialization, limited reserves of fossil fuels and alarming environmental pollution necessitated to search for some more alternatives of conventional fuels. This ultimately resulted in fuels like CNG, LPG, Acetylene, ethanol, methanol, biodiesel, some vegetable oils and other such biomass resources. Alternative fuels should be easily available, should also have higher calorific value and should be non-polluting. Good quality fuel should fulfil environmental and energy needs without compromising the performance of the engine. Acetylene has many such qualities to be a good fuel among other alternative fuels because of its calorific value and combustion efficiency. NOx emission is a significant challenge for such an engine. Lean- burn technology with conventional and modified diesel combustion strategies would give encouraging results. Recent technologies like advanced combustion strategies which makes use of high levels of intensity to reduce the in-cylinder NOx formation. and post-combustion emissions control devices can be opted. Nevertheless, carrying cylinder and arresting the backfiring restricted the use of acetylene as a fuel in automobiles. We have worked out a system with which the acetylene can be used as an automobile fuel with better performance on par with Diesel engine. As in the present context, the world is facing difficulties with the 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), SO_x (Sulphur oxides), and particulates which are highly harmful to human health. CO_2 from Greenhouse gas increases global warming. Promising alternate fuels for internal combustion engines are natural gas, liquefied petroleum gas (LPG), hydrogen, acetylene, producer gas, alcohols, and vegetable oils. 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. And among these wide area of research, use of acetylene as internal combustion source in engine could be most appropriate field to research as alternative source of fuel and can be used as the synthetic fuel for transportation. [1]

1.1Overview

As we are well informed about the extinction of fossil fuels and its deteriorating effect on environment causing:

- 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 an absence of a compatible and eco-friendlier fuel we are still depend on these hydrocarbons 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 vapours. But as it has high ignition temperature certain engine modification are required.

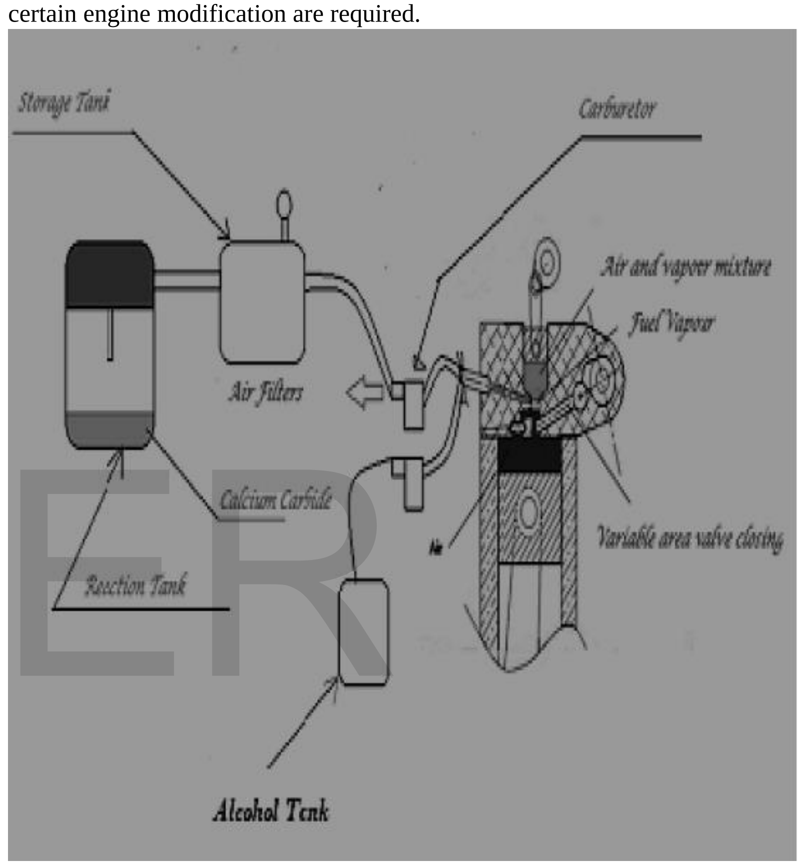

Fig.1.1. Overview of Experimental Setup

1. 1.2 Acetylene Gas

Acetylene (C_2H_2) is colourless gas used as a fuel and a chemical building block. As an alkyne, acetylene is unsaturated because its two carbon atoms are bonded together in a triple bond having CCH bond angles of 1800. It is unstable in pure form and thus is usually handled as a solution. Pure acetylene is odourless, but commercial grades usually have a marked odour due to impurities. [6]

In 1836 acetylene identified as a "new carburet of hydrogen" by Edmund Davy. The name "acetylene" was given by Marcelin Berthelot in 1860. He prepared acetylene by passing vapours of organic compounds (methanol, ethanol, etc.) through a red-hot tube and collecting the effluent. He also found acetylene was formed by sparking electricity through mixed cyanogen and hydrogen gases. [7]

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1.3 Acetylene Gas Production by Calcium Carbide

It was first prepared by the hydrolysis of calcium carbide, a reaction discovered by Friedrich Wohler in 1862.

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$$

Calcium carbide is manufactured from lime and coke in 60:40 ratios and Calcium carbide production requires extremely high temperatures, ~20000C, in an electric arc furnace.

1.4 Manufacturing Methods of Acetylene Gas by

Calcium Carbide There are two methods

1. Wet process
2. Dry process

In the wet process, calcium carbide is added to large quantity of water releasing acetylene gas and calcium hydrate as residue. Later is discharged in the form of lime slurry containing approximately 90% water. Amount of water is added to CaC2 (1:1 ratio) in a generator. The heat of reaction (166 Btu/ft3 of acetylene) is used to vaporize the excess water over the chemical equivalent.

In the dry process, in order to eliminate the waste of calcium hydrate equal, leaving a substantially dry calcium hydrate which is suitable for reuse as a lime source. The temperature must be carefully controlled below 150^0C at 15psi pressure throughout the process because the acetylene polymerizes to form benzene at 60^0C and decomposes at 780^0C. Further with air-acetylene mixture explodes at 480^0C.The crude acetylene gas containing traces of H_2S, NH_3 and phosphine (PH_3)

1.5 Safety and Handling

Acetylene is not especially toxic but when generated from calcium carbide it can contain toxic impurities such as traces of phosphine and arsine. It is also highly flammable. Acetylene can explode with extreme violence if the absolute pressure of the gas exceeds about 200kPa (29 psi). The safe limit for acetylene is 101kPag or 15 psi. That so it is shipped and stored by dissolving in acetone or dimethyl form amide (DMF), contained in a metal cylinder

1.6 Physical and Combustion Properties of Acetylene Gas.

Table No 1.1. Physical and Combustion Properties of Acetylene Gas [7]

Properties	Acetylene
Formula	C_2H_2
Density kg/m3 (At 1 atm & 20^0 C)	1.092
Auto ignition temperature (^{0}C)	305
Stoichiometric air Fuel ratio, (kg/kg)	13.2
Flammability limits (volume %)	2.5 – 81
Flammability limits (equivalent ratio)	0.3 – 9.6
Lower Calorific Value (Kj/kg)	48,225
Lower calorific Value (kj/m3)	50,636
Max deflagration Speed (m/sec)	1.5
Ignition energy 3333(MJ)	0.019
Lower heating Value of stoichiometric mixture (kj/kg)	3396

Before testing acetylene, its properties and their implications relative to the safety of test personnel were analysed. Some of these properties, for both acetylene and unleaded reference gasoline (clear Indolence), are shown in Table I. Those characteristics which represent a hazard are discussed below, whereas the remainder are provided for information only.

There are basically two ways of providing acetylene for use in a vehicle. The fuel can either be carried in pressurized tanks or it can be generated on board. Hazards of these two approaches, and safety problems common to both, will be presented in the following paragraphs. The greatest danger associated with pressurized acetylene storage is the fuel's potential to decompose explosively. Acetylene can, even in the absence of oxygen, decompose rapidly by the process.

$$C_2H_2 = 2C + H_2 + 230 \text{ kJ}$$

If this decomposition occurs, and either the fuel tank or fuel lines rupture, fire will likely follow. As a result, U.S. Department of Transportation regulations limit the maximum pressure of shipped acetylene cylinders to 1825 kPa. A pressure this high is permissible only because the acetylene is dissolved in a stabilizing agent (acetone) absorbed in a filler The filler is designed to divide the tank into small cells in which decomposition would be quenched. When acetylene is removed from the tank, most of the acetone remains behind. To avoid explosion at this time, the delivery pressure must not be raised above 205 kPa Since the delivery pressure must be kept low, it is not possible to meter acetylene into an engine using critical flow. One way to avoid some of the dangers inherent to storing high pressure acetylene aboard a vehicle is to generate it on board at relatively low pressures. The calcium carbide-water reaction

$$CaC_2 + 2H_20 = C_2H_2 + Ca(OH)_2$$

could be used for this purpose. Depending on the purity of the calcium carbide, toxic gases such as arsine and phosphine might also be produced. If calcium carbide comes in contact with human skin, the above reaction will occur, leaving a residue of calcium hydroxide which is caustic and may cause skin burns. Even if this problem is minimized by careful handling procedures, the large amount of calcium hydroxide produced in the acetylene generating process would present a disposal problem.

1.7 Ozone Layer Depletion

Despite playing a protective role in the stratosphere, at ground-level ozone is classified as a damaging trace gas. Photochemical ozone production in the troposphere, also known as summer smog, is suspected to damage vegetation and material. High concentrations of ozone are toxic to humans. Radiation from the sun and the presence of nitrogen oxides and hydrocarbons incur complex chemical reactions, producing aggressive reaction products, one of which is ozone. Nitrogen oxides alone do not cause high ozone concentration levels. Here are some of the comparisons of POPC between several compounds. [5]

Note that acetylene has very low POPC that implies it has low reactivity towards OH - radical. The total emissions vary greatly with fuel structure. Two factors have been identified for this large variation: diffusion and reactivity. Diffusion of fuel molecules from boundary layers near the cylinder wall into the hot core gas causing partial oxidation of this fuel may be a significant source of burn-up of HC species exiting crevices during the expansion stroke. Thus, higher molecular weight fuels, which diffuse more slowly, tend to exhibit higher emissions.

VOC	POCP
Ethane	8.8
Propane	18.3
n-Butane	36.3
n-Pentane	36.6
2.2Dymethylpropane	20.3
n-Hexane	45.6
n-octane	40.1
Ethylene	100
Propene	105.4
Acetylene	9.9
Formaldehyde	47.1
Acetone	7.5
Butanone	35..3
Methanol	16.5
Benzene	20.3
Toluene	51.0
Beazaklehyde	10.3

Table 1.2 POPC comparison of different compounds [5]

3. 2.EXPERIMENTAL WORK

2.1 Production of Acetylene Gas.

Calcium carbonate reacts with graphite in nature and forms as calcium carbide rocks. These reactions are taking place naturally. For production of acetylene, calcium carbide should mix with normal water. So anyone can produce acetylene gas if one can have a gas collecting container and storage device. In welding shops acetylene is producing in acetylene gas generators by following this equation only. [2]

(i) $CaCO_3 + C(graphite) \rightarrow CaC_2$

(ii) $CaC_2 + H_2O \rightarrow Ca(OH)_2+C_2H_2$

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Properties	Acetylene	Petrol	Diesel
Formula	C_2H_2	C_8H_{18}	C_8—C_{10}
Density kg/m^3 (At 1 atm & 20°C)	1.092	800	840
Auto ignition temperature(°C)	305	246	257
Stoichiometric air fuel ratio (kg/kg)	13.2	14.7	14.5
Flammability Limits (Volume %)	2.5-81	1.2-8	0.6-5.5
Flammability Limits (Equivalent ratio)	0.3—9.6	----	-----
Lower Calorific value (kJ/kg)	48,225	44500	42,500
Lower Calorific value (kJ/m^3)	50,625	----	-----
Max deflagration speed (m/sec)	1.5	----	0.3
Ignition energy(MJ)	0.019	----	-----
Lower Heating value (kJ/kg)	3396	----	2930

Table No 3.1-Physical and combustion properties of fuels [7]

Use of Acetylene as an Alternative Fuel in IC Engine the overview of project in three steps is as follows

Step 1: The first step involves the production of acetylene gas through the Calcium Carbide reacting with water in the reaction tank. $CaC_2+2H_2O \rightarrow C_2H_2+Ca(OH)_2$. The reaction tank constitutes of calcium carbide.

Step 2: The water from the water tank is released in the reaction tank and the reaction occurs spontaneously. The water is passed through the control valve. In the reaction tank the calcium carbide is kept in desirable amount to react with water. Through reaction tank a valve is connected to the supply line.

Step 3: In this step the acetylene gas is stored in the reaction 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 reaction tank is provided pressure through pressure gauge so the gas is of high concentration.

Step 4: The gas is passed in the pipe in very sophisticated manner and then pipe is joined in the carburettor fitted with the filter, this then filters the air and then combines with air.

Step 5: Before supplying gas some amount of petrol is use to start the engine and then the mixture is passed in the engine

2.2 Working Process of the Setup

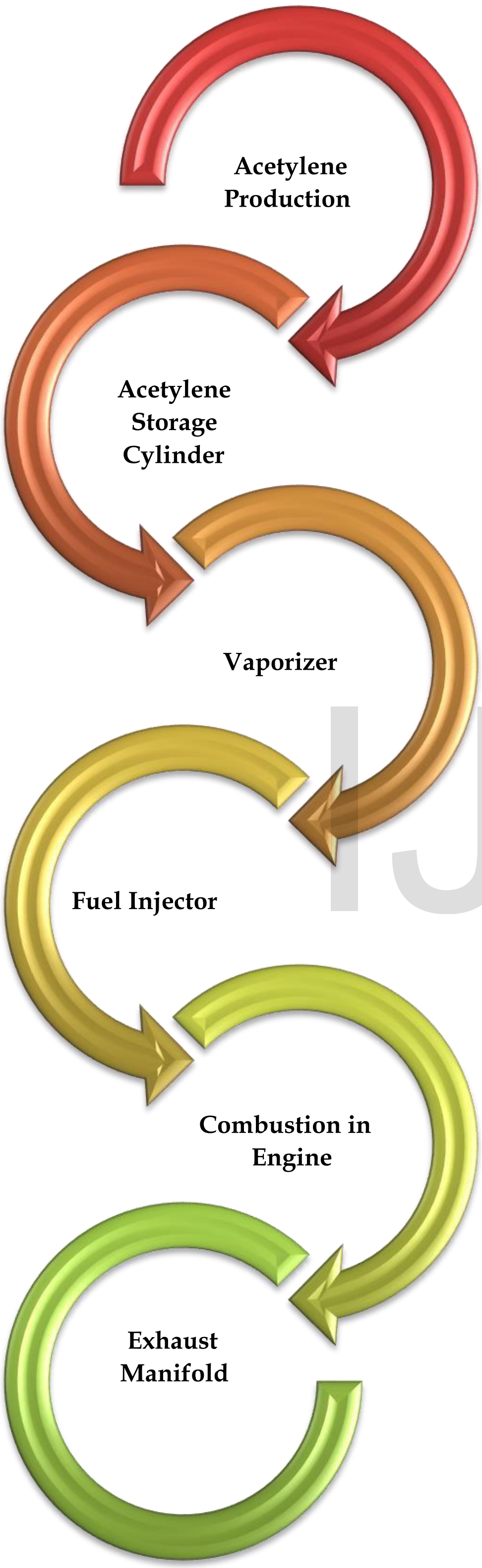

Fig. 2.1 Working Process

3 2.3 Basic Component of Project

i. Storage tank
ii. Vaporizer
iii. Reaction tank
iv. Pressure gauge
v. Pressure relief valve
vi. Calcium Carbide
vii. S I engine
viii. Base frame

3 2.3.1 Acetylene Storage Tank

In this calcium carbide reacts with water to produce acetylene and calcium hydroxide. Small amount of aluminium oxide is mixed to enrich the above reaction. Specification of production tank Cylinder is made up steel which can withstand 2MPa pressure and dimension of tank are 33inch in length and 13inch in diameter. In this tank on board exothermic reaction takes place on which acetylene is formed through this reaction.
The acetylene gas then enters in the storage tank.

$$CaCO_3 + 2H_2O \rightarrow C_2H_2 + Ca(OH)$$

Fig. 2.2 Acetylene Storage Tank [3]

This storage tank is made up of steel and consists of pressure gauge to measure the internal pressure of acetylene. The inner lining of cylinder is made up of sponge which is shucked in acetone due to which it absorbs acetylene in large volume and maintains it in subcritical condition eliminating the condition of detonation and maintains its stability.

Fig. 2.3 Gas Storage Tanks [3]

2.3.2 Vaporizer

It is very similar to carburettor, as carburettor mixes air and liquid fuel but vaporizer mixes air and gaseous fuel. It consists of four valves:

- Water in
- Acetylene in
- Water out
- Gaseous fuel out

The acetylene gas enters the regulator and then is vaporized using heat from the engine's coolant. Tank pressure is reduced to approximately 1.5 psi. As negative pressure is transmitted from the carburettor to the regulator, the regulator releases acetylene vapour to the carburettor.

2.3.3 Reaction tank

A Reaction tank is an enclosed volume in which a chemical reaction takes place. In chemical engineering, it is generally understood to be a process vessel used to carry out a chemical reaction, which is one of the classic unit operations in chemical process analysis. The design of a chemical reactor deals with multiple aspects of chemical engineering. Chemical engineers design reactors to maximize net present value for the given reaction. Designers ensure that the reaction proceeds with the highest efficiency towards the desired output product, producing the highest yield of product while requiring the least amount of money to purchase and operate. Normal operating expenses include energy input, energy removal, raw material costs, labour, etc. Energy changes can come in the form of heating or cooling, pumping to increase pressure, frictional pressure loss or agitation.

Fig. 2.4 Reaction Tanks [3]

2.3.4Water Storage tank

A water tank is a container for storing water. Water tanks are used to provide storage of water for use in many applications, drinking water, irrigation agriculture, fire suppression, agricultural farming, both for plants and livestock, chemical manufacturing, food preparation as well as many other uses. Water tank parameters include the general design of the tank, and choice of construction materials, linings. Various materials are used for making a water tank: plastics (polyethylene, polypropylene), fiberglass, concrete, stone, steel (welded or bolted, carbon, or stainless). Earthen pots also function as water storages. Water tanks are an efficient way to help developing countries to store clean water.

Fig. 2.5 Water Storage tank

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2.3.5 Pressure Gauge

Pressure measurement is the analysis of an applied force by a fluid (liquid or gas) on a surface. Pressure is typically measured in units of force per unit of surface area. Many techniques have been developed for the measurement of pressure and vacuum. Instruments used to measure and display pressure in an integral unit are called pressure gauges or vacuum gauges. A manometer is a good example as it uses a column of liquid to both measure and indicate pressure. Likewise, the widely used Bourdon gauge is a mechanical device which both measures and indicates and is probably the best known type of gauge.

Fig. 2.6 Pressure Gauge

A vacuum gauge is a pressure gauge used to measure pressures lower than the ambient atmospheric pressure, which is set as the zero point, in negative values (e.g.: -15 psi or -760 mmHg equals total vacuum).

2.3.6 Pressure Relief Valve

A safety valve is a valve that acts as a fail-safe. An example of safety valve is a pressure relief valve (PRV), which automatically releases a substance from a boiler, pressure vessel, or other system, when the pressure or temperature exceeds present limits. valves are a specialized type of pressure safety valve. A leak tight, lower cost, single emergency use option would be a rupture disk.

Fig. 2.7 Pressure Relief Valve

2.3.7 Calcium Carbide

Calcium carbide is a chemical compound with the chemical formula of CaC_2. Its main use industrially is in the production of acetylene and calcium cyanimide. The pure material is colourless, however pieces of technical-grade calcium carbide are grey or brown and consist of about 80–85% of CaC_2 (the rest is CaO (calcium oxide), Ca_3P_2 (calcium phosphide), CaS (calcium sulphide), Ca_3N_2 (calcium nitride), SiC (silicon carbide), etc.). In the presence of trace moisture, technical-grade calcium carbide emits an unpleasant odour reminiscent of garlic.

Applications of calcium carbide include manufacture of acetylene gas, and for generation of acetylene in carbide lamps; manufacture of chemicals for fertilizer; and in steelmaking.

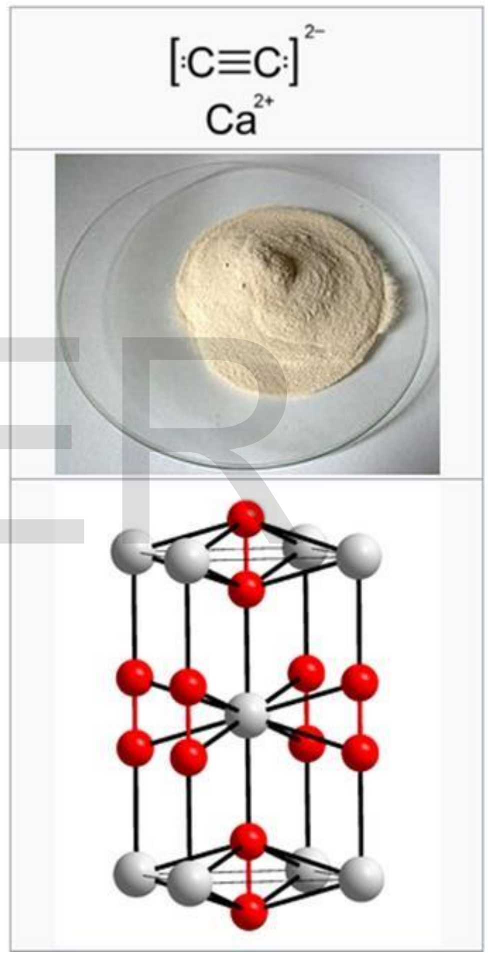

Fig. 2.8 Calcium Carbide

2.3.8 Spark-Ignition Engine

A spark-ignition engine is an internal combustion engine, generally a petrol engine, where the combustion process of the air-fuel mixture is ignited by a spark from a spark plug. This is in contrast to compression-ignition engines, typically diesel engines, where the heat generated from compression together with the injection of fuel is enough to initiate the combustion process, without needing any external spark.

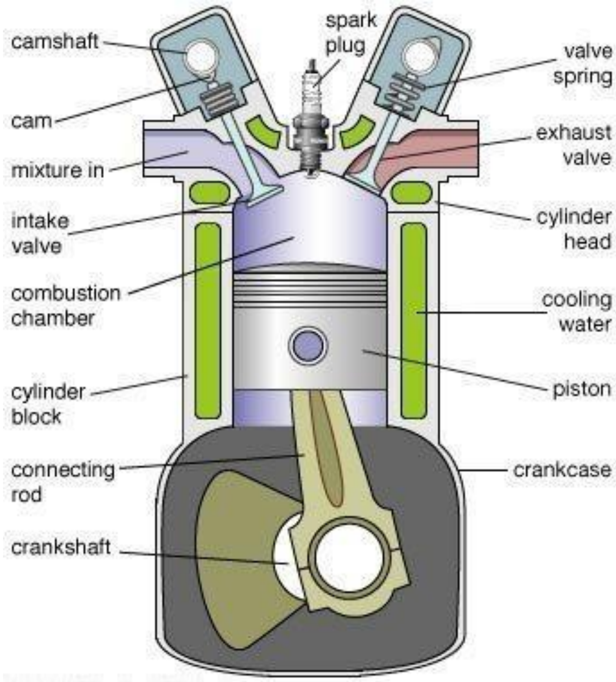

Fig. 3.9 Spark-Ignition Engine

2.3.8.1 Engine Specifications

The engine is single cylinder four stroke 110 cc engine we used. Specification of the engine is as below.

Model	Honda Kinetic
Type	Air Cooled, 2 Stroke
Displacement	110 Cc
Max. Power	7.8 Ps @ 5600 rpm
Max. Torque	9.4 Nm @ 4500 rpm
Bore x Stroke	51.7 x 52.4 mm
Compression Ratio	7:7:1
No. of Cylinders	One
Starting	Kick
Fuel System	Petrol
Transmission	Auto
Oil Sump Capacity	1.2 Lubricating Oil Tank
Weight of Engine	24.4 Kg
Final Drive	Belt

Table 3.2 Engine Technical Specification

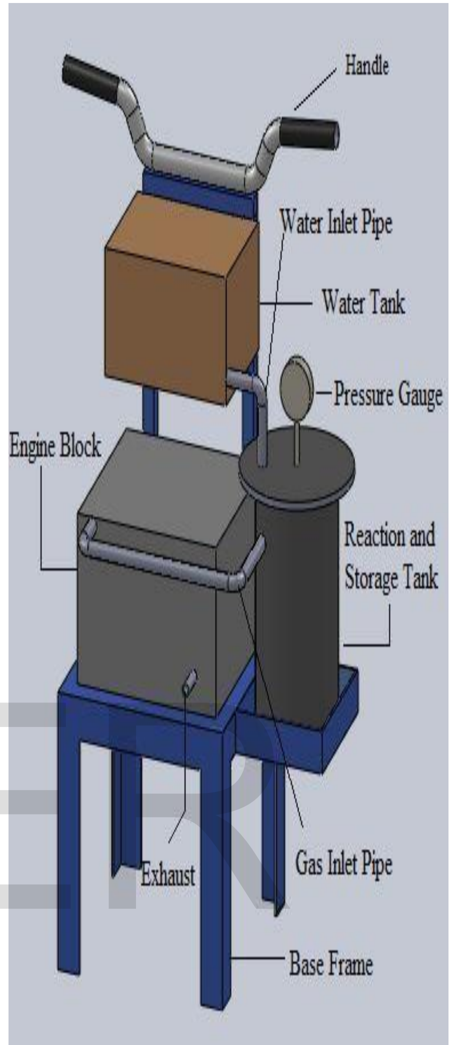

Fig. 3.10 Experimental Setup Model

3. EQUATIONS

Diameter of reaction cylinder = 180mm

Volume of cylinder = $(\pi/4) \times d^2 \times L$

$= (\pi/4) \times 180^2 \times 300$

$V = 7634070.15 \text{ mm}^3$

During the test run of Setup,

Amount of water used is 200 ml = 200000 mm^3 ($\because$1 ml = 1000 mm^3)

Amount of Calcium carbide used 500 grams = 500000 mm^3 ($\because$1 gm = 1000 mm^3)

Total mixture is 700 ml = 700000 mm^3

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Out of total volume of cylinder 9.16 % volume is occupied with water + carbide mixture.
Remaining volume available is the volume occupied by gas which is used as fuel. i.e. = 6934070.15 mm^3
Therefore,

100 - 9.16 = 90.84 %

Hence, 90.84 % of cylinder volume is filled with fuel gas.

Amount of gas available inside the cylinder is 6934070.15 mm^3.

It is observed that during the test run, the engine worked for about 4-5 min.

Hence it can be stated that, 500 gm + 200 ml of water = 700 ml of mixture is sufficient to run the engine for 5 min.

According to this, in 1 litter of water + carbide mixture the engine will run for approximately 7 – 8 minutes.

3.1 Engine Modification

After successful run of engine with acetylene gas we came to know that engine has knocking. Knocking in internal combustion engines occurs when combustion of some of the air/fuel mixture in the cylinder does not result from propagation of the flame front ignited by the spark plug, but one or more pockets of air/fuel mixture explode outside the envelope of the normal combustion front. The fuel-air charge is meant to be ignited by the spark plug only, and at a precise point in the piston's stroke. Knock occurs when the peak of the combustion process no longer occurs at the optimum moment for the four-stroke cycle. The shock wave creates the characteristic metallic "pinging" sound, and cylinder pressure increases dramatically. Effects of engine knocking range from inconsequential to completely destructive. Knocking should not be confused with pre-ignition they are two separate events. However, pre-ignition is usually followed by knocking. Due to the large variation in fuel quality, a large number of engines now contain mechanisms to detect knocking and adjust timing or boost pressure accordingly in order to offer improved performance on high octane fuels while reducing the risk of engine damage caused by knock while running on low octane fuels. So to eliminate this knocking property we had to options, either modify the engine or else degrade the fuel properties. Modification of Engines include –

3.1.1 Twin Spark Ignition

After analysis of the efforts of researchers trying to run on acetylene we have come across the conclusion to use twin spark plugs in a single cylinder for acetylene due to this reasons. As there is no delay in combustion, the gas entering the combustion chamber burns instantaneously causing knocking effect. So twin spark for valve engine will reduce the knocking effect in engine also knocking wear and tear even distortion in the engine structure which would be reduced to produce negligible effect.

Fig. 3.11 Twin Spark Plugs [3]

3.1.2 Increasing Swept Volume

By increasing length of connecting rod or by increasing diameter of cylinder which increases the combustion time. For this increasing the diameter of cylinder of cylinder would be better according to Indian aspects and oversized piston can be used in that case, while in case of western countries increasing length of connecting rod would be beneficial. [3]

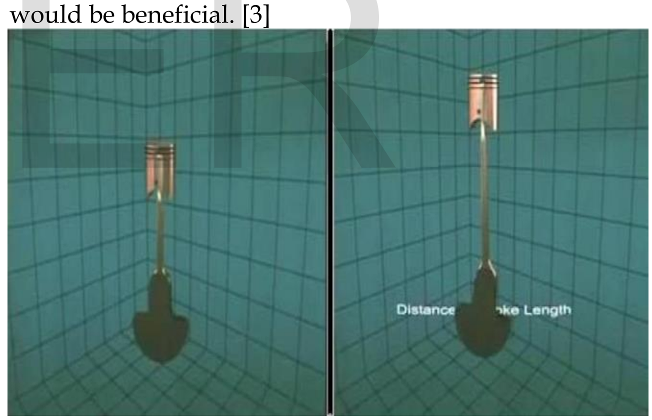

Fig. 3.12 Increment in length of connecting rod [3]

*3.1.3.*Cam Timings

Cam monitors the sequence and timing of opening and closing of inlet and outlet valves thus variation in design of cam would be for change in timing of inlet valve. The timing of inlet valve should be increased i.e. inlet valves should be open slowly and for longer time than normal. [3]

3.1.4.Fuel Alteration

As acetylene gas is having highly in flammability property, it also affects the smooth running of engine. For that purpose, we need to alter the acetylene gas properties by adding secondary fuel to it. We can illustrate that the use of secondary fuel is very essential in this project for the control of the user over the auto-ignition and knocking in the vehicle. The illustration of this phenomenon isn't mentioned here but we can simply compare the temperatures of the following fuels. [3]

Table 3.3 Flame temperature comparison

Acetylene	2908.120K
Gasoline	2068.980K
Acetylene with vapour	2072.840K
Acetylene with alcohol	2569.540K

From above results we can say that alcohol is to be introduced so as to reduce the temperature inside the combustion chamber. For start-up and operation of the engine, two stages are involved: first the engine is started by secondary fuel (use of ethyl alcohol or water) after certain warm up period, operating the engine by the use of primary fuel (acetylene) is done to generate power output from the engine. The use of secondary fuel reduces the thermal expansion inside the cylinder and hence the pressures and temperatures inside the cylinders are reduced. Moreover, the problem of knocking and auto-ignition of the fuel inside the engine is eliminated and the engine thus runs smoothly.

3.2.Emission Test

The variation of smoke level with brake power is seen. 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. 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.

Table no. 3.4 Emission Test

Fuel mode	Carbon Monoxide in %	Hydrocarbon In PPM	Non Methane HC %	Reactive HC
Acetylene gas	2.759	272	--	--

3.2.1 Hydrocarbon Emissions

Depicts the variation of hydrocarbon emissions with load. The HC emissions are 900 ppm in baseline petrol operation and 272 ppm 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.

3.2.2 Carbon Monoxide Emissions

The variation of carbon monoxide emissions with load exhibits similar trend of HC. The CO emissions are quit higher than compared to the base line petrol operation. The CO emission is 1.361% by volume followed by base line petrol and 2.759% at full load followed by base line as an acetylene gas. The CO emissions are higher due to the incomplete burning of the fuel.

3.2.3*Carbon Dioxide Emissions*

The CO_2 emissions are lower compared to the base line petrol, the minimum being 0.18% by volume at full load in acetylene induction technique followed by 3.04% by volume in baseline petrol operation. The CO_2 emission of acetylene is lowered because of lower hydrogen to carbon ratio.

1 4.Advantages

i. Emission is non-polluting as only carbon dioxide and water vapours are emitted.
ii. Homogenous mixture is formed due to which complete combustion.
iii. Better efficiency. iv. It is very cheap and available in abundance.
v. It uses same handling system which is used in CNG and LPG cylinders.
vi. It has very low Photochemical Ozone Creation Potential (POCP).
vii. An engine operated on such a fuel can be interchangeably utilized for indoor and outdoor operations without environmental concerns.
viii. The need for a three-way catalytic converter or other EGR device is eliminated.
ix. Due to reduced operating temperatures, there are fewer tendencies for viscosity breakdown of engine lubricants and less component wear.
x. It provides a better thermal efficiency.
xi. The fuel can be prepared at any temperature any pressure conditions in any corner of the world. [6]

5.Disadvantages

i. Modification in SI engine is required
ii. Knocking possibilities.
iii. Decrease in power of engine.
iv. It cannot be available everywhere because there is no filling station as it is a new initiative. [3]

6. Applications

i. A good replacement for gasoline and petrol.
ii. It can be used in place of LPG directly with minor manipulation in engine.
iii. As it emits CO_2, so it is eco-friendlier thus its use can be beneficial in countries like India where in year 2050 fossil fuel will get depleted (shown by studies). [3]

7. Conclusion

i. The study highlights the use of acetylene as a fuel for SI engine; this fuel can be used with conventional S.I. engine with minor fabrication and manipulations
ii. As acetylene has wide range of merits on environmental as well as economic grounds. It produces only carbon dioxide during combustion and is less costly than conventional fuel acetylene is produced from calcium carbonate which is in abundance.
iii. Acetylene have proved out to be better fuel due its non – polluting nature and more economic.

8.Future Scope

i. In nearby future, fossil future going to exhaust soon and at present we are facing acute scarcity of fuel due to which prices are rising day by day. On the other acetylene is cheap and is produced from calcium carbide which is in abundance.
ii. Another advantage which justifier the use of acetylene in future is in the exhaust emission on one hand fossil fuel during combustion produces CO2, CO, NOx, some unburnt hydrocarbon are produces but in case of acetylene carbon dioxide is produced with traces of water vapours.
iii. Acetylene being gas makes better homogenous mixture with air therefore better mixing of fuel which leads to better combustion; this is not possible with conventional SI engine fuel.
iv. Acetylene as a fuel can be used as power generator fuel in rural areas.
v. Acetylene gas can be useful for all SI and CI engine vehicles in future, especially in vintage cars.

REFERENCES

[1] S. Swami Nathan, J.M. Mallikarjuna, A. Ramesh. "Effects of charge temperature and exhaust gas re-circulation on combustion and emission characteristics of an acetylene fuelled HCCI engine." Fuel 89, (2010) 515–521

[2] Mr. Rushikesh D. Jadhav, Mr. Vivek U. Mitkari. "Experimental Analysis of

Acetylene Gas as an Alternative Fuel for S.I. Engine." International Engineering

Research Journal (IERJ) Special Issue Page 208-215, June 2016, ISSN 2395-1621

[3] Suyash Kamal Soni, Rahul Jain, Adarsh Choubey, Abhineet Sharma. "Fabrication of S.I. Engine to Use Acetylene as Fuel." IRF International Conference, 15th February (2015)

[4] Mehmet Ilhan Ilhak, Selahaddin Orhan Akansu, Nafiz Kahraman, Sebahattin

Unalan. "Experimental study on an SI engine fuelled by gasoline/acetylene mixtures." Energy, (2018)

[5] Prabin K. Sharma, Harihar Kuinkel, Praveen Shrestha, Suman Poudel. "Use of

Acetylene as an Alternative Fuel in IC Engine" Rentech Symposium Compendium, Volume 1, (2012)

[6] Mitul Prajapati, Panchal Nandkishor H., Patel Meet J., Patel Krishn P. "Use of

Acetylene as an Alternative Fuel in Modified SI Engine" International Journal of Advance Research, Volume 4, Issue 2, (2018)

[7] T. Lakshmanan, G. Nagarajan. "Performance and Emission of Acetylene-

Aspirated Diesel Engine" Jordan Journal of Mechanical and Industrial Engineering, Volume 3, Number 2, (2009), Pages 125-130

[8] Pritinika Behera, S. Murugan, G. Nagarajan. "Dual fuel operation of used transformer oil with acetylene in a DI diesel engine" Energy Conversion and Management 87, (2014), 840-847

[9] T. Lakshmanan, G. Nagarajan. "Study on using acetylene in dual fuel mode with exhaust gas recirculation" Energy 36, (2011), 3547-3553