© 2019 IJSRSET | Volume 6 | Issue 2 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section : Engineering and Technology
DOI : https://doi.org/10.32628/IJSRSET196219

Experimental study of carbide as an alternative fuel using in Internal Combustion Engine

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ABSTRACT

The emerging world need alternative fuel for diesel and petrol. This is the experiment that using the carbide as the alternative fuel for internal combustion engine by converting the carbide as the acetylene using water. The brake thermal efficiency, exhaust gas temperature, smoke emission, CO2 emission, NOx emission, hydrocarbon emission, performance of the engine is studied under this Experiment

Keywords : Alternative Fuel, Carbide To Acetylene Gas , Comparisons, Performance

I. 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. CO2 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. 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.

However, as fuel displaces equivalent amount of air the engines may have poor volumetric efficiency. There are fairly few gaseous fuels that can be used as alternative fuels. As we are well informed about the extinction of fossil fuels and its deteriorating effect on environment causing: Environmental Effects like 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 follow. 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.

Review of literature

G.Nagarajan and T.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

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

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

II. PREPARATION OF ACETYLENE GAS

Acetylene Gas Acetylene (C2H2) 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. 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 acetylene torches for welding or welding-related applications. 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 straight forward chemical process in which calcium carbide reacts with water and generates acetylene gas and slurry of calcium carbonate. It needs no sophisticated apparatus or equipment and the reaction is spontaneous. It was widely used in acetylene lamps, to light homes and mining tunnels during 1980s. It is a gaseous hydrocarbon highly combustible and unstable. It also produces high flame temperatures ranging from 3000°C to 5400°C when combined with oxygen. Acetylene has been commonly utilized for lighting in mine areas by street vendors, besides which industrial uses of acetylene are many out of which it is used as a fuel for motors or lighting sources. The use of acetylene as a fuel has been largely limited in the recent times to acetylene torches for welding or welding-related applications.

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.

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.

$$CaC2+2H2O \rightarrow C2H2+Ca\ (OH)2$$

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 carburetor 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.

Calcium carbide (CaC2) 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:

$$CaO + 3C \rightarrow CaC2 + CO$$

Lime for the reaction is usually made by calcining 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, aluminium 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 (CO2) 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. Electrode paste composed of coal tar pitch binder and anthracite coal is fed into a steel casing where it is baked by heat from the electric arc furnace before being introduced into the furnace. The baked electrode exits the steel casing just inside the furnace cover and is consumed in the calcium carbide production process. Molten calcium carbide is tapped continuously from the furnace into chills and is allowed to cool and solidify.

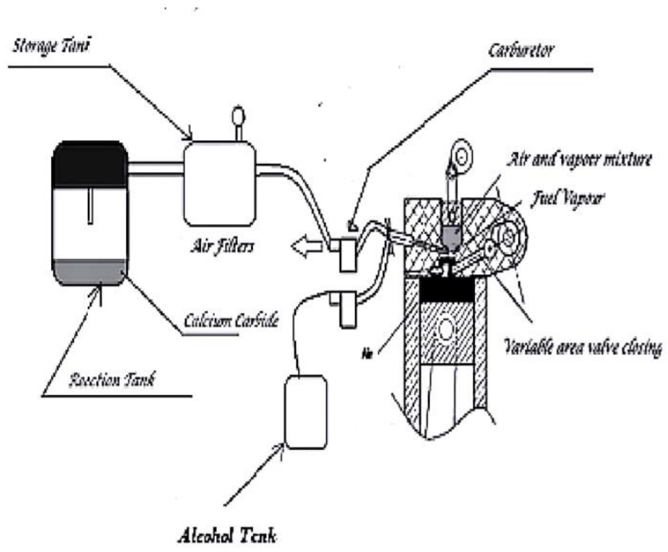
Then, the solidified calcium carbide goes through primary crushing by jaw crushers, followed by secondary crushing and screening for size. To prevent explosion hazards from acetylene generated by the reaction of calcium carbide with ambient moisture, crushing and screening operations may be performed 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.

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 baselinepetrol 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.

Experimental setup

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



Parts of experimental setup

Reaction tank (calcium carbide with water), Air filter ,Carburetor

Working 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 gas passed through the carburetor and gas open and close is 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.

III.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.

Brake Thermal Efficiency

The variation of brake thermal efficiency with brake power is shown in figure. 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. 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.

Exhaust Gas Temperature:

The exhaust gas temperature at full load, depicted in figure reaches 368oC in acetylene induction technique and 444oC in the case of base line petrol operation. Acetylene induction 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.

Oxides of Nitrogen (NOx):

It can be observed from figure 4 that NOx emission is 1866 ppm at maximum output with neat petrol fuel operation. In dual fuel operation with acetylene induction, NOx emission is increased by 17% when compared to baseline petrol operation. According to zeldovich mechanism model, the formation of NOx is attributed to the reaction temperature, reaction duration, and the availability of oxygen. When acetylene is inducted, increase in NOx may be attributed to the increased peak cycle temperature level because of faster energy release, which is confirmed by increased peak cycle pressure.

Smoke:

The variation of smoke level with brake power is shown in figure . 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. The smoke level is reduced by 14% 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.

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.

Carbon Monoxide Emissions:

The variation of carbon monoxide emissions with load exhibits similar trend of HC. 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.

Carbon Dioxide Emissions:

The CO2 emissions are lower compared to the base line petrol, the minimum being 8.7% 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 CO2 emission of acetylene is lowered because of lower hydrogen to carbon ratio.

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 in dual 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 3bar when acetylene is inducted. The peak pressure for acetylene inducted dual fuel engine is advanced by 5°CA 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.

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. 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.

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. Load (Kg) ,Speed (rpm) , Time for 10 ml of fuel consumption of petrol (Sec) ,Mass of fuel for acetylene gas (Kg/Sec) On the basis of above parameters following different results are calculated for various reading. Break power (KW), Break specific fuel consumption (Kg/KW.hr) ,Break thermal efficiency (%). Different graphs were plotted on above results are as follows. Break power Vs BSFC, Load Vs Break thermal efficiency ,Load Vs BSFC, Specific fuel consumption Vs Break power

Specifications 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

Calculation procedure for performance testing:

1. Brake power (kw) : BP = (W*N)/K
   Where K=2719.2 = constant of dynamometer
2. Fuel consumption:

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

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

3. Brake specific fuel consumption (kg/KW-hr):

= Fuel consumption (kg/sec) *3600 / Brake power

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

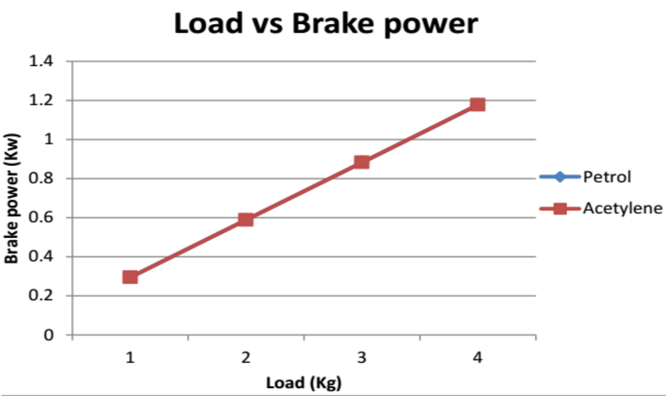
=calorific value of fuel *fuel consumption = (kJ/hr)

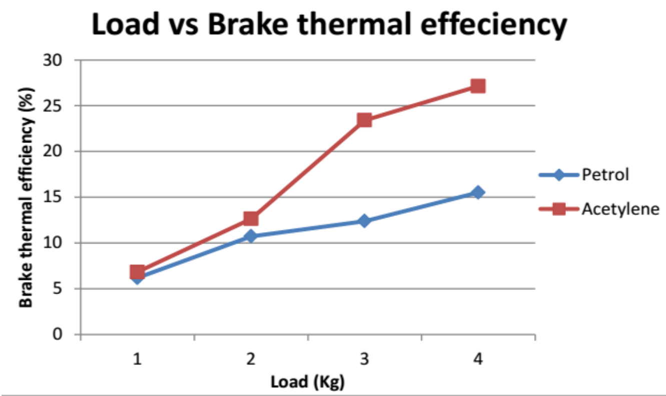
5. Brake thermal efficiency:

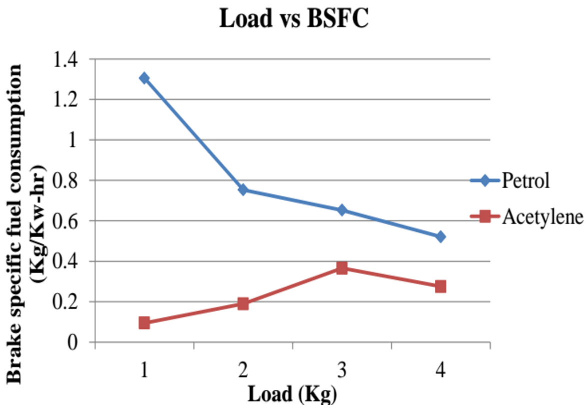
ηbth = Heat equivalent of bp/hr / heat supplied fuel per hour

Observations:

Measurement and result got by conducting trial using petrol, acetylene gas of graphical representation given below :







IV. 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 baseline petrol operation. Exhaust temperature, HC, CO, CO2and smoke emissions were less than baseline petrol operation. However, a significant increase in the NOx 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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Cite this article as :

Prof. Ganesh. M, Jagadeesan. S, Bharathwaj. S, "Experimental study of carbide as an alternative fuel using in Internal Combustion Engine ", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), ISSN : 2456-3307, Volume 6 Issue 2, pp. 106-114, March-April 2019.
Available at doi :
https://doi.org/10.32628/IJSRSET196219
Journal URL : http://ijsrset.com/IJSRSET196219