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Experimental Analysis of S.I. Engine Using Acetylene and Petrol Blended Fuel

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***Abstract-* Depletion of fossils fuels and environmental degradation have prompted researchers throughout the world to search for a suitable alternative fuel for internal combustion engine. In this study, acetylene gas has been considered as an alternative fuel for spark ignition engine, which has excellent combustion properties. The experimental investigation has been carried out on a single cylinder, spark ignition and air-cooled engine run in dual fuel mode with acetylene as primary fuel and petrol inducted as secondary fuel.**

Engine being run at various speeds and the perfect volumetric blending mixture ratio of acetylene and petrol for smooth functioning of a Spark ignition petrol engine, problems like knocking and pre- ignition eliminated.

Index Terms- Spark Ignition Engine, Petrol, Acetylene Gas, Combustion, Carburetor.

I. INTRODUCTION

Conventional hydrocarbon fuels used by internal combustion engines, which continue to dominate many fields like power generation, transportation and agriculture leads to pollutants like particulates, HC (hydrocarbons) and SOx (Sulphur oxides), which are highly harmful to human health. CO2 from Greenhouse gas increases global warming, sea level rise and Climatic changes [1]. To tackle these problems there is need for alternate sources of fuel for power generation which should not produce harmful emissions like fossil fuels. Promising alternate fuels for internal combustion engines are natural gas, liquefied petroleum gas (LPG), hydrogen, acetylene, producer gas, alcohols, and vegetable oils [2-3]. 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 [4-5].

They have a high self-ignition temperature; and hence are excellent spark ignition engine fuels. The principal objective of the present project includes providing a charge comprising acetylene as a primary fuel and petrol as secondary fuel for an internal combustion engine [6-7]. By using acetylene, the pollutants like CO, CO2, SOx and HC are proved be minimum by many experiments conducted. Hence, we chose acetylene as the primary fuel for our research on alternate fuel for SI engines which is cheap, renewable and less polluting. Acetylene is the chemical compound with the formula C2H2. It is a hydrocarbon and the simplest alkyne. This colorless gas is widely used as a fuel and a chemical building block. It is unstable in its pure form and thus is usually handled as a solution. Acetylene (C2H2) is not only an air gas but also a synthesis gas and produces a very hot flame (over 5400°F or 3000°C) when combined with oxygen.

II. EXPERIMENTAL SETUP

The setup needed to do the experiment consists of some new components added to vehicle and some modifications done to the existing components. The major components needed for the experimentation of acetylene gas as fuel in SI engine are as follows: Acetylene gas generator, SI Engine, Non- Return valve, Carburetor, Gas Mixer, Modified Inlet Manifold, Calcium carbide.

A. Acetylene gas generator

Acetylene gas generator has two chambers one like a cylinder and at the bottom of that cylinder for the carbide supply. The carbide is put inside the lower chamber and half of the cylinder is filled with water, there is pipe with a control valve running into the lower chamber from the cylinder to supply water for reaction. When the valve is opened, the water reacts with the carbide and gas produced is stored above the water level in the cylinder. This gas is extracted with a control valve at the top of the cylinder. The cylinder is also fitted with a safety valve and a pressure gauge as a precautionary measure.

Fig.1: Acetylene gas generator

The reaction of calcium carbide with water, producing acetylene and calcium hydroxide, was discovered by Friedrich Wöhler in 1862.

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

Modified inlet manifold

Fig.2:Modified Inlet Manifold

The Inlet manifold is modified to suit the needs of the Dual fuel mode of the SI engine. In this we need to start the engine using secondary fuel i.e., petrol so we need carburetor and then supply primary fuel i.e., acetylene gas so we need gas mixer as well. Hence, we had to modify the Inlet manifold to accommodate both the carburetor and the gas mixer into one assembly

B. Other required accessories

- Gas valve regulators: Used to regulate the gas supply to the gas mixer, by doing this there will be a change the speed of the engine because the more gas goes in the more speed it achieves. Hence, the gas regulators can be used as throttle valves.
- Gas pipes: Used to supply the gas generated from the storage tank to the gas mixer.
- Petrol testing can: Used to know the amount of petrol used in certain run time of engine. This is helpful in calculating the blending ratio of petrol and acetylene.

C. Overall assembly of the experimental setup

The Acetylene gas generator is fitted with the extra accessories needed for safe and correct operation. All the fittings are sealed tightly with the Teflon tape. The accessories like pressure gauge, safety valve and Non- return valve. These are important accessories in a gas generator. Now the supply from the gas generator is given to the gas mixer through the gas pipes only. Since, gas pipes are made specially to pass gas through the suitable pipe lines for gas supply.

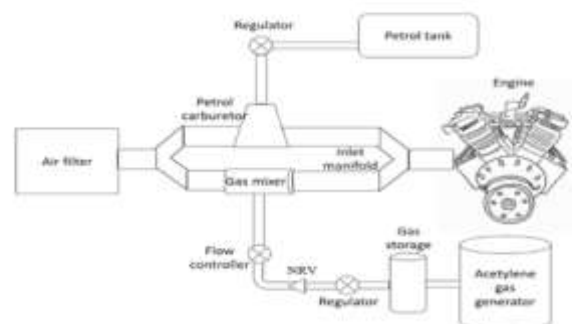

Fig.3 : Overall Assembly

Now the inlet manifold is placed in the place of original manifold, where one inlet is connected to carburetor with the rubber bushings and the clamps are tightened. To the other inlet, the gas mixer is fitted with the rubber or gas pipes and clamping should be done to avoid slipping. Now this whole assembly is fitted to the modified air duct which is a perfect fit with the air filter. All the joints in this assembly must be fixed with no gas leakage. After the assembly is done it will look like the figure show below.

III. CALCULATION

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

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

The gas generator constitutes two chambers: In first chamber the water is filled. In second chamber the calcium carbide is kept. The water from the first chamber is released in such a way to proceed the reaction spontaneously. The water is passed through the control valve on to calcium carbide which is kept in desirable amount for reaction. Through second chamber the gas produced will occupy the space above water in the first chamber. So, the gas generator acts both as generator unit and storage tank for acetylene gas. The upper part of generator is fitted with a control valve, safety valve and a pressure gauge as shown in figure.

D. Sample Calculations

As the analysis was carried on various speed for no of time, the calculations have been done on the average reading at each speed.

A sample calculation is given below .

At a given speed the following are noted down.

Data acquired from only petrol run

Amount of petrol consumed: Yp ml

Sample Table Calculation

Amount of CaC_2 (in gms)	Amount of petrol consumed (in ml)	Pressure reading (in Kg/cm2)		Engine running time (in mins)
		Initial	Final	
X	Y	Pi	Pf	T
Average				
X	Y	Pi	Pf	T

Engine run time: T min

Data acquired from dual fuel run

Amount of calcium carbide used: X gm

Amount of petrol consumed: Y ml

Initial pressure of acetylene: Pi kg/cm2

Final pressure of acetylene: Pf kg/cm2

Engine run time: T min

From the above data

Amount of calcium carbide consumed = X gm

The volume at STP is

Step1:

Convert grams of CaC2 to moles of CaC2

X g CaC2 x 1mol CaC2 / 64.10 g CaC2

= X/64.1 mol CaC2

Step2:

Use the molar ratio from the balanced equation to convert moles of CaC2 to moles of C2H2.

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

X/64.1 mol CaC2 x 1 mol C2H2/1 mol CaC2

= X/64.1 mol C2H2

Step3:

Use the ideal Gas Law to calculate the volume of C2H2 at STP.

STP is defined as a pressure of 100 KPa and a temperature of 273.15 K.

PV = nRT

V = nRT/P

= X/64.1 mol x 8.314 KPa. L. K mol x 273.15 K / 100 KPa = 0.355X Lit = 355X ml

Step4:

Use the Ideal Gas Law to calculate the volume at 25 0C and 1.01 atm.

V = nRT / P

= X/64.1mol x 0.08206L.atm.K mol x 298.15 K / 1.01 atm = 0.378X Lit = 378X ml

Therefore

Amount of acetylene produced is Vi lit.

Also Percentage of petrol consumption in dual fuel is Comparing with only petrol

When Yp ml = 100%

Y ml =?

Hence in dual fuel composition % of petrol = 100Y/Yp % (Cp)

Therefore, Percentage of acetylene in dual fuel composition = 100 – (100Y/Yp) % (Ca)

Which gives volumetric blending ratio of Cp: Ca Ans

Also

When Vi lit = Pi

Then, ? lit = Pf = Vf lit

Vf = (Vi x Pf)/ Pi

Hence

Total amount of acetylene consumed = Vi – Vf lit

= V lit… Ans

IV. ACTUAL CALCULATIONS

Table 1: Calculations at engine speed of 3000 rpm

Amount of CaC_2 (in gms)	Amount of petrol consumed (in ml)	Pressure reading (in Kg/cm2)		Engine running time (in mins)
		Initial	Final	
200	30	3.2	0.9	14min 09sec
230	25	3.4	0.9	15min 2sec
220	50	3.1	0.9	9min 8sec
250	35	3.3	0.9	13min 51sec
200	30	3.5	0.9	14min 37sec
Average				
220	34	3.3	0.9	13min 21sec

Table 2: Calculations at engine speed of 4000 rpm

Amount of CaC_2 (in gms)	Amount of petrol consumed (in ml)	Pressure reading (in Kg/cm2)		Engine running time (in mins)
		Initial	Final	
250	30	3.6	0.9	13min 29sec
220	35	3.3	0.9	11min 13sec
225	35	3.3	0.9	13min 42sec
230	30	3.4	0.9	12min 57sec
200	30	3.1	0.9	8min 54sec
Average				
225	32	3.34	0.9	11min 59sec

Table 3 : Calculations at engine speed of 5000rpm

Amount of CaC_2 (in gms)	Amount of petrol consumed (in ml)	Pressure reading (in Kg/cm2)		Engine running time (in mins)
		Initial	Final	
190	40	3	0.9	10min 01sec
240	35	3.4	0.9	12min 28sec
250	40	3.5	0.9	11min 34sec
190	35	3	0.9	10min 10sec
250	30	3.5	0.9	12min 29sec
200	40	3.1	0.9	12min 42sec
Average				
220	36.66	3.25	0.9	11min 40sec

Table 4: Calculations at engine speed of 6000rpm

Amount of CaC_2 (in gms)	Amount of petrol consumed (in ml)	Pressure reading (in Kg/cm2)		Engine running time (in mins)
		Initial	Final	
210	40	3.2	0.9	9min 59sec
220	40	3.3	0.9	10min 57sec
245	40	3.5	0.9	10min 22sec
250	45	3.5	0.9	9min 26sec
250	45	3.6	0.9	11min 43sec
Average				
235	42	3.42	0.9	10min 27sec

Table 5: Calculations at engine speed of 7000rpm

Amount of CaC_2 (in gms)	Amount of petrol consumed (in ml)	Pressure reading (in Kg/cm2)		Engine running time (in mins)
		Initial	Final	
210	40	3.2	0.9	9min 34sec
200	40	3.2	0.9	9min 14sec
240	45	3.4	0.9	11min 16sec
200	55	3.1	0.9	9min 03sec
Average				
212.5	45	3.22	0.9	9min 58sec

Table 6:Calculations at engine speed of 8000 rpm

Amount of CaC_2 (in gms)	Amount of petrol consumed (in ml)	Pressure reading (in Kg/cm2)		Engine running time (in mins)
		Initial	Final	
200	50	3.1	0.9	8min 16sec
180	45	2.8	0.9	9min 26sec
190	55	3	0.9	8min 55sec
210	60	3.2	0.9	8min 08sec
Average				
195	52.5	3.03	0.9	8min 51sec

V. RESULTS AND ANALYSIS

Engine speed (rpm)	Petrol consumption in initial run (in ml)	Petrol consumption in dual fuel mode (in ml)	Acetylene consumption in dual fuel mode (in lit)	Petrol consumption in dual fuel mode (in %)	Acetylene consumption in dual fuel mode (in %)	Volumetric blending ratio
3000	180	34	60.39	18.2	81.8	1: 4.48
4000	190	32	62.12	16.8	83.2	1: 4.95
5000	210	36.66	60.05	17.4	82.6	1: 4.74
6000	235	42	65.32	17.8	82.2	1: 4.61
7000	250	45	57.76	18.0	82.0	1: 4.55
8000	275	52.5	51.76	19.0	81.0	1: 4.28

After all the calculations done before we arrived at the results which are tabulated below.

ANALYSIS OF RESULTS :Only Petrol run

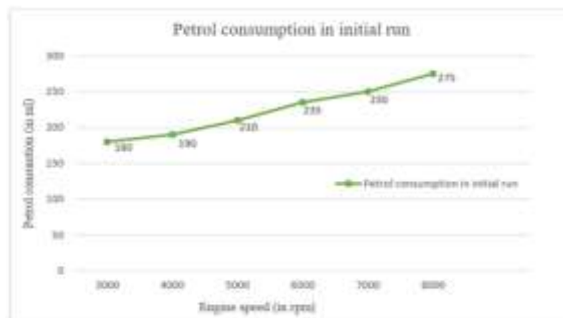

Fig.4:Graph of Petrol consumption in single fuel run

As we can see, when the engine is run on single fuel i.e., petrol for a known time the petrol consumption is increasing continuously from 180 ml to 275ml with speed increasing from 3000rpm to 8000rpm.

The time of run is same as the time the engine was able to run in dual fuel mode at that speed before the acetylene gas was no longer available for engine to function. By this we can directly relate and compare both the results. This finally helped us in analyzing the effectiveness of acetylene gas as a fuel for S.I. Engine.

Dual fuel mode:

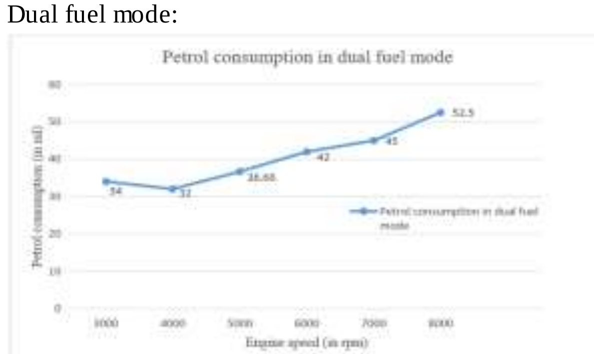

Fig.5:Graph of Petrol consumption in duel fuel run

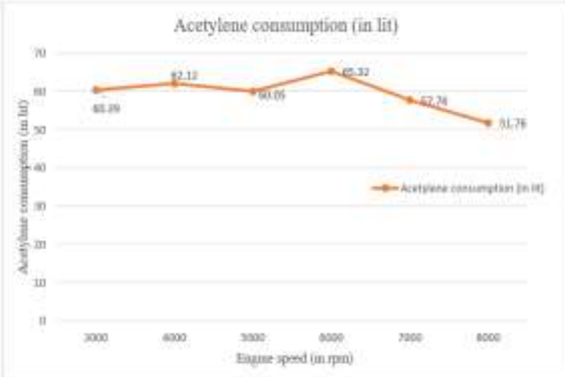

Fig.6: Graph of Acetylene consumption in duel fuel mode

Fig.7: Blending ratio vs engine speed

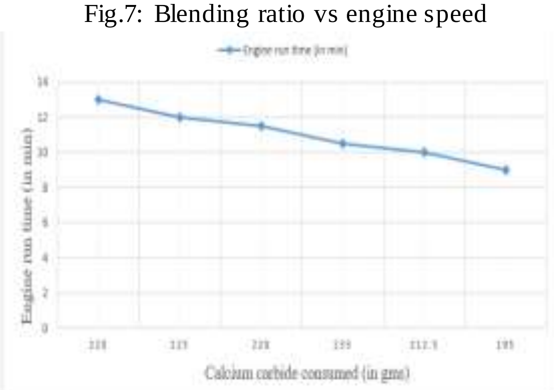

Fig.8: Calcium carbide vs engine run time

From the above analysis, we can see that petrol percentage in the acetylene- petrol mixture first dropped from 18.2% to 16.8% (at 3000rpm to 4000rpm), then gradually increased back with engine speed to 19%. This occurred because of the fact that all most all the commuter motorcycles engines are manufactured to be efficient at 4000- 4500rpm. Hence, we saw a drop in the percentage of petrol in the mixture of Acetylene and petrol. Also, we can understand that an average of 250gms of calcium carbide can give us a run time of 10- 11 mins with varying speeds in the combination of petrol.

VI. CONCLUSION

As per comprehensive experimental study on the successful working of petrol engine and to convert it to dual fuel engine with the help of gas mixer has been carried out successfully. The results obtained during experiment shows that the feasibility of dual fuel engine to replace conventional petrol engine are very high as it reduces the major pollutants such as Sulphur oxides, carbon dioxide and other smoke. It has been observed that dual fuel has shown a better overall performance and reduction of SO_x. Experiments were conducted to study the blending ratio of SI petrol engine in dual fuel mode of operation by aspirating acetylene gas in the inlet manifold for various speeds, with petrol as an ignition source.

The following conclusions have been arrived at, based on the experimental results:

- The percentage of petrol varies in a range of 16.8% - 19%, depending on the speed of engine.
- The blending ratio of the fuels is about 1: 4.26 to 1: 4.95 of petrol and acetylene.
- As we theoretically estimated, addition of petrol also eliminates the pre- ignition issue and thus knocking and backfire of the S.I. Engine when acetylene is used as a primary fuel.
- We also were able to conclude that engine gets overheated if enough cooling is not available. Air cooling alone cannot cool the engine because acetylene produces more heat energy than petrol.

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