Experimental Analysis of Acetylene Gas as an Alternative Fuel for S.I. 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.

Keywords: Alternative fuel, Efficiency, Analysis, Comparison, Emission.

I. INTRODUCTION

In the present context, the world is facing difficulties with environmental degradation and the crisis of fossil fuel depletion. 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. CO2from Greenhouse gas increases global warming, sea level rise and Climatic changes.
The search for an alternative fuel promises a harmonious correlation with energy conservation and management, sustainable development, efficiency and environmental preservation. Therefore, any attempt to minimize the consumption of petroleum based possible alternative fuels will be the most welcome. Hence fuels which are clean burning, renewable and can be produced easily are being investigated as alternative fuels.

A lot of research has gone into use of alternative fuels in IC engines from few decades. Vegetable oils seem to be a forerunner as they are renewable and easily available. In an agricultural country like India use of vegetable oil would be economical because of reduced dependability and large productivity on import of petroleum products. But because of poor atomization and high viscosity and of straight vegetable oils leads to improper mixing and causes improper combustion. Further to minimize viscosity problem researchers went for vegetable oils.

G.Nagarajan and T.Lakshamanan et.al. [1] Conducted experiments on a diesel engine aspirated acetylene along with air at different flow rates without dual fuel mode. Acetylene aspiration results came with a less thermal efficiency, reduced CO emissions, Smoke and HC when compared with baseline diesel operation. With acetylene induction, due to the high combustion rates, the NOx emission significantly increased. Swami Nathan et.al. [2] conducted experiments on sole acetylene fuel in HCCI mode and shown the results with high thermal efficiencies in a wide range of BMEP. The values of NOx, smoke are reduced by HCCI combustion, but HC emissions are more compared with base line diesel fuel. T.Lakshamanan et.al. [3] conducted experiments to study the performance and emission characteristics of DI diesel engine in dual fuel mode of operation by aspirating acetylene gas at constant 3lpm in the inlet manifold for various loads, with diesel as an ignition source. The brake thermal efficiency in dual fuel mode was found as lower than diesel operation at full load, as a result of continuous induction of acetylene in the intake. T.Lakshamanan et.al. [5] Studied the performance and emissions characteristics of acetylene fueled engine at different flow rates by using timed manifold injection technique. The study revealed that the optimum condition in manifold injection technique was 10° ATDC with injection duration of 90° crank angle and resulted a marginal increase in brake thermal efficiency was noticed for all gas flow rates. John W.H. Price et.al. [7] Described the explosion of an acetylene gas cylinder, which happened in1993 in Sydney. The results shows more information to prevent accidents regarding while using acetylene and the reactions take place in combustion and safety precautions. B.B.Sahoo et.al. [10] Reviewed on the effect of engine parameters while using gaseous fuels in dual fuel mode. There was a minor reduction in power output and higher BSFC for the engines. Mohamed Y.E. Selim et.al. [11] Investigated the effects of differences in gas composition on engine performance, ignition limits, knocking and combustion noise characteristics of a dual fuel engine. The effects of some engine operating and design parameters e.g. load, speed, pilot fuel injection timing and pilot fuel mass

on the combustion characteristics for the three gases, compression ratio, performance, ignition limits, knocking and combustion noise of the dual fuel engine shall be studied.

The principal objective and advantages of the present project include: providing a fuel comprising acetylene as a primary fuel for an internal combustion engine.

II. ACETYLENE GAS

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 odor, it is colorless, 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. In most such application, acetylene is used in solution form such as acetylene dissolved in acetone for example.

2.1 Reaction for Production

Calcium carbonate reacts with graphite in nature and forms as calcium carbide rocks. These reactions (i & ii) 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.

$CaCO3+C(graphite) \rightarrow CaC2$ (i)

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

Table 1.Comparison of Physical and Combustion Properties of C_2H_2, H_2, CNG and Petrol

Properties	Acetylene	H_2	CNG	Petrol
Composition	C_2H_2	H_2	CH_4: 86.4-90%; C_2H_6: 3-6% C_3H_8: 0.35-2%	C_8H_{18}
Density kg/m^3 (At 1 atm& 20 ^{o}C)	1.092	0.08	0.72	800
Auto ignition temperature (^{o}C)	305	572	450	246
Stoichiometric 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	--------	
Ignition energy (MJ)	0.019	0.02	--------	
Lower Heating value of Stoichiometric mixture (kJ/kg)	3396	3399	--------	

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.

III. METHODOLOGY

3.1 Acetylene gas as SI engine fuel

Prabin K. Sharma et al.: 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 two chambers:

• The water is kept in first (upper) chamber.

•The calcium carbide is kept in second (lower) chamber. The water from the first chamber is released in such away to carry out 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.

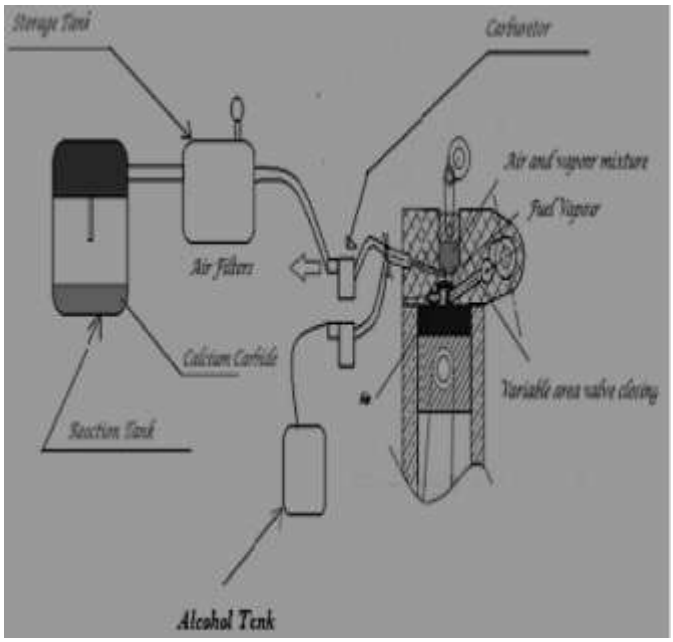

Fig.1: Overview of the project

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.

Step 3: The gas is passed in the pipe in very 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.

3.2 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

3.3 Experimental setup for testing

A Bajaj 4S champion engine is coupled with water brake dynamometer. Engine is loaded with the help of this water brake dynamometer. The measurement is carried out included brake power.

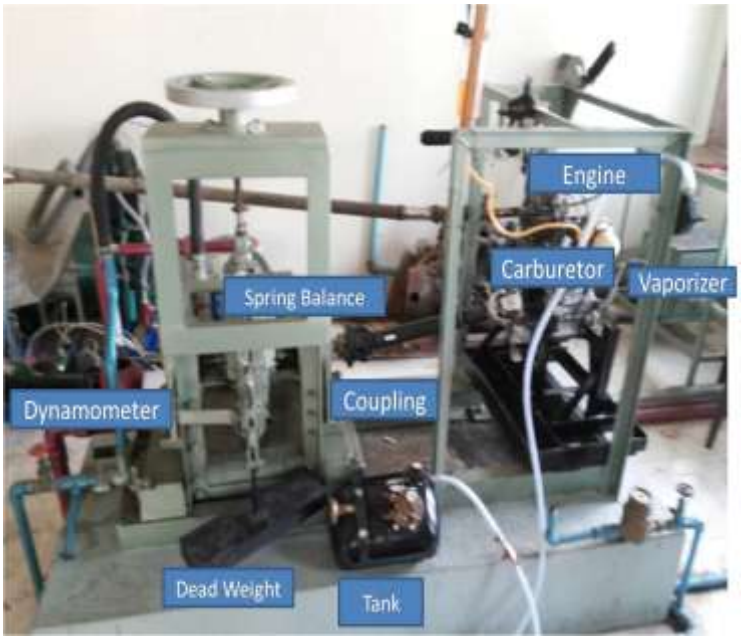

Fig.2: Experimental Setup for testing

The main components are as follows:

1. Engine
2. Engine mounting
3. Water brake dynamometer
4. Universal coupling
5. Vaporizer Kit
6. Gas storage Tank
7. Digital tachometer
8. Exhaust Gas Analyzer
9. Vacuum Plate
10. Mixer
11. Mixer Ring
12. Regulator
13. ON/OFF Valve

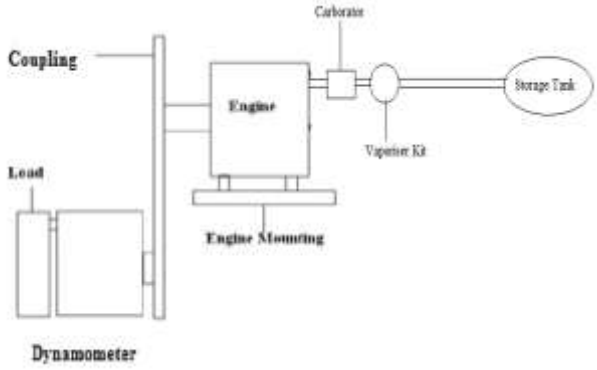

Fig.3.Schematic Diagram of Experimental Setup

Table2: 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

IV. OBSERVATIONS & CALCULATION

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 3: Observation for 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 4: Observation for Acetylene gas

Sr. No.	Load (kg)	Speed Rpm	Mass of fuel$X10^{-4}$ (kg/sec)
1	1	800	0.89285
2	2	800	0.89435
3	3	800	0.89635
4	4	800	0.89885

5	5	800	0.90185
6	6	800	0.90953
7	7	800	0.90942
8	8	800	0.91400
9	9	800	1.09385

Calculation procedure for performance testing:

1. Brake power (kw) :-

$$BP = \frac{(W*N)}{K}$$

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):-

$$= \frac{\text{Fuel consumption (kg/sec)}}{\text{Brake power}} *3600$$

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

=calorific value of fuel *fuel consumption

= (kJ/hr)

5. Brake thermal efficiency:-

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

V. RESULT AND DISCUSSION

5.1 Effect of BSFC and B.P. [N=800rpm]

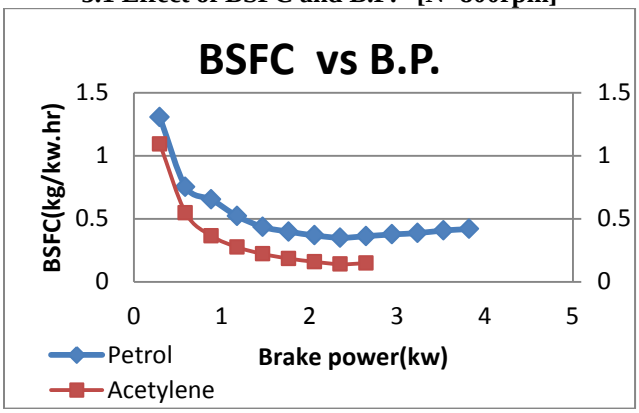

Fig.4 BSFCvsBrake power

The graph shown in fig. is BSFC vs Brake power. Initially as brake power increases BSFC decreases & then constant, at the end it is increases for petrol as well as acetylene but brake specific fuel consumption for petrol is greater than acetylene.

5.2 Effect of Brake thermal efficiency [N=800rpm]

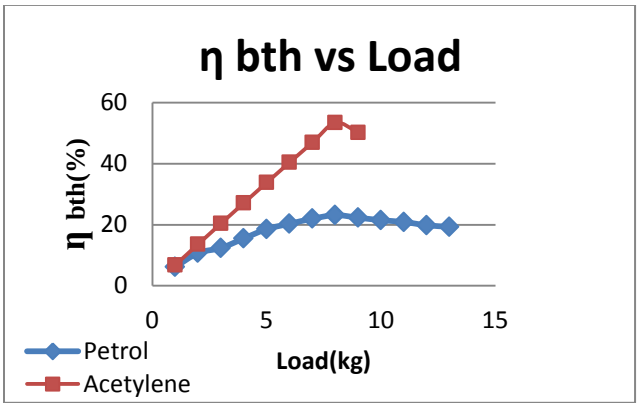

Fig.5 Brake thermal efficiency vs Load

As load increases brake thermal efficiency increases and then decreases. Brake thermal efficiency for acetylene is greater than petrol. Thermal efficiency is minimum at low load and maximum at high load.

5.3 B.P vs S.F.C for petrol [N=800rpm]

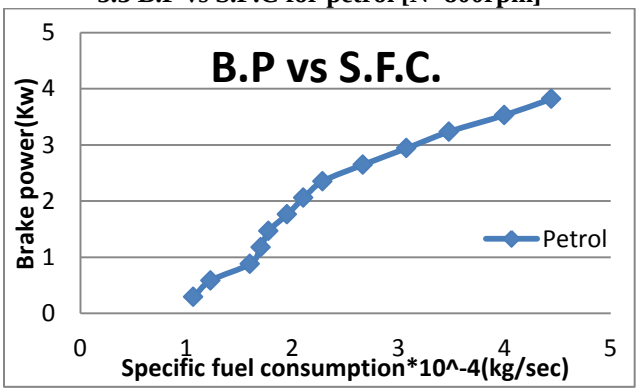

Fig. 6: Brake power Vs SFC

Break power increases with increase in specific fuel consumption for petrol.

5.4 B.P vs S.F.C for Acetylene [N=800rpm]

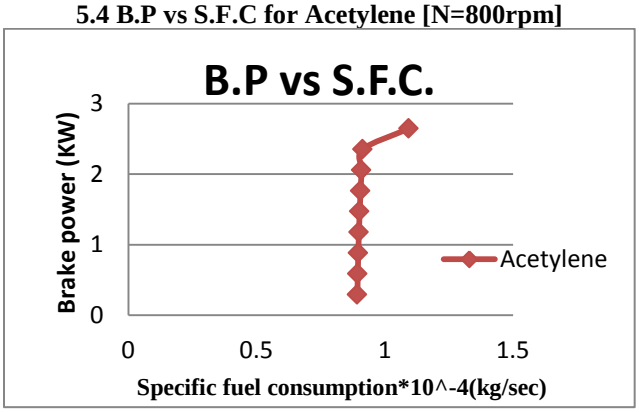

Fig. 7: Brake power Vs SFC

Break power increases with increase in specific fuel consumption for petrol.

VI. CONCLUSIONS

The study highlights the use of acetylene as a fuel for S.I engine; this fuel can be used with conventional S.I engine with minor fabrication and manipulations.

As acetylene has wide range of merits on economic as well as environmental grounds. It is less costly than conventional fuel as acetylene is produced from calcium carbonate which is in large quantity.

From above results shows that

1. Brake specific fuel consumption for petrol is greater than acetylene

2. Brake thermal Efficiency of Acetylene Gas is more than Petrol.
3. Break power increases with increase in specific fuel consumption for petrol.
4. Break power increases with increase in specific fuel consumption for petrol.

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