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Experimental performance on 100cc SI engine using acetylene as a fuel

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ABSTRACT

Studies reveal that Acetylene gas produced from Calcium Carbide (CaC_2) is renewable in nature and exhibits similar properties to those of hydrogen. A fixed quantity of Acetylene gas is aspirated and then we will take readings at various loads. Our focus is on less smoke production through emission and a better environment. In the experimentation on the engine, we have used Acetylene gas to run the engine without using petrol or any other secondary fuel. This acetylene gas is formed by a mixture of Calcium Carbide (CaC_2) and water. Calcium Carbide is formed by limestone and coal. To form the acetylene gas by using the few grams of calcium carbide and some amount of water which is mixed in reaction tank which is made-up of using Mild steel; because when CaC_2 and H_2O are get mixed, within the fraction of second this mixture will form an inflammable gas. While the handling of this gas safety is required. We have used this gas to run the engine. The engine drive shaft was attached to the Rope brake dynamo-meter and slowly applied to the weight on dynamo-meter and calculate the various parameters.

Keywords— *Alternative fuel, Acetylene gas, Si engine, Better emissions*

1. INTRODUCTION

Internal combustion engines are dependent on crude oil and a large part of the oil produced is consumed by the transportation sector. According to the data of 2015, the transport sector was dependent on oil at a rate of 95.1% and it is expected that this ratio will decrease to 91% by 2035. On the other hand, the world's oil reserves are limited and expected to be consumed in the near future. One of the ways to extend this time is to reduce petroleum consumption by increasing the fuel variety. Gasoline and diesel are crude oil derivatives and they have superior properties as a fuel for internal combustion engines. However, these fuels emit high rates of emission pollutant into the environment when used in internal combustion engines. The European Union has set a target to reduce the reducing greenhouse gas emissions by 80–95% in 2050 in comparison to 1990. The targets set by governments on this issue have been compelling the researchers and manufacturers to look for alternative fuels with renewable, higher reserves and lower emissions. Gaseous fuels have great potential due to fewer exhaust emissions and abundance. Some of them such as biogas and hydrogen can be obtained from renewable sources. In this study, since acetylene can be produced from non-petroleum resources, it has been suggested as a possible alternative to petroleum-based fuels to spark ignition engines. Acetylene is a synthetic gas that can be produced from coal and limestone. It has excellent combustion characteristics and can be used in internal combustion engines when necessary precautions are taken. In the present statuesque where fossil fuel is on the verge to exhaust, the need of the hour is to search for 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. Thus reducing the running cost and minimum pollutant emission, this makes it fit for use on economic and environment standard. It is more eco-friendly fuel option. 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.

1.1 Problem statement

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.

1.2 Objectives

- 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 qualities to be good fuel among other alternative fuels because of its calorific value and combustion efficiency.
- Acetylene produces exhaust gases containing very fewer emissions i.e. good combustion of a fuel occurs.
- Acetylene gas is a better alternative to conventional fuels like petrol in terms of emissions as well as the economy.

1.3 Scope

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 this wide area of research, use of acetylene as internal combustion source in the engine could be most appropriate field to research as an alternative source of fuel and can be used as the synthetic fuel for transportation. The principle objective and advantages of the present project include: providing a fuel comprising acetylene as a primary fuel for an internal combustion engine; providing such a fuel including a secondary fuel for eliminating knock which might otherwise arise from the acetylene.

1.4 Methodology

Use of Acetylene as an Alternative Fuel in IC Engine the overview of the 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 the first (upper) chamber. The calcium carbide is kept in the second (lower) chamber. The water from the first chamber is released in such a way to carry out the reaction spontaneously. The water is passed through the control valve. In the second chamber, the calcium carbide is kept in a 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 the 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 a 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 amounts (in about 10 to 15%) to prevent knocking for smooth operation of an engine. Then the mixture is passed in the engine.

2. EXPERIMENTAL MODEL

We have designed the experimental model by CATIA v5 software. The isometric view of the experimental model is as follows:

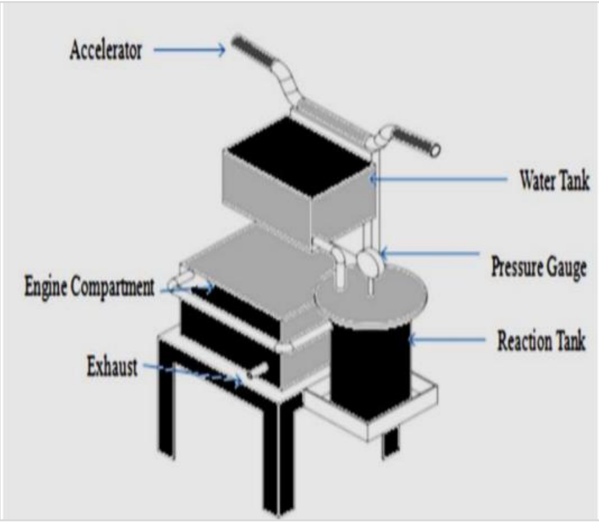


Fig. 1: Experimental model

We took the references from the various research papers to design the experimental model as shown above in figure 1.
The various basic components required they are as follows:

2.1 Acetylene storage tank

In this calcium carbide reacts with water to produce acetylene and calcium hydroxide. A small amount of aluminum oxide is mixed to enrich the above reaction. Specification of production tank:

The cylinder is made up of steel which can withstand 2 MPa pressure and dimension of the tank are 33 inches in length and 13 inches in diameter. In this tank on board, an exothermic reaction takes place on which acetylene is formed through this reaction. The acetylene gas then enters the storage tank.

$$CaCO_3 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$$

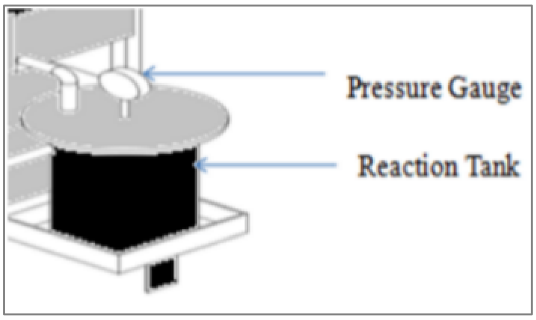


Fig. 2: Reaction Tank

Dimensions of Acetylene Tank:
- Acetylene Gas Cylinder Height = 300.00 mm
- Diameter of the cylinder = 170.00 mm

2.2 Engine
We have used 100cc Hero-Honda engine its specifications are as follows:

Table 1: Engine Specifications

Type	Air cooled, 4 - stroke single cylinder OHC
Displacement	97.2 cc
Max. Power	6.15kW (8.36 Ps) @8000 rpm
Max. Torque	0.82kg - m (8.05 N-m) @5000 rpm
Max. Speed	87 Kmph
Bore x Stroke	50.0 mm x 49.5 mm
Fuel System	Carburetor

2.3 Water tank

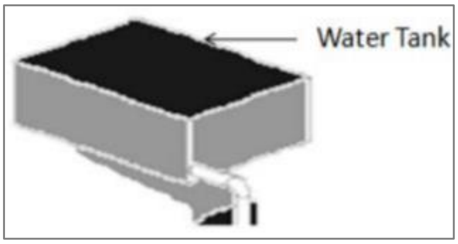


Fig. 3: Water tank

The material used is 1mm sheet metal.
The sheet is then folded and welded to form the water tank.

Dimensions:
- Length: 280 mm
- Width: 200 mm
- Height: 150 mm

2.4 Fabrication
The manufacturing process in which an item is made from raw or semi-finished materials instead of being assembled from readymade components or parts. Fabrication involves the following steps:
- Material selection
- Assembly

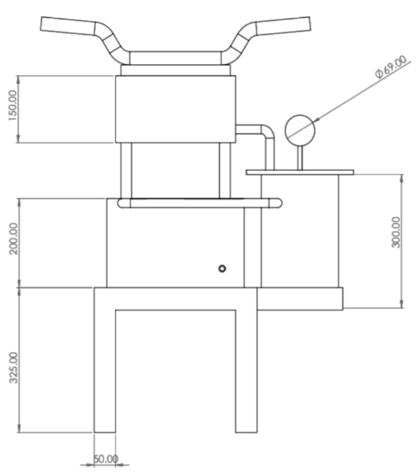
2.4.1 Material selection
Material selection is an important step in design procedure mechanical properties are very important considerations. A list of selection criteria for the material is as follows:
- Weight of material
- Fatigue
- Specific strength
- Fracture toughness and crack growth
- Corrosion and embrittlement
- Environmental stability

- Availability and productivity
- Material costs
- Fabrication and characteristics

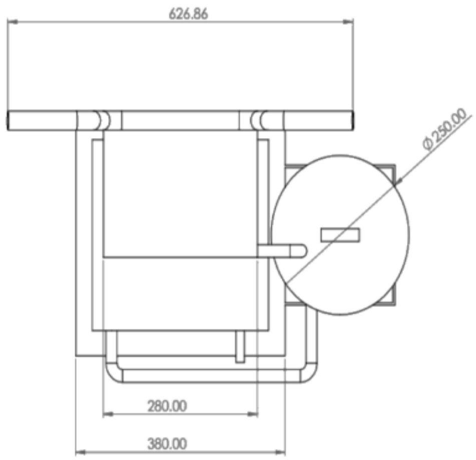
Hence material used in the experiment is Mild Steel.

2.5 Drawing

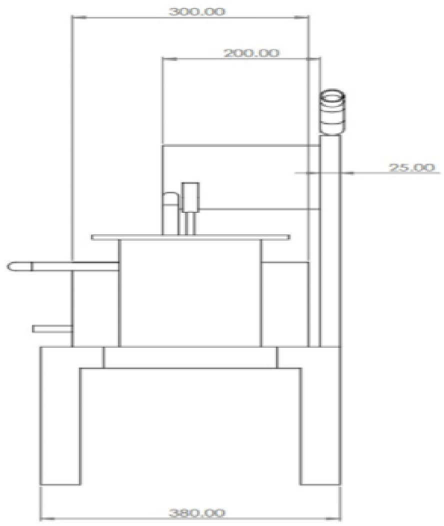
2D CAD Design of Experimental Setup by Using CATIA Software:



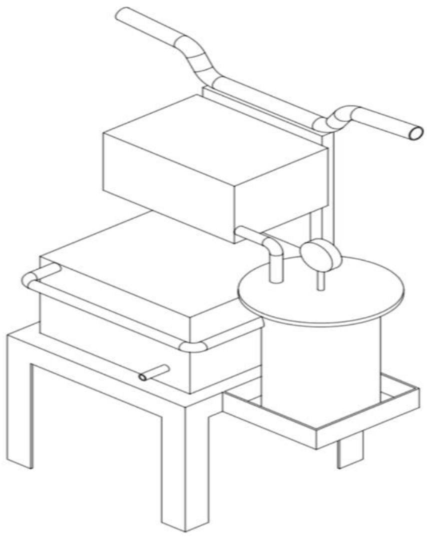
(a) Front View



(b) Top View



(c) Side View



(d) Isometric View

Fig. 4: (a), (b), (c), (d) CAD Model

3. EXPERIMENTATION AND CALCULATION

3.1 Emission Test

Table 2: Pollution test

S no.	Fuel	CO In %	HC in ppm
1	Petrol	4.5	900
2	Acetylene Gas	3.6	120

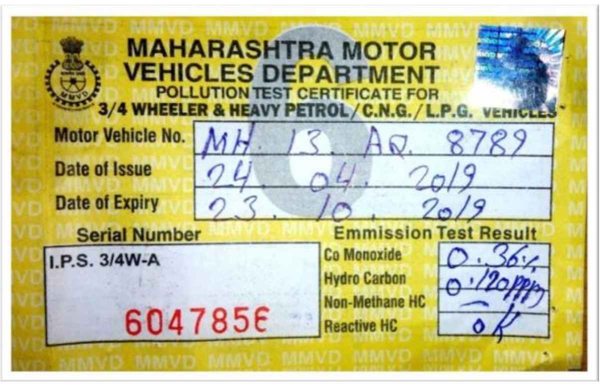


Fig. 5: Pollution test certificate

3.2 Theoretical Calculation

Diameter of cylinder = 180 mm
Length of Cylinder = 300 mm

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

$$V = (\pi/4) \times (180)^2 \times 300 = 7634070.15\ mm^3 = 0.0076\ m^3$$

During the test run, Amount of water use 200ml = 200000 mm^3 = 0.0002 m^3
Amount of Calcium carbide used = 200 grams = 0.2 Kg
Let, Total mixture is 400ml = 400000 mm^3 = 0.0004 m^3

Out of the total volume of the cylinder 5.23% volume is occupied with water + carbide mixture. Remaining available volume is the volume occupied by gas which is fuel. Therefore,

$$100 - 5.23 = 94.77\%$$

Hence, 94.77% of cylinder volume is filled with fuel gas. Amount of gas available inside the cylinder is = 0.0076 m^3. It is observed that during the test run, the engine worked for about 8-10min.

Hence it can be stated that 200gm + 200ml of water = 400 ml of mixture is sufficient to run the engine for 10 min. According to this, an in1 liter of (water + Calcium carbide) mixture the engine will run for approximately 30-35 minutes.

3.3 Fuel consumption

- As bike runs at 50- 60 km/hr by using petrol hence we can also run the bike by using acetylene at the same speed.
- Fuel required to run the engine for 10 min is 200 grams of Calcium Carbide.
- Therefore, to run the engine for 1 hour, it requires 1200 grams of Calcium Carbide.
- Fuel Consumption = Fuel used to run engine for 1 hour/ distance cant ravel in 1 hour
- Fuel Consumption = 1200/60 = 20 grams/km = 0.02 Kg/km = 2 Kg/100 km
- Mileage = 1/Fuel consumption = 1/0.02 = 50 km/Kg

3.4 Experimental calculation

Firstly the engine runs on by using Petrol and seconds the engine run by using Acetylene gas. The rope brake is a device for measuring brake power of an engine. It consists of some turns of rope wound around the rotating drum attached to the output shaft. One side of the rope is connected to a spring balance and the other side to a loading device. The power is absorbed in friction between the rope and the drum. We apply the same amount of load (kg) on rope brake dynamometer and calculate the various parameters with the help of formulas. These are as follows:

3.4.1 for Petrol

Table 3: Engine run by using petrol

S no.	Load, W (kg)	Spring load (kg)	RPM (rad/s)	Torque (N-m)	Brake Power (KW)	Speed (m/s)	Indicated Power (KW)	Mech. Eff. (%)
1	10	1	450	11.0362	0.52	21.20	0.7687	67.64
2	7	2	1100	6.1291	0.7060	51.83	1.3443	52.51
3	6	1.5	1270	5.5162	0.7336	59.84	1.5520	47.26

3.4.2 for Acetylene

Table 4: Engine Run by Using Acetylene Gas

S no.	Load, W (kg)	Spring load (kg)	RPM (rad/s)	Torque (N-m)	Brake Power (KW)	Speed (m/s)	Indicated Power (KW)	Mech. Eff. (%)
1	10	2	600	9.8100	0.6163	28.27	1.0146	60.74
2	7	1.5	1050	6.7420	0.7413	49.48	1.2832	52.54
3	6	1	1300	5.8343	0.8343	61.26	1.5887	52.51

3.5 Calculation procedure for performance testing

(A) Braking Torque (N-m)

$$\text{Braking Torque} = (W - S) \times R_b$$

Where,
W = Dead weight in Newton (N)
S = spring balance Reading (N)
R_b = Radius of the brake drum (D/2)

(B) Brake power (KW)

$$BP = (W - S) \times R_b \times 2\pi N/60000$$

(C) Indicated power (KW)

$$IP = (IMEP)\ LAnK\ /60000$$

Where,
IP = indicated power (kW)
IMEP = indicated mean effective pressure (kN/m^2)
L = length of stroke (m)
A = cross section area of piston (m^2)
n = number of power strokes
n = N/2 for four strokes, and N = for two strokes
N = crankshaft speed (revolutions per minute)
K = number of cylinders

(D) Mechanical efficiency

$$\eta_m = BP / IP$$

(E) Speed (m/s)

$$V = RPM/60 \times (2\pi \text{ rad})$$

3.6 Sample calculations

(A) Braking Torque (N-m)

Braking Torque = (W – S) × Rb
Braking Torque = [(10 – 1) × 9.81] × [(250/2) × 10^-3]
Braking Torque = 11.0324 N-m

(B) Brake power (KW)

BP = (W- S) ×Rb×2πN/60000
BP = [(10 – 1) × 9.81] × [(250/2) × 10^-3] × [(2π × 450)/60000]
BP = 0.5200 KW

(C) Indicated power (KW)

IP = (MEP) LAnK / 60000

We have used the standard value of engine,
Mean Effective Pressure:

7 HP = 5219.8991 Watts ≈ 5220 Watts
MEP = (Work Done/Stroke Volume)
MEP = 21.09 bar

$$IP = [(21.09 \times 10^5) \times (50 \times 10^{-3}) \times (\pi/4) \times (49.5 \times 10^{-3})^2 \times (450/2) \times 1]/60000$$

IP = 0.7687 KW

(D) Mechanical efficiency:

ηm = BP / IP
ηm = (0.5200/0.7687)
ηm = 0.6764
ηm = 67.64%

(E) Speed (m/s):

V= (RPM/60) × (2π rad)
V = (450/60) × (2π × 0.45)
V = 21.20 m/s

4. RESULTS

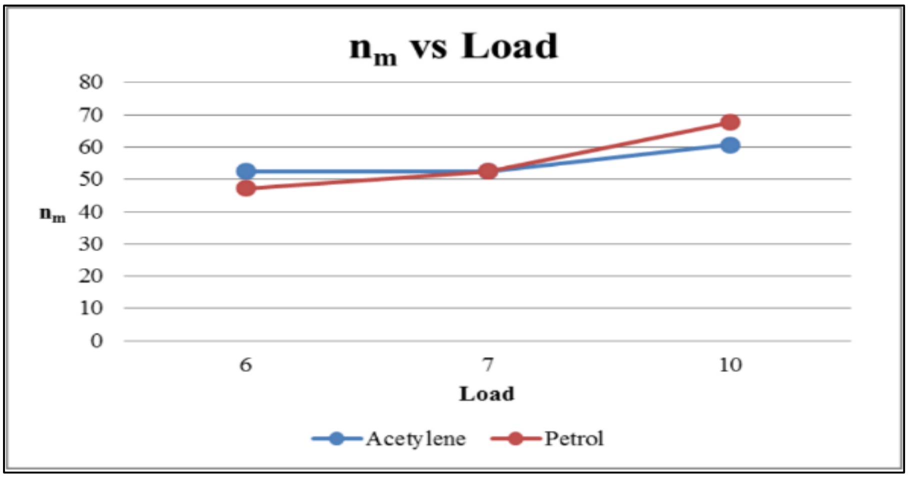


Fig. 6: η_m vs. Load (kg)

The graph shown in the figure is η_m vs. Load (kg). Initially, we get better efficiency at low load for acetylene but as we increase the load the efficiency of acetylene is decrease.

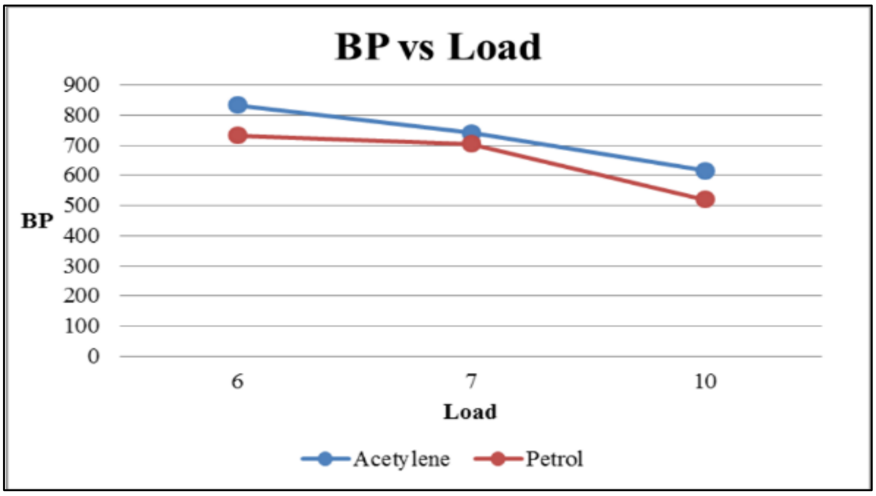


Fig. 7: BP vs. Load (kg)

The graph shown in the figure is BP vs. Load (kg). Initially, we get high BP for the same load for acetylene. At mid-range, we find a slight decrease and then at higher load again for acetylene the slope of decrease remains same and for petrol the slope increases.

5. CONCLUSION

- In the actual experiment, we have only used the acetylene gas to run the engine.
- Previous researches are done with mixing acetylene gas with conventional fuels.
- By experimentation on the engine, we are concluding that Acetylene Gas is a better alternative for conventional fuels in terms of emissions and economically.
- Also by emission test, it is cleared that Acetylene Gas burns to produce fewer pollutants than conventional fuels like petrol.

Table 5: Emissions for petrol and acetylene gas

S no.	Fuel	CO In %	HC in ppm
1	Petrol	4.5	900
2	Acetylene Gas	3.6	120

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