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Use of Acetylene as an Alternative Fuel in Modified SI 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. So we tried to find out more suitable way to make it safe and work. And also a way to filtration and new way to remove water or moisture.

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

1. INTRODUCTION

The main reasons for customers to consider alternative fuels are rising fuel costs and pressure to reduce the environmental impacts of non-renewable fuel combustion. ... Sectors with high greenhouse gas (GHG) emissions are under greater pressure to reduce their environmental impact.

Until the middle of 19th century, animal force was the driving source of transportation. The industrial revolution that followed was sparked by the invention of the internal combustion engine, promising to deliver autonomous power to individual vehicles, thereby releasing their owners from the need to use livestock. But with the current challenges imposed by climate change, and the amount of carbon dioxide released in the atmosphere by burning gasoline through the engine of a car, our current modes of transportation no longer seem like realistic ways to live sustainably.

However, getting rid of a system of distribution that encompasses a large network of filling stations and refineries is far from the most efficient way to ensure that more vehicles will be powered by carbon-neutral sources. The natural successor of gasoline is the still relatively new biofuel – fuel derived from biomass, such as agricultural crops – that can be used in current combustion engines with no need for modifications. Recently, researchers from the Oak Ridge National Laboratory have developed genetically engineered switch grass in an effort to produce a plant with a higher energy density and a simpler conversion process.

Most biofuels, like ethanol, are produced by releasing sugars from stored starches in agricultural products such as corn or sugarcane. This is accomplished by the method of enzyme digestion, which breaks down polymeric macromolecules into their smaller building blocks. The sugars are left to ferment, and then distilled and dried – a long process requiring a lot of energy. The Oak Ridge researchers were able to limit the amount of lignin – a chemical compound found in the cell wall of plants – by encoding a piece of RNA that would limit three quarters of the lignin production and placing it into the switch grass's DNA. Since lignin is the main element that keeps the cells together, decreasing the production makes it easier to access the sugars that are trapped inside plants. As a result, the conversion rate from biomass to fuel shoots up significantly, with up to a 40 per cent improvement.

But is it possible to completely replace the fossil fuels used in transportation with biomass products? Risks associated with the conversion to biomass include a potential change in biodiversity, since a bigger portion of land would need to be used to cultivate the appropriate plants. According to the Millennium Ecosystem Assessment, converting land for bio fuel production would translate into a massive burst of greenhouse gases. The conversion of a hectare of prairie land could liberate up to 300 tonnes of carbon dioxide, and this number goes up to 1,000 tonnes if a forest is removed to make room for bio fuels.

Then there is the question of the energy efficiency of biofuels. For certain agricultural products, the energy savings can vary from about 25 to 70 per cent, and for others – such as corn – there are no energy savings when compared to traditional gasoline. Ethanol, on the other hand, is usually mixed with gasoline because its energy density – the amount of energy stored in a unit of volume – is 34 per cent lower, but this is made up by its higher octane rating, which makes it overall more efficient.

Another major factor in choosing a bio fuel replacement will be its ability to reduce greenhouse gas emissions. There is a 75 per cent net reduction in emissions when using ethanol instead of gasoline, and a 90 per cent reduction when compared to diesel emissions. But according to the International Energy Agency, the bio fuels would need to account for 26 per cent of global fuel produced in order to limit the atmospheric concentration of carbon dioxide to 450 parts per million by 2050.

When it comes to genetically modified crops, the controversial nature of GM foods undoubtedly becomes a factor, and many farmers are still proceeding with caution. The challenge of creating ecosystems with genetically modified crops can seem daunting, as there have been many cases of regular crops being contaminated by GM ones. This might then put the entire bio fuel market in the hands of a couple big producers of genetic crops who have patented the lignin-reducing technology.

In the coming years, ethanol and other bio fuels will inarguably be a part of the alternative energies explored for use in the transportation industry. Bio fuel production does have the ability to distribute energy sources geographically, but given the initial carbon emissions associated with converting land into bio fuel crops – along with the decrease in space available for food production – another fuel source may need to replace biofuels as frontrunner in the alternative energy race.

Why is there a need for alternative fuels?

As a result, gases from fossil fuel emissions have caused and are continuing to cause great damage to the atmosphere (such as the greenhouse effect and acid rain). ... The use of alternative fuels to power our cars, buses, and trucks would significantly reduce our dependence on foreign oil.

What are the alternative fuels?

Alternative fuels, known as non-conventional and advanced fuels, are any materials or substance that can be used as fuels, other than conventional fuels like; fossil fuels (petroleum (oil), coal, and natural gas) as well as nuclear materials such as uranium and thorium as well as artificial radioisotope fuels.

What is an alternative fuel vehicle?

An alternative fuel vehicle is a vehicle that runs on a fuel other than traditional petroleum fuels and also refers to any technology of powering an engine that does not involve solely petroleum.

Why are alternative fuels important to learn about?

Often, they produce less pollution than gasoline or diesel. Acetylene is produced domestically from calcium carbide stone. It produce less greenhouse gas (GHG) emissions than gasoline or diesel.

ACETYLENE GAS:

Acetylene (C2H2) 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 odour, it is colourless, 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.

2. IDENTIFY, RESEARCH AND COLLECT IDEA

1) Filtration and Regulation problem:

Setup:

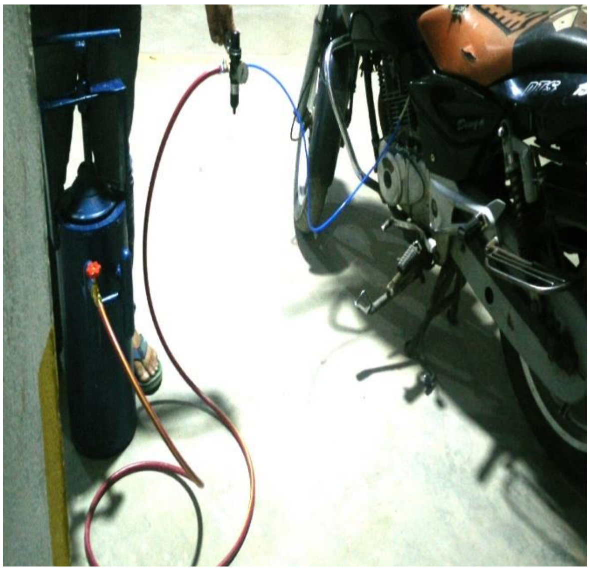

Figure Experiment Setup

Aim: To find solution for filtration and regulation of gas transferred from storage tank to engine.

Observation:

1) Checking without any filter or regulator we observed starting trouble since its require minimum press to start and while it is in running due to some water went inside it stop.

2) Checking with filter or regulator we observed that engine start near 0.2 psi

Conclusion: We found using Filter-Regulator system IMI Norgren B07-233-M1KA (500-21-264) solve this issue.

2) Reducing knocking:

Aim: To find solution for reducing knocking.

Observation: As we study research paper it suggest that by adding alcohol as a secondary fuel it can be reduce.

Conclusion: We can use alcohol as a secondary fuel to reduce knocking.

3) Experimental setup for testing Brake power:

Aim: A Bajaj Pulsar 150cc engine is coupled with rope brake dynamometer. Engine is loaded with help of this rope brake dynamometer. The measurement is carried out to calculate Brake Power.

Methodology

Production of acetylene gas:

I} Production from calcium carbide (selected)

Calcium carbide (CaC_2) is manufactured from lime and coke in 60:40 ratio in electric furnace at 2000 deg C to 2100 deg C temperature. The size of the calcium carbide is first reduced to fine powder in pulveriser. The pulverized calcium carbide is then added though a gas tight hopper valve arrangement to the acetylene gas generator in which the quantity of water used is sufficient to discharge the calcium hydroxide as lime slurry containing 85 % to 90 % water. In the gas generator the temperature is kept below 90 deg C while the pressure is maintained at 2 atm.

Acetylene is produced in the gas generator by the hydrolysis reaction of calcium carbide with water. During hydrolysis the following chemical reaction take place.

$CaC_2 + 2H_2O = Ca(OH)_2 + C_2H_2$ Delta H = – 32.5 kcals

The crude acetylene gas from generator contains traces of H_2S, NH_3 and PH_3. It is scrubbed with water in a scrubber then sent to purifier where the gas is purified and dried with iron oxide and silica gel. The dry gas is filled into cylinders or sent through pipe line to continuous casting machines.

The flow diagram of the process is given in Fig 1.

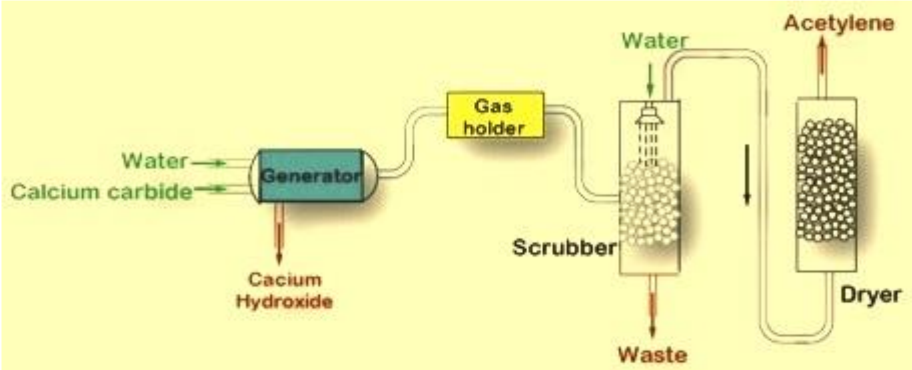

Figure Flow diagram of production of acetylene from calcium carbide

The production process is environmental friendly. The by-product of the process is slaked lime which has several uses such as in construction activities as well as for Ph adjustment.

II} Production from paraffin hydrocarbons by pyrolysis

In the Wulff process acetylene is produced by thermal decomposition of hydrocarbons such as methane, ethane, propane, butane, ethylene etc. as per the following reactions.

$C_4H_{10} = C_2H_2 + C_2H_4 + CO + H_2$

$C_2H_4 = C_2H_2 + H_2$

$2\ CH_4 = C_2H_2 + 3\ H_2$ Delta H = + 96.7 kcals

Pyrolysis is carried out in the Wulff regenerative furnace which is a rectangular steel box filled with refractory bricks checker work. Yield of acetylene (98.5 % to 99.3 % purity) varies with the hydrocarbon feed stock used. The off-gas is principally ethylene, carbon monoxide, hydrogen and methane.

III} Production from natural gas by partial oxidation (Sachasse process).

These days acetylene is mainly manufactured by the partial combustion of methane or appears as a side product in the ethylene stream from high temperature cracking of hydrocarbons. The feed stock can be a variety of hydrocarbon such as natural gas, LPG, naphtha, fuel oil, even crude oil etc. Heat for the cracking operation is developed by partial oxidation of the feed stock with oxygen. The heat evolved cracks the excess hydrocarbon to acetylene. After rapid quenching with water, the acetylene is separated from the gas stream by absorption-desorption in a suitable solvent. The process is known as Sachasse process using natural gas as raw material. the reactions are as follows.

$CH_4 + 2O_2 = CO_2 + H_2O$

$2CH_4 = C_2H_2 + 3\ H_2$ Delta H= + 79.8 kcals

Components: The main components are as follow:

1. Engine
2. Engine mounting
3. Rope brake dynamometer
4. Universal Coupling
5. Vaporizer kit
6. Gas Production tank
7. Digital tachometer
8. Filter & Regulator (FR)
9. ON/OFF Valve
10. Battery

Engine specification:

Type of fuel used: Petrol
Cooling system: Air cooled
Number of Cylinder: Single
Number of stroke: Four stroke
Arrangement: Vertical
Cubic Capacity: 150 cc (143.9 cc calculated)

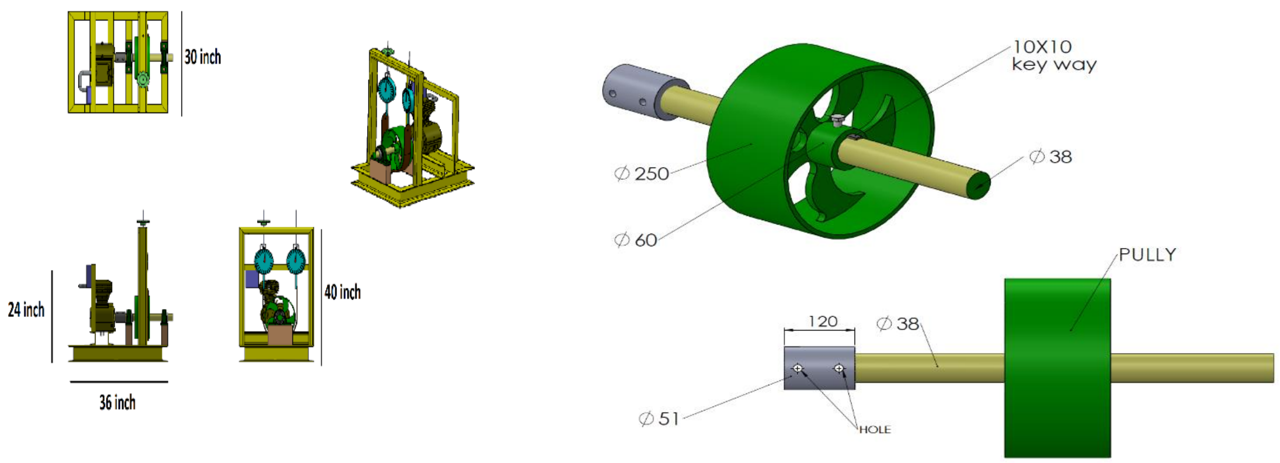

Figure 3d model of setup and of Brake Drum

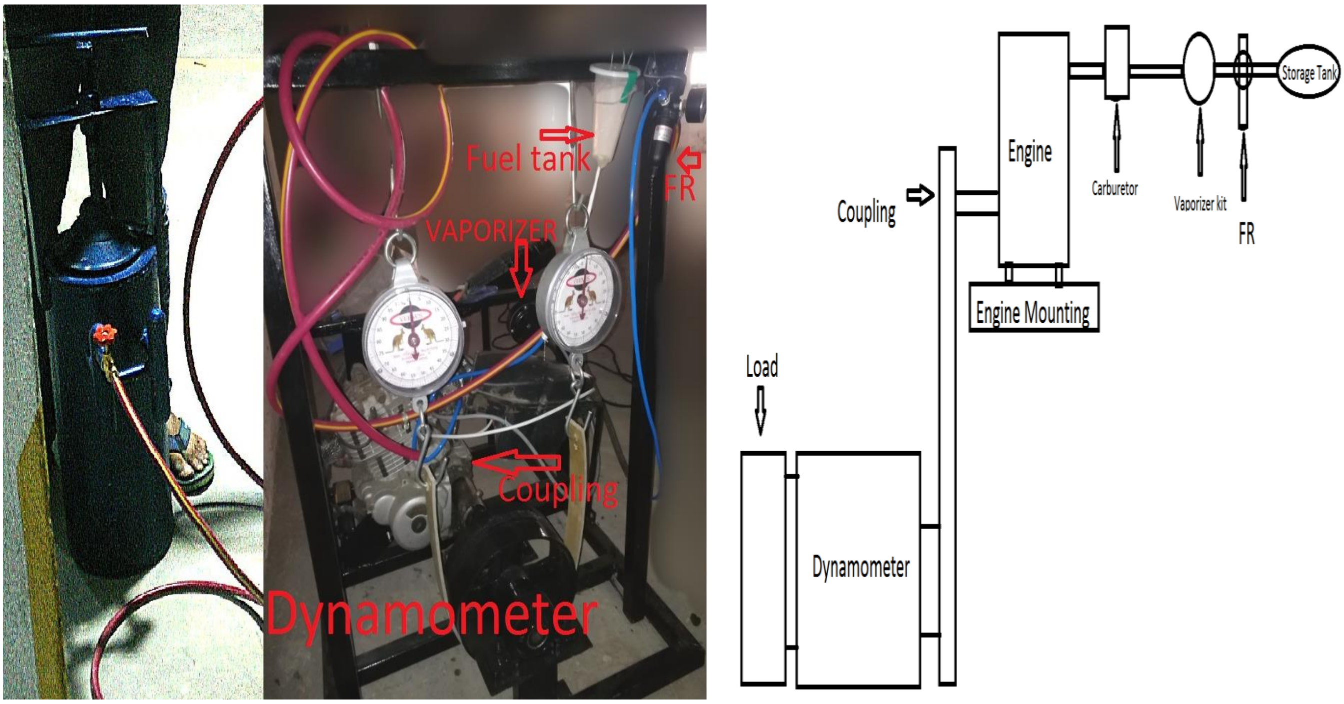

Figure Actual Experiment setup & Schematic diagram

Observation and calculation:

I) For Petrol:

S.No.	Position of gear	Load (w) kg	Spring load (kg)	rpm(rad/s)	Torque (N-m)	Brake Power (W)	Speed (m/s)	Indicated Power (W)	Mech. Eff.
1.	1	10	1	450	11.0324	519.88	5.89	549.94	94.53%
2.	4	7	2	1100	6.1291	706..0216	14.388	1344.32	52.51%

3.	5	6	1.5	1270	5.5162	733.62	16.61	1552.07	47.26%

II) For Acetylene:

S.No.	Position of gear	Load (w) kg	Spring load (kg)	rpm(rad/s)	Torque (N-m)	Brake Power (W)	Speed (m/s)	Indicated Power (W)	Mech Eff.
1.	1	10	2	600	9.8066	616.16	7.848	733.26	84.03%
2.	4	7	1.5	1050	6.7420	741.32	13.734	1283.21	52.54%
3.	5	6	1	1300	6.1291	834.32	17.004	1588.74	52.51%

Calculation:

Calculation procedure for performance testing.

1) Braking Torque (N-.m):

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

Where,

W = Dead weight in Newton (N)

S = spring balance Reading (N)

R_b = Radius of brake drum (D/2)

2) Brake power (w) :

$Bp = (W- S) \times R_b \times 2\pi N/60$

3) Indicated power (w) :

Ip = (imep) LAnK / 60

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

4) Mechanical efficiency:

$\eta_m = bp / ip$

5) Speed (m/s):

V= rpm x (2π rad)/ rev x (r/rad)

Theoretical calculation:

Sample calculation (using experimental method):

Bore dia. (dc) = 57 mm
Stroke (L) = 56.4mm
Compression ratio = 9.5
Rpm = 8500
Petrol calorific value = 45.6 MJ/KG
Acetylene calorific value = 56 MJ/KG

Cylinder Swept Volume (Vs)
Vs = Cylinder area x Stroke length

$= \frac{\pi}{4}(dc)^2$ x L
$= \frac{\pi}{4}(57)^2$ x 56.4
= 143.91 cc / cylinder

Compression ratio = 9.5
Air standard efficiency = $1 - 1/r^{\gamma-1}$
= $1 - 1/(9.5)^{0.4}$ = 0.5936
Eff. = Relative eff. x Air standard eff.
= 0.5 x 0.5936 = 0.2968
Heat supplied = 9.57 / 0.2968 = 32.24

Assume, the thermal eff. = 0.5
B.P = 9.57 KW (Power output)
Fuel Consumption Acetylene = Heat Supplied x 3600 (hrs) / Cv
= 32.24 x 3600 / 56000
= 2.07 Kg / hr Acetylene
For petrol,
Fuel Consumption Petrol = 32.24 x 3600 / 45600
= 2.54 Kg / hr
Acetylene < Petrol
For same power 150cc engine 500 gm / hr fuel saved.

3. RESULT AND DISCUSSION

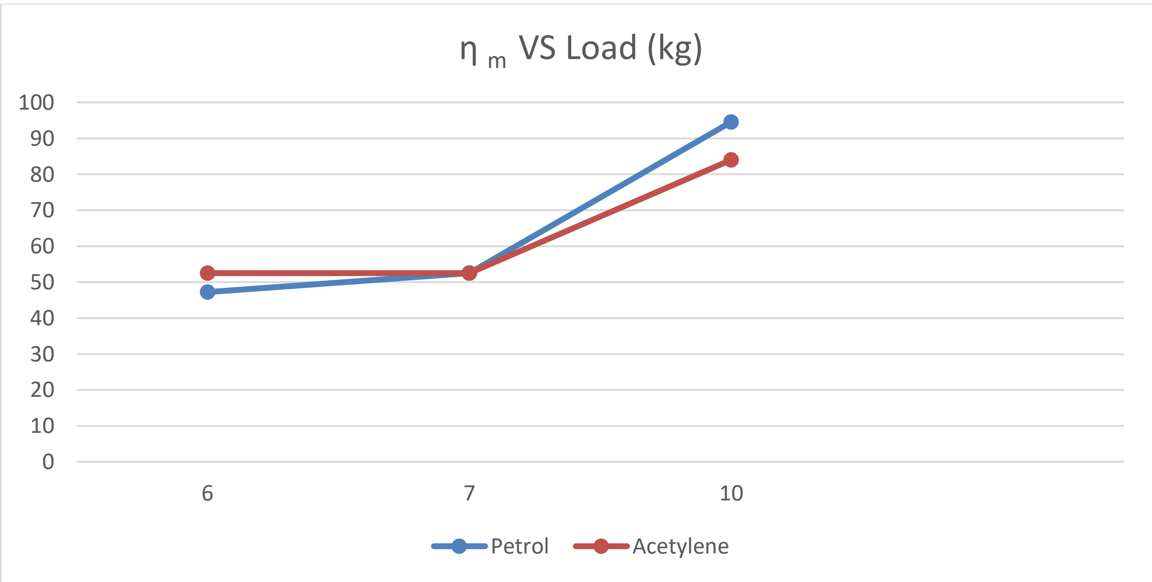

Figure: η_m vs Load (kg)

The graph shown in 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.

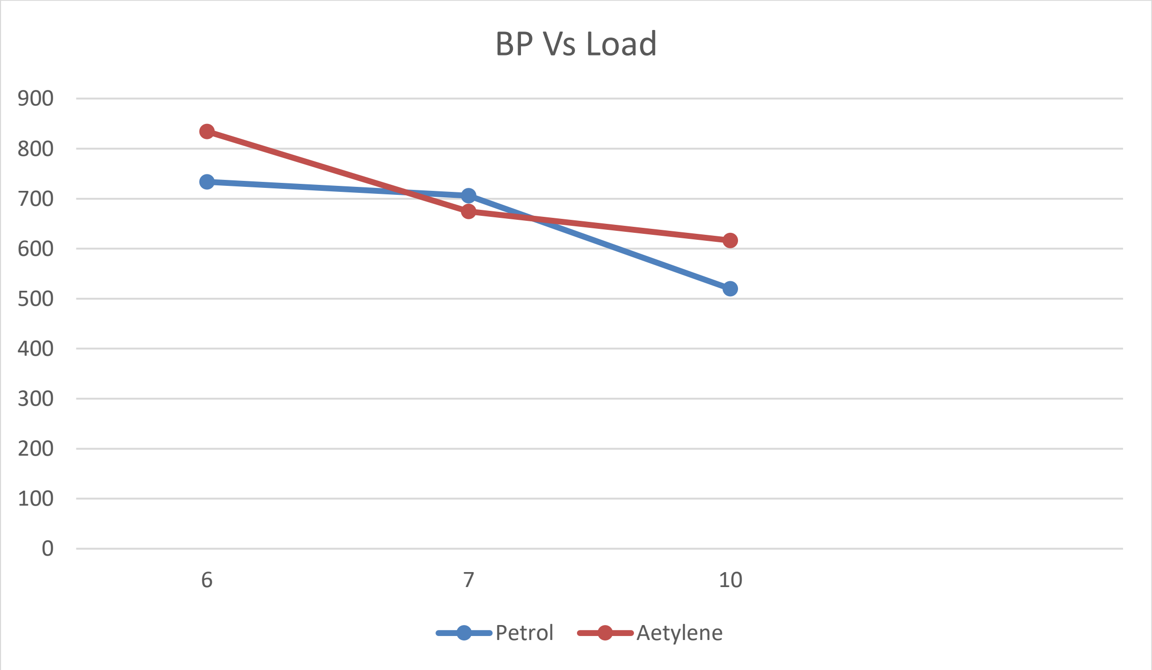

Figure: BP vs. Load

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

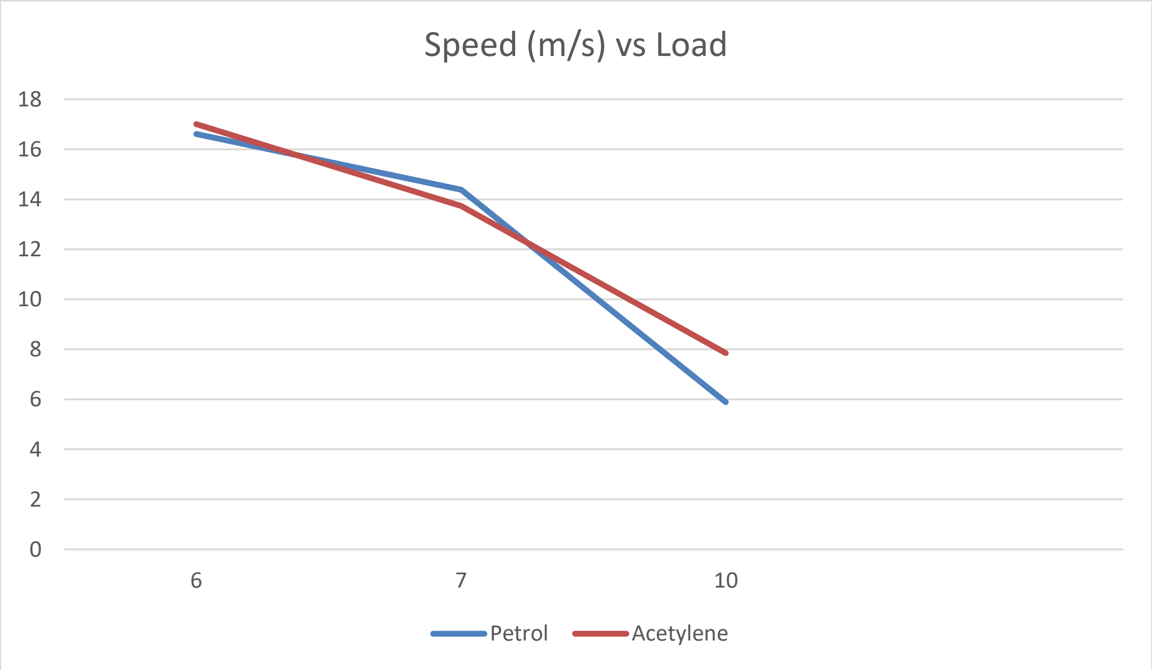

Figure: Speed (m/s) vs Load

The graph shown in figure is Speed (m/s) vs Load (kg). From our experiment we found that for same load we get higher speed for acetylene.

4. CONCLUSION

Outcomes:

- In past all experiment carried out uses air drier for removing moisture which can be possible solution for 4-wheelers but not for two wheeler since it require constant power supply. So, we tried FR which worked fine with our setup and even help us to filter the gas which was not done in future which increases chances of rusting inside engine.
- As there is already a solution for storing acetylene which can be further study and developed for vehicles like a cng kit. We tried a standard acetylene tank which is specially designed so that it can be transported. While storing they add acetone (liquid) to make it safe from transport.
- By our experiments we observe that on wheel production is idea of past and can't be applied on future vehicles. As mention above a smaller version of acetylene tank can be manufactured just like cng kit.
- The idea of on wheel production is not safe.

- Since there are specialized companies which manufacture acetylene gas which is much more purified then the normal gas produced by reacting calcium carbide with water. And as per over observation it give much more efficiency and power.

Advantages:

- Comparably easy and less expensive to manufacture. (water + calcium carbide)
- Amount of CO2 emitted is minimum and other emission like NOx and Sox are less compare to CO2.
- Doesn't require 3-way catalytic convertor, could be directly use in place of LPG and CNG and less working temperature which reduce chances of engine breakdown.
- Emission is non-polluting as only carbon dioxide and water vapours are emitted. Homogenous mixture is formed due to which complete combustion.
- Better efficiency.
- It is very cheap and available in abundance.
- It uses same handling system which is used in CNG and LPG cylinders.
- It has very low Photochemical Ozone creation Potential (POCP)
- An engine operated on such a fuel can be interchangeably utilized for indoor and outdoor operations without environmental concerns.
- Due to reduced operating temperatures, there are fewer tendencies for viscosity breakdown of engine lubricants and less component wear.
- Due to cleanliness of the combustion process, buildup of carbon- and sulphur compounds are eliminated thereby substantially extending the time intervals between routine maintenance.
- The waste slurry formed after reaction of calcium carbide and water to form acetylene gas can be used in agriculture.
- The small engine can be used for generating electricity in small town.

Future scope:

- 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 form calcium carbonate which is in abundance.
- Another advantage which justifies the use of acetylene in future is in the exhaust emission. On one hand fossil fuel during combustion produces CO_2, CO, NO_x, Some un-burnt hydrocarbon are produces but in case of acetylene carbon dioxide is produced with traces of water vapours.
- 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.
- Can be used as a power generator in rural area.
- Can be a useful fuel for all SI and CI engine vehicles in future. And specially for vintage cars.

Summary:

- The Project carried by us is a step to move towards better economy and less polluting vehicle.
- Our vehicle can be seen as a future vehicle.
- As we have observed that this gas can be easily produced at any local gas welder shop we can easily setup gas station for our vehicle.
- As our fuel i.e. acetylene that show similar properties to that of petrol while combustion process.
- If acetylene use as a alternative fuel it will help the old and vintage vehicle running.

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