An Investigational Study on Development of 4-stroke IC Engine to use Acetylene as an Alternative Fuel - A Review

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***Abstract*—The intention behind the paper is focusing on idea of using an alternative fuel in the internal combustion engine. In the present context the world is facing lot of difficulties with the crisis of fossil fuel depletion and environmental degradation and therefore the need of present world is to discover some alternative resources, we have many choices like LPG, CNG with their drawbacks. Due to which it is complicated to use them among various option Acetylene gas is a very good fuel for automobiles. Hence, study on such paper fuel is needed.**

The principal objective and advantage of the present project includes providing fuel comprising acetylene as primary fuel for an IC engine. Here we are considering 4 Stroke SI Engine for our research purpose , this paper may definitely reduce the running cost of vehicle and may create minimum emission, which will surely be beneficial for use. Also it will favour an economic and environmental standard. It is one of the eco-friendly fuel options

Keywords*— *Alternative fuel, Emission, Comparision, Efficiency, 4-stroke petrol Engine, Performance, Acetylene.

I. INTRODUCTION

The enormous growth of the world population during the last decade , technical development and increasing in standard of living in the development nation of twin crisis of fossil fuel depletion and environment degradation resulting local air pollution to global warming climate changes and sea level rise. The search for an alternative fuel promises a harmonious correlation with sustainable development ,energy conservation and management efficiency and environment preservation .therefore any attempt to reduce the consumption of petroleum based possible alternative fuels will be the most welcome.

Hence fuel which are renewable, clean burning and can be produced easily are being investigated as alternative fuel. Over few decades, a lot of research has gone into use of alternative fuel in IC engine.

II. ABOUT ACETYLENE

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 straightforward 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. He use of acetylene as a fuel has been largely limited in the recent times to acetylene torches for welding or welding related applications. He easy availability of economical and effective fuel which has better calorific value and effective flame speeds motivated to study and experiment on acetylene engine.

III. COMPARISION OF ACETYLENE WITH VARIOUS FUEL

The specifications of the engine which has been selected for the experimentation are tabulated in Table 1 and Table 2 lists the physical properties of acetylene. He experimental setup is as shown in Figure 1 which illustrates the setup clearly.

Table: 1

Properties	Acetylene	CNG	Petrol	Diesel
Composition	C2H2	CH4:86.4-90% C2H6:3-6% C3H8	C8C18	C8C20
Density (kg/m3) At 1atm &200c	1.092	0.72	800	840
Auto ignition(k)	598	723	519	530
Stoichiometric A/F ratio (kg/kg)	13.2	17.3	14.7	14.5
Flammability limit (vol %)	2.5-81	5.3-15	-	0.6-5.5
Lower Calorific Value (kJ/kg)	48225	45800	44500	42500
Ignition energy (mJ)	0.019	0.28	-	-

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IV. COMPARISION BETWEEN PETROL ,GAS AND DIESEL ENGINE

Table:2

Parameter	Diesel	Petrol	Stationary Gas
Engine load	Low to high	Low to high	High
Combustion temperature	High	High	Higher
Ignition	Compression	Spark	Spark or compression
Cycle	4-stroke, 2-stroke	4-stroke	4-stroke, 2-stroke
Fuel phase	Liquid	Liquid	Gas
Combustion products	CO_2, H_2O	CO_2, H_2O	CO_2, H_2O
Combustion pollutants	Soot, NO_x	CO, HC, NO_x	CO, HC, NO_x
Exhaust catalyst	No	Yes	Sometimes
Major oil contaminant	Soot	Oxidation	Nitration

V. ENGINE SPECIFICATION OF MARUTI 800

Table:3

ENGINE		
Type	Water Cooled SOHC Petrol	
Displacement	796 cc	
Cylinders	3	
Valvetrain	2 Valves / Cylinder	
Bore & Stroke	68.5 x 72.0 mm	
Max Power	37 BHP @ 5000 rpm	
Max Torque	59 Nm @ 2500 rpm	
Power / Weight Ratio	56.92 BHP / ton	55.63 BHP / ton
Torque / Weight Ratio	90.76 Nm / ton	88.72 Nm / ton
BHP / Liter	46.25	
Drivetrain	FWD	
Transmission	4-Speed Manual	
Service Intervals		

A. Technical specifications

1) Dimensions and weights

- Overall length: 3,335 mm (131.3 in)
- Overall width: 1,440 mm (56.7 in)
- Overall height: 1,405 mm (55.3 in)
- Wheelbase: 2,175 mm (85.6 in)
- Ground clearance: 160 mm (6.3 in)
- Curb weight: 650 kg (1,433 lb)
- Gross vehicle weight: 2,000 kg (4,409 lb)

2) Capacities

- Seating capacity: 5 people maximum
- Fuel tank capacity: 28 L (7.4 US gal)
- Engine oil : ~2.7 Lt including oil filter
- Transmission oil: ~2 Lt
- Coolant: 3.6 Lt
- Windscreen Washer Fluid: 1.75 Lt

3) Performance

- Maximum speed: 145 km/h (90 mph)
- 0–100 km/h (0–62 mph): 20 seconds

4) Fuel economy

- Mileage highway: 20.1 km/l (5.0 l/100 km; 47 mpg_{US})
- Mileage city: 18.1 km/l (5.5 l/100 km; 43 mpg_{US})
- Mileage overall: 17.5 km/l (5.7 l/100 km; 41 mpg_{US})

5) Engine

- Engine model: F8B MPFI
- Displacement: 796 cc (49 cu in)
- Valves per cylinder: 2
- Number of cylinders: 3 inline
- Fuel type: Petrol
- Power: 37 BHP at 5500 rpm

6) Transmission

- Transmission type: Manual
- Gears: four-speed gearbox, 5-speed gearbox (limited edition)

7) Suspension

- Front suspension: MacPherson strut and coil spring
- Rear suspension: Coil spring with gas-filled shock absorbers

8) Steering

- Steering type: Rack and pinion
- Minimum turning radius: 4.42 m (14.5 ft)

9) Brakes

- Front brakes: Disk
- Rear brakes: Drum
- Brake mechanism: Hydraulic

10) Wheels and tyres

- Tyres (radial optional): 145/70 R13,

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VI. EXHAUST GAS COMPOSITION PER UNIT MOLE

Table:4

Gasoline ($C_8H_{14.96}$)		Acetylene (C_2H_2)	
CO_2	0.0695	CO_2	0.0804
H_2O	0.1239	H_2O	0.720
CO	0.0642	CO	0.058
H_2	0.00124	H_2	0.00836
N_2	0.7410	N_2	0.7586

The molecular weight of acetylene is 26 with two carbon atoms (C2H2 gas density = 0.068 lb/ft3 typically the Material and Safety Data sheet will provide this detail of information) while the molecular weight of CO2 is 44 with one carbon 66 atom. Given that each mole of acetylene, under complete combustion, will create two moles of CO2 (i.e., each pound of acetylene combusted will produce 3.38 pounds of CO2 (2x44/26)). Use the following conversion calculations to derive an emission factor for acetylene:

The result obtained from this calculation illustrates that the amount of CO2 emitted is fairly minimum and other emissions like NOx, Sox are highly negligible compared to CO2. This indicates that acetylene can be relatively more environmental friendly than gasoline.

VII. ERROR ANALYSIS

The error in the measured value of the instantaneous speed of the engine was estimated by considering the error in the tachometer. The error in the measurement of the fuel mass flow rate was estimated by considering the error in the measurement of the time used for the engine to consume 25 cc of fuel. The error in the measurement of the gases exhaust temperature was estimated by considering the error in the thermocouple used. Three runs of tests were performed under identical conditions to check for the repeatability of all the results. Each reading of the basic quantities measured was the average of three values. The repeatability of the results was found to be within 3%, based on Gaussian distribution.

An error analysis for the derived quantities, such as brake power and thermal efficiency, was performed based on route mean square method [14].

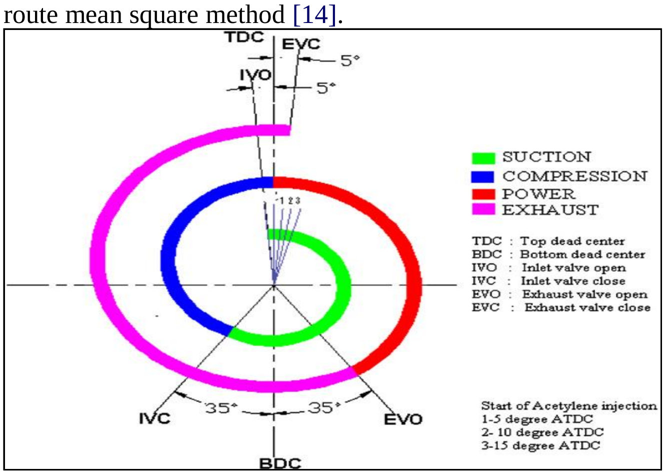


Fig:1 valve timing diagram

Where R is the computed value, DR is the error limit, x1, x2, xn are measured parameters, and Dx1,Dx2, Dxn are error limits for the measured variable. Percentage uncertainties of various parameters like total fuel consumption, brake power, specific fuel consumption and brake thermal efficiency were calculated using the above equation. The details of the uncertainties of some measured and calculated parameters are given in Table 5. It is clear that the estimated error in the measurement of the basic and derived quantities does not significantly influence the overall uncertainty in the final results.

VIII. OVERVIEW OF PROJECT

Step1: The first step involves the production of acetylene gas through the calcium carbide reacting with water in the reaction tank.

Cac2+ 2H2O ⟶ C2H2 + Ca(OH)2

The reaction tank constitutes two chambers:

- first water is fill in tank
- Second the carbide is kept in desirable amount in the tank.

As both the reactant are fill into the tank the reaction process carried out in the tank and that final product form in the form of gas that gas is nothing but the acetylene gas

Fig:2 Acetylene gas tank

Step2: In this step the acetylene gas is store 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 tank is provided pressure through pressure gauge so the gas is of high concentration.

Fig:3 wooden clamping arrangement

Step3: The gas is passed in the pipes in a very sophisticated manner and then pipe is joined in the vaporizer

Step4: vaporizer needed when vapour acetylene from natural vaporization is not enough to meet high acetylene consumption demands, a vaporizer can assist to provide the sufficient vaporization rate required. So vaporizers are needed when consumption is greater than natural vaporization.

Fig:4 vaporizer fitting arrangement engine

Step5: All over this vaporize gas is supply to the engine and over engine start running.

IX. COMBUSTION PARAMETER

Ignition Delay

Ignition delay is defined as the time (or crank angle interval) from when the fuel injection starts to the onset of combustion.

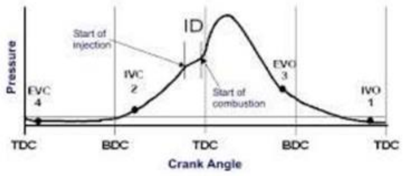


Figure 3.6: Pressure – Crank Angle diagram for a four-stroke cycle

Delay period is the commencement of injection and it is indicated by the dot on the compression line 15° before dead centre. The period 1 is the delay period during which ignition is being initiated, but without any measurable departure of the pressure from the air compression curve which is continued as a broken line in the diagram as it would be recorded if there were no injection and combustion.

Volumetric efficiency

Volumetric efficiency indicate the breathing ability of the engine. so the engine must be able to take in as much in as much air as possible. The most domain reason is that acetylene as being a gas it displace some of the air that would otherwise be induce i.e. while inducing acetylene in the intake pipe along with air, some amount of air was replace by acetylene gas resulting in reducing in volumetric efficiencies at every load.

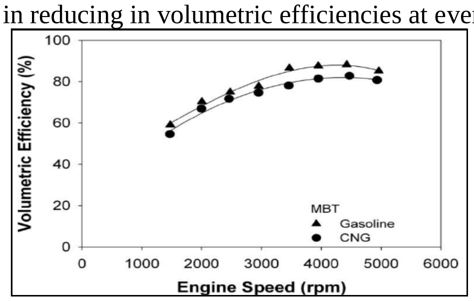


Fig:5 Variation of Volumetric efficiency with load

Exhaust gas temperature

The fig shows the graph between exhaust gas temperature and load .

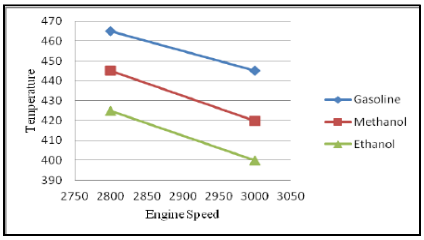
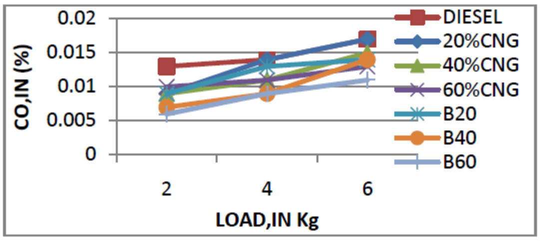


Fig 6: Variation of Exhaust Gas temperature with load

A. EMISSION PARAMETERS

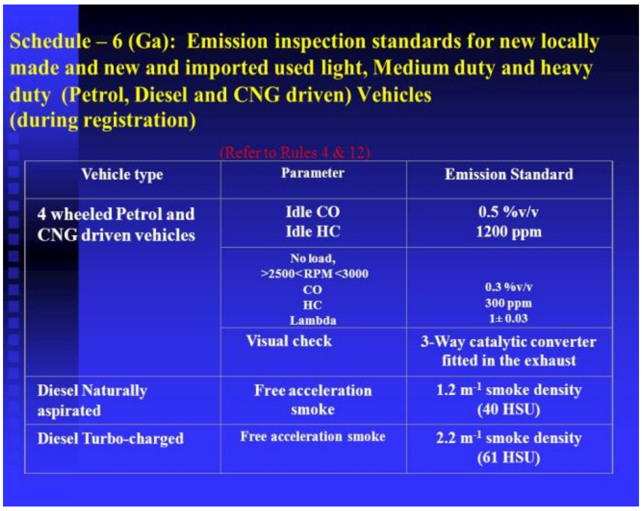
- *CARBON MONOXIDE*

Carbon monoxide (CO) emissions increased with the load increase as shown in figure 8, because of incomplete combustion of fuel inside engine cylinder, this is due to either inadequate oxygen or flame quenching or air-fuel mixture may not be a homogeneous throughout the cylinder. But at high loads (fourth and fifth loads) the CO emission reached to the maximum and there after slightly decreased, because of the availability of oxygen in sufficient quantity. In this research as the engine is equipped with a carburetor to supply fuel to the engine cylinder. Therefore, there is slightly increase in the carbon monoxide emissions with the increased of plastic oil proportion in blend. It has been observed that the CO emissions in 50% PO are 1.7 times more than that of the engine fuelled with the 100% Petrol. The reason behind increased CO emission is incomplete combustion due to absence of oxygenated compounds in plastic oil.



(C)

Fig 7: Variation of carbon monoxide with load



Schedule – 6 (Ga): Emission inspection standards for new locally made and new and imported used light, Medium duty and heavy duty (Petrol, Diesel and CNG driven) Vehicles (during registration)

(Refer to Rules 4 & 12)

Vehicle type	Parameter	Emission Standard
4 wheeled Petrol and CNG driven vehicles	Idle CO Idle HC	0.5 %v/v 1200 ppm
	No load, >2500<RPM <3000 CO HC Lambda	0.3 %v/v 300 ppm 1± 0.03
	Visual check	3-Way catalytic converter fitted in the exhaust
Diesel Naturally aspirated	Free acceleration smoke	1.2 m⁻¹ smoke density (40 HSU)
Diesel Turbo-charged	Free acceleration smoke	2.2 m⁻¹ smoke density (61 HSU)

Fig 8: EMISSION INSPECTION STANDARDS

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B. Total Emissions in Metric Tons

The molecular weight of acetylene is 26 with two carbon atoms (C_2H_2 gas density = 0.068 lb/ft3 typically the Material and Safety Data sheet will provide this detail of information) while the molecular weight of CO_2 is 44 with one carbon atom. Given that each mole of acetylene, under complete combustion, will create two moles of CO_2 (i.e., each pound of acetylene combusted will produce 3.38 pounds of CO_2 (2x44/26)). Use the following conversion calculations to derive an emission factor for acetylene:

$$\frac{0.068\text{ld}}{1\text{ cubic feet C2H2}} \times \frac{453.6\text{g}}{1\text{lb}} = \frac{30.845\text{g}}{1\text{ cubic feet C2H2}}$$

$$\frac{30.845\text{g}}{1\text{ cubic feet C2H2}} \times \frac{1}{26.04/1\text{ mol C2H2}} = \frac{1.185\text{ mol C2H2}}{1\text{ cubic feet of C2}}$$

$$\frac{0.068\text{lb}}{1\text{ cubic feet C2H2}} \times \frac{453.6\text{g}}{1\text{ lb}} = \frac{30.845\text{g}}{1\text{ cubic feet C2H2}}$$

$$\frac{30.845\text{g}}{1\text{ cubic feet C2H2}} \times \frac{1}{26.04/1\text{ mol C2H2}} = \frac{1.185\text{ mol C2H2}}{1\text{ cubic feet C2H2}}$$

$$\frac{1.185\text{ mol C2H2}}{1\text{ cubic feet C2H2}} \times \frac{2\text{ mol CO2}}{1\text{ mol C2H2}} = \frac{2.370\text{ mol CO2}}{1\text{ cubic feet C2H2}}$$

$$\frac{2.370\text{molCO2}}{1\text{ cubic feetC2H}} \times \frac{44.01}{1\text{ mol CO2}} = \frac{104.304\text{g Co2}}{1\text{ cubic feet C2H2}}$$

$$\frac{104.304\text{gCo2}}{1\text{cubicfeetC2H2}} \times \frac{1\text{ metric ton}}{10^6} = \frac{1.403 \times 10^{-4}\text{ m.tonCO2}}{1\text{ cubic feet C2H2}}$$

The result obtained from this calculation illustrates that the amount of CO_2 emitted is fairly minimum and other emissions like NO_x, SO_x are highly negligible compared to CO_2. This indicates that acetylene can be relatively more Environmental friendly than gasoline .

B. Ozone Layer Depletion (Photochemical Ozone Creation Potential (POCP)

Despite playing a protective role in the stratosphere, at ground-level ozone is classified as a damaging trace gas. Photochemical ozone production in the troposphere, also known as summer smog, is suspected to damage vegetation and material. High concentrations of ozone are toxic to humans.

Radiation from the sun and the presence of nitrogen oxides and hydrocarbons incur complex chemical reactions, producing aggressive reaction products, one of which is ozone. Nitrogen oxides alone do not cause high ozone concentration levels. Here are some of the comparisons of POPC between several compounds.

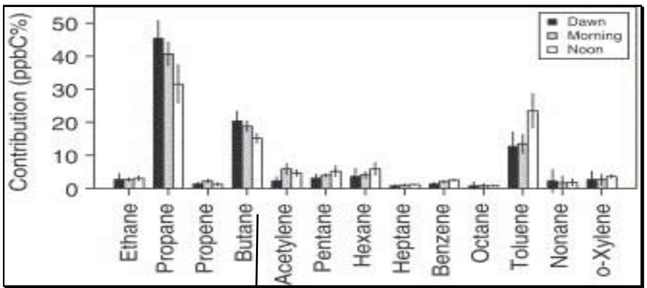

Fig 9: comparision with different compound

Table:5

VOS	POCP
ETHANE	8.8
PROPANE	18.3
n-BUTANE	36.3
n-hexane	45.6
Benzene	20.3
Acetylene	9.9
n-pentane	36.6

Note that acetylene has very low POPC that implies it has low reactivity towards OH- radical

The total emissions vary greatly with fuel structure. Two Factors have been identified for this large variation: diffusion and reactivity. Diffusion of fuel molecules from boundary layers near the cylinder wall into the hot core gas causing Partial oxidation of this fuel may be a significant source of Burn-up of HC species exiting crevices during the expansion Stroke. Thus, higher molecular weight fuels, which diffuse More slowly, tend to exhibit higher emissions.

XI. ABUNDANCE OF CALCIUM CARBONATE IN NEPAL

As mentioned earlier, acetylene is the outcome of calcium carbide. Similarly, calcium carbide is the outcome of calcium carbonate. According to Krishna Dev Jha, senior divisional metallurgical engineer at Department of Mines and Geology, Nepal has a billion tons and proven reserves of 210 million tons. This indicates that Nepal has an abundance of calcium carbonate which is the key factor for the production of acetylene. This seems to be one of the fruitful aspects in the development of acetylene gas in our own country, hereby reducing the maximum use of gasoline.

XII ADVANTAGES

- Emission in non-polluting as only carbon dioxide and water vapors are emitted
- Homogeneous mixture is formed due to which complete combution
- Better efficiency
- It is very cheap and available in abundance
- It uses same handling system which is use in cng and lpg cylinder

It has very less photochemical ozone creation potential

- An engine operated on such a fuel can be interchangeably utilized for indoor and outdoor operations without environmental concerns.
- The need for a three-way catalytic converter or other EGR device is eliminated.

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- 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 there by substantially extending the time intervals between routine mai

XIII. FUTURE SCOPE AND CONCLUSION

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 CO2, CO, NOx, Some unburnt hydrocarbon are produces but in case of acetylene carbon dioxide is produced with traces of water vapors.
- 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.

CONCLUSION *:*

The study highlights the use of acetylene as a fuel for SI engine, this fuel can be used with conventional S.I. engine with minor fabrication and manipulations. As acetylene has wide range of merits on environmental as well as economic grounds. It produces only carbon dioxide during combustion and is less costly than conventional fuel as acetylene is produced from calcium carbonate which is in abundance. Acetylene have proved out to be better fuel due its non-polluting nature and more economic.

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