Improvement in Efficiency of Four Stroke Petrol Engine Blend with Butanol Using Hydrogen Supplementation

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Abstract - Hydrogen is seen as one of energy vector of the next century. Hydrogen, as a renewable energy source provides a potential form sustainable development particular in transportation sector. The hydrogen driven engine reduces both local as well as global emission. Hydrogen gas is in brown color and form of un-separated hydrogen and oxygen generated by the electrolysis process of water by a unique electrode design. Hydrogen gas was used as a supplementary fuel in a petrol engine with few modifications and without need of storage tanks. As hydrogen, Butanol is also used as fuel in engine. Blending of small proportion of petrol and butanol can be used in petrol engine without modification of engine. Using of butanol with petrol improve performance of engine. As hydrogen gas is used as a supplementary and butanol is blend with petrol, it will enhance the combustion characteristics of petrol engine and improve performance. In this project we are going to analyze the performance characteristics of petrol engine with butanol blends using HHO kit.

Key Words: Hydrogen, Four stroke petrol engine, Butanol

1. INTRODUCTION

Fossil fuels which meet most of the world's energy demand today are being depleted rapidly. Many engineers and scientists agree that the solution to all of these global problems would be to replace of the existing fossil fuel system with the clean hydrogen energy system and alcohol based fuel. Hydrogen is a very efficient and clean fuel. Its combustion will produce no greenhouse gases, no ozone layer depleting chemicals, and little or no acid rain ingredients and pollution. From series of alcohol based fuel butanol is effective for using blending with petrol in engine. Butanol also improves performance of engine which results in increase in the efficiency of engine.

1.1 HHO Gas

The HHO gas is nothing but the electrolyte form of water. It is also called as oxy-hydrogen or brown gas. It is produced by electrolysis process, where an electrical power source is connected to two electrodes and which are placed in a mixture of water and electrolyte. Oxy-hydrogen appears to be a favorable alternative fuel on account of its high specific energy per unit weight, its all-time availability as a component of water, good combustion characteristics and eco-friendly, fast burning and higher flame propagation rates are the attractive features of HHO gas. HHO gas is a mixture of hydrogen and oxygen gases, typically in a 2:1 atomic ratio; the same proportion as water. At normal temperature and pressure, oxy-hydrogen can burn when it is between about 4% and 94% hydrogen by volume, with a flame temperature around 2000^0C. Oxy-hydrogen will combust (turning into water vapour and releasing energy which sustains the reaction) when brought to its auto ignition temperature.

1.1.2 Use of H_2 as IC engine fuel

In the early years of the development of internal combustion engines hydrogen was not the "exotic" fuel that it is today. Water splitting by electrolysis was a well-known laboratory phenomenon. Otto, in the early 1870s, considered a variety of fuels for his internal combustion engine, including hydrogen. He rejected gasoline as being too dangerous. Later developments in combustion technology made gasoline safer.
Most early engine experiments were designed for burning a variety of gases, including natural gas and propane. When hydrogen was used in these engines it would backfire. Since hydrogen burns faster than other fuels, the fuel-air mixture would ignite in the intake manifold before the intake valve could close. Injected water controlled the backfiring. Hydrogen gave less power than gasoline with or without the water.

1.1.3 Production of hydrogen

Hydrogen is not a fuel that occurs free in nature like fossil fuel. Primary source of energy like solar,
nuclear or hydro-electric is necessary to separate it from original combined state. The following
methods are considered suitable for hydrogen production:

- Electrolysis of water
- Thermochemical method
- Photobialysis
- Thermal decomposition of water

Electrolysis of water

In this method, electrical energy is used to break water into H_2 and O_2. In principle, an electrolysis cell consists of two electrodes, commonly flat metal or carbon plates, immersed in an aqueous conducting solution called the electrolyte.

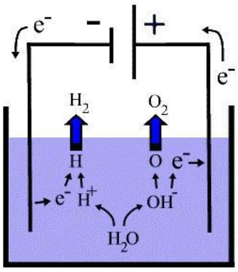

Figure-1.1: Electrolysis of water.

A source of DC voltage connected to the electrodes so that an electric current flows through the electrolyte from anode to cathode. As a result, water in the electrolyte solution is decomposed into H_2 which is released at the cathode and oxygen at the anode. Since water itself is the poor conductor of electricity an electrolyte like KOH is used increase the electric conduction.

Thermochemical method

This method is considered potentially most promising. It depends on complex series of interactions between the primary energy, water and some specific chemicals to produce hydrogen at temperatures substantially lower than thermal decomposition. The chemicals used are recyclable. A variety of compounds of iron, iodine, lithium and cadmium are used for the purpose.

Photobialysis

In this process, action of certain catalyst to produce H_2 from water by use of directs sunlight at ambient temperature. Though, it appears attractive, the present efficiency of production is only 1%.

Thermal decomposition of water

In this method, heat at high temperature (3000^{0}C) is used to thermally decompose water into H_2 and O_2.

1.1.4 Basic Detail of HHO Gas Production Kit

The HHO generator (kit) is basically an electrolyte cell. Here the kit used is of simple in construction, whose case (container) is made of PVC pipe and the electrodes are made from copper plate of length 500mm and thickness 1mm.The 500mm length copper plate is cut into pieces such that two equal lengths plate are of 250mm respectively. The lengths of both plates are of 250mm respectively and the plates are separated from each other by means of an insulator. Now these arrangements are placed inside a case (container) of diameter 150mm and it's both sides are sealed with end caps (PVC). The upper end cap houses the electrode terminals and also a hole for HHO gas outflow. The lower end cap has a hole for inlet of electrolyte solution. The electrode connections are made in such a way that the small part of the electrode is projected outwards so the melting of the connection between the electrode and the connection is eliminated.

In the electrolysis process the oxygen is generated at anode & hydrogen is generated at cathode. A small free space at the top of the cylinder will allow the gases to mix together. The HHO gas generated from the kit is supplied to the engine. A hole at 30degrees is drilled at the engine manifold to supply the gas. Since HHO gas is highly inflammable, the gas is passed through the water. The container of water acts as a Back Fire Arrestor. This is for safety reasons. Then the gas is passed through the carburetor to run the engine.

Figure-1.2: component of HHO Kit.

1.1.5 Features of HHO kit

Some of the features of kit are as given below,

1) Water temperature

The output voltage of battery or an alternator of a vehicle depends on the engine speed i.e. between 12 volts and 13.8 volts. If the source of power supply to the kit is car battery, the voltage and the current to the kit will always be fluctuating due to the varying engine speed. The amount of gas produced in the kit depends on the voltage applied to the system i.e. at 12 volt the hydroxyl production will be less however at 13.8 volts the Hydroxy production will be at peak. Similarly when the water is cold the voltage required to break the water molecules is around 2 volts. The voltage required to break the water molecules decreases as the water temperature of water increases, as this reduces the resistance. In the kit, reduction in the voltage drop due to lower of resistance. At this point of time there is an additional voltage available at set of electrodes, which further heats up the water.

2) Operation characteristics

As per the Faradays law thumb rule around 3.24 watts energy is required to produce 1 lap of gas per hour. The kit is producing 1 Ppm at 13.8 volts and 12 amps i.e. 165 watts. As per our experiment the most efficient water temperature to operate a kit is between 45-55^0 centigrade. At this stage the production of the Hydroxy is at peak.

3) NaOH Concentration

In most of the cells, it is required to increase the concentration of the solution on time to time basis. However in this kit, a mesh is fixed just above the coils to hold the KOH foams coming out with the Hydroxy produced in the system. Cost of KOH is also high. Due to these problems we started to use NaOH solution. This NaOH produces fewer fumes. So there is no problem of reduction in concentration.

1.1.6 Introduction to Butanol

History of Butanol

Butanol first gained widespread industrial use during the prohibition era in the 1920s. The booming automotive industry at that time was utilizing byproducts from the alcohol production industry as solvents for their lacquer paints. When the legal production of alcohol was halted and that stream of solvents dried up, the industry discovered that butanol could fulfill their needs. Though researchers looked at the possibility of using butanol as a fuel for internal combustion engines in the 1970s and 1980s, its use did not gain much visibility until 2005 when a man named David Ramey toured the United States in a butanol-powered car.

Butanol as fuel

Butanol is a type of alcohol that has received renewed interest recently as a potential green alternative to petroleum fuels. Its potential use a biofuel in gasoline and diesel engines.

Several research studies suggest that butanol can be blended into either gasoline to as much as 45 percent without engine modifications and sever performance degradation. When produced from biomass, butanol is a biofuel that will help reduce net production of greenhouse gasses and meet federal mandates for fuels produced from renewable resources.

Properties of Butanol

Butanol is a colorless, neutral liquid of medium volatility with a characteristic banana like odour. Butanol has a lower vapour pressure so it is not as volatile as other fuels. It has a wider flammable range than gasoline. Butanol is less corrosive than butanol.

1.1.7 Butanol-Gasoline Blending Technique

There are mainly two techniques for blending butanol-gasoline which are as follow:

1. Ratio-Blending

In ratio-blending each component of the final blend flows through its own individual meter and is controlled by a dedicated flow control valve. Each individual blend component quantity is measured independently by the meter dedicated to that single component. This method requires one meter and one control valve per blend component.

2. Sequential-Blending

In sequential blending all component quantities of the blend are individually measured through the same single meter. To accomplish this, each component of the blend is loaded sequentially, one at a time, until all blend components are dispensed. This method requires a single meter and control valve, and relies on subsequent mixing to affect the proper blend.

1.2 Problem Definition

- In naturally aspirated engine we found that chemical species in exhaust gas of engine which cause global warming, depletion of ozone layer, etc. are much more.
- Power output of naturally aspirated engine is low.

1.3 Aim and Objectives of Project

- To increase the efficiency of the four stroke petrol engine.
- For more power generation using same amount of fuel thus increasing fuel efficiency.
- Fulfilling above task by means of small modification in current automobile system.
- Minimizing the cost of creation and to maintain the quality of both product and society.

1.4 Problem Specification

- After the long use of HHO kit, Performance is not well as initial condition.
- Requirement of small modification in current automobile system.

1.5 Literature Review

Research Papers: - Today, there are many researches and development program available, which are much related to this study. Therefore, there are several technical papers, journals and some other sources which are reviewed and discussed in this chapter. For gating more knowledge about our project we had study many research papers and net searching. Some research papers of that are as under.

Following research paper are studied for the literature review.

Feasibility Establishment With On Board Generated Hydrogen Supplementation and Studies on Emission Characteristics of Gasoline Engine- Saumya Khulbe, Narayan Khatri, P. S Ranjit (E-ISSN: 2278-1684)

Hydrogen has great potential to do wonders in energy revolution. Being the most common element in the universe hydrogen can be easily extracted from tap water to yield power fo vehicles and houses. This experiment was started with a similar idea of utilizing normal water to power IC engines and it brings noticeable difference in emissions and fuel consumption. Slight introduction of distilled water after electrolysis into the combustion chamber drastically improved fuel efficiency of a normal bike engine and brought down the fuel consumption by almost 25%.Similar was the effect on emission levels with HC levels decreasing by 38% while NOX by 50%. First traces of NOX and HC were found to be generated at around 800 RPM on adding hydrogen to gasoline while with normal gasoline as a fuel such emission starts at around 400 RPM. This reduction level clearly indicates the hidden potential of using water (basically hydrogen inside water molecules) as a fuel to run automobiles.

Performance and Emission Characteristics of Spark Ignition Engine Fuelled with Gasoline/n- Butanol Blends- Anil Kumar.Y, B.Prabakaran (ISSN: 2277-9655)

Performance and emission characteristics of butanol - gasoline blends are experimentally evaluated in spark ignition engine without any modification or tuning the engine. The results that obtained are: Brake thermal efficiency of the blends increases with addition of nbutanol to gasoline due to lower calorific value of butanol blends. It is observed that BU50 have higher brake thermal efficiency of 19% at high speeds. Brake specific fuel consumption of blends is higher than the gasoline as the heating value of butanol is lesser than gasoline. CO and HC emissions of gasoline-butanol blends are lower compared to neat gasoline. There is a reduction of emission along with the increase of load. NOx emissions of gasoline-butanol blends are higher compared to gasoline. As the load increases the NOx emissions are gradually increases .This study gives an opportunity to utilize n-butanol, future renewable fuel to reduce the dependency of gasoline the fossil fuel to certain extent.

Performance and Emission Analysis of an Alternative fuel- S.Alphone Infant Leo , K.Sibi Kumar, S.gowtham, E.maria Derrik Jerry , S.sathyanarayanan , Dr.L.Muruganandam (ISSN (Online): 2395-6755)

An experimental study was carried over a four stroke SI engine using AVL DIGAS (gas analyzer), along with a Data acquisition system through electrical loading setup. Cold start emission readings were noted in a no-load condition, followed by the performance test. Both the performance and emission test were conducted under load and no load condition on it using gasoline-butanol blend at varying proportion .The above results indicate that butanol-gasoline blended fuel can be a promising alternative fuel for automotive application. Thus to conclude emission of various pollutants was drastically reduced and performance characteristics were increasing.

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Comparative Study of Performance of Four-Stroke Two Wheeler using Butanol-Gasoline and Butanol Gasoline Blends-Prem Kumar B G, Nithin H S, Dr. Ravishankar M K (ISSN: 2278-0181)

From the experiments carried out by running the test vehicle on gasoline and different butanol-gasoline, Butanol-gasoline blends, the following observations can be made In terms of torque and power characteristics, the E25 and B5 blends are better for the test vehicle. Whereas in terms of better fuel economy the E45 and B50 blends show favorable results when compared to the remaining blends. However, in terms of acceleration time E5 and B5 blends showed better results, but gasoline is still better in terms of acceleration time. Thus we conclude that, Butanol and Butanol can be blended with gasoline in percentages equal to E45 and B50 to obtain good result in fuel consumption.

2. SYSTEM ANALYSIS AND DESIGN METHOD

2.1 Description of Test Rig

2.1.1 Layout of Naturally Aspirated Engine

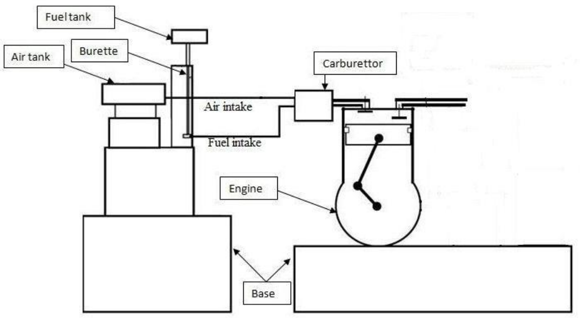


Figure-2.1: Layout of naturally aspirated engine.

Figure-2.2: Experimental Setup of naturally aspirated engine

2.1.2 Layout of Petrol-Butanol And Hho Aspirated Engine

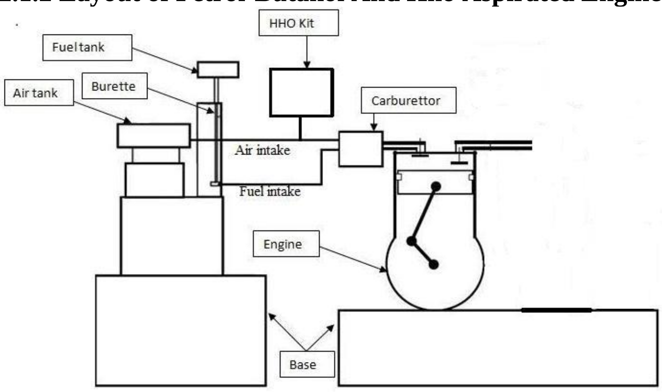


Figure-2.3: Layout of petrol-butanol and hho aspirated engine.

Figure-2.4: Experimental Setup of petrol-butanol and hho aspirated engine**.**

2.1.3 Engine Specification

Type: 4-stroke air cooled

- Cylinder: single
- Displacement: 97.2CC
- BHP: 5.5KW
- Speed: 8000RPM
- Fuel: Petrol
- Bore: 50mm
- Stroke length: 49.5mm
- Compression ratio: 8.8:1
- Transmission: 4-Speed constant mesh

2.1.4 Instruments Used In Experimental Test Rig

2.1.4.1 Tachometer

A tachometer is an instrument measuring the rotation speed of a shaft or disk, as in a motor or other machine. The device usually displays the revolutions per minute (RPM) on a calibrated analogue dial, but digital displays are increasingly common. Specifications of tachometer

1. Rotation speed display is five-digit LCD number with maximum of 19999
2. Display 0 below 50 RPM
3. Measurement mode 0-5

Figure-2.5: Tachometer.

2.1.4.2 Burette

Burette is the device which is used to measure the flow rate of petrol. A burette is a uniform bore glass tube with fine gradations and a stop valve at the bottom, used especially in laboratory procedures for accurate fluid measurement.

Figure-2.6: Burette.

2.1.4.3 Fuel Tank

It is used to store fuel and protect the fuel from outside environment (like dust). Also it is supply the petrol and blend of petrol-butanol engine at the end of compression stroke by means of hose pipe**.**

Figure-2.7: Fuel Tank

2.1.4.4 Air Chamber

It is used to store the air at required pressure and also supply the air to the engine at intake stroke.

Figure-2.8: Air Chamber

3. IMPLEMENTATION

3.1 Resultant Table

From observation table, we can calculate brake power and fuel consumption for different fuel as petrol, blend of petrol-butanol, and blend of petrol-butanol with hho gas as fuel supplement. Result table shown below give some performance parameter of single cylinder 4-stroke petrol engine.

Table-3.1: Result table for petrol fuel

No.	RPM	M_f (ml)	T_f (s)	TORQE (Nm)	B.P. (KW)	F.C. (kg/hr)	F.P. (KW)	I.P. (KW)	η_{mech} (%)	η_{bth} (%)
1	960	10	12.2	1.38	0.14	0.29	0.097	0.24	58.72	3.98
2	1060	10	10	1.53	0.17	0.36	0.097	0.27	63.46	3.99
3	1160	10	9.6	1.67	0.20	0.38	0.097	0.30	67.54	4.58
4	1260	10	8.6	1.81	0.24	0.42	0.097	0.34	71.05	4.84
5	1380	10	7.5	1.99	0.29	0.48	0.097	0.38	74.64	5.06

Observation table for B.P, Mechanical efficiency, brake thermal efficiency of Petrol fuel is showed above.

Table- 3.2: Result table for Petrol+Hho

No.	RPM	M_f (ml)	T_f (s)	TORQE (Nm)	B.P. (KW)	F.C. (kg/hr)	F.P. (KW)	I.P. (KW)	η_{mech} (%)
1	960	10	13.6	1.38	0.14	0.26	0.08	0.22	63.42
2	1060	10	11.0	1.53	0.17	0.33	0.08	0.25	67.92
3	1160	10	10.8	1.67	0.20	0.33	0.08	0.28	71.72
4	1260	10	9.8	1.81	0.24	0.37	0.08	0.32	74.95
5	1380	10	8.3	1.99	0.29	0.43	0.08	0.37	78.20

Observation table for B.P, Mechanical efficiency of Petrol-hho fuel is showed above.

Table 3.3 Result Table for Petrol+Butanol (10%)

No.	RPM	M_f (ml)	T_f (s)	TORQE (Nm)	B.P. (KW)	F.C. (kg/hr)	F.P. (KW)	I.P. (KW)	η_{mech} (%)	η_{bth} (%)
1	960	10	10.1	1.38	0.14	0.36	0.2050	0.34	40.35	3.58
2	1060	10	9	1.53	0.17	0.40	0.2050	0.37	45.24	3.89
3	1160	10	8.2	1.67	0.20	0.44	0.2050	0.41	49.74	4.25
4	1260	10	7.6	1.81	0.24	0.47	0.2050	0.44	53.87	4.65
5	1380	10	6.9	1.99	0.29	0.52	0.2050	0.49	58.34	5.06

Observation table for B.P, Mechanical efficiency, brake thermal efficiency of Petrol-butanol blend fuel is showed above. Percentages of butanol are 10%.

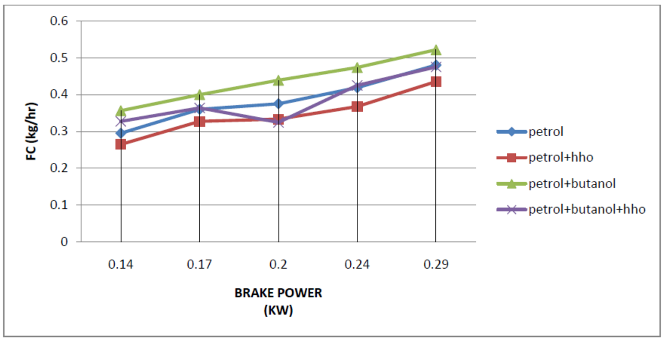
Table-3.4: Result Table for Petrol+Hho+Butanol (10%)

No.	RPM	M_f (ml)	T_f (s)	TORQE (Nm)	B.P. (KW)	F.C. (kg/hr)	F.P. (KW)	I.P. (KW)	η_{mech} (%)
1	960	10	11	1.38	0.14	0.33	0.1850	0.32	42.84
2	1060	10	9.9	1.53	0.17	0.36	0.1850	0.35	47.79
3	1160	10	11.1	1.67	0.20	0.32	0.1850	0.39	52.30
4	1260	10	8.5	1.81	0.24	0.42	0.1850	0.42	56.40
5	1380	10	7.6	1.99	0.29	0.47	0.1850	0.47	66.81

Observation table for B.P, Mechanical efficiency of Petrol-butanol blend-hho fuel is showed above. Percentages of butanol are 10%.

3.2 Resultant Graph

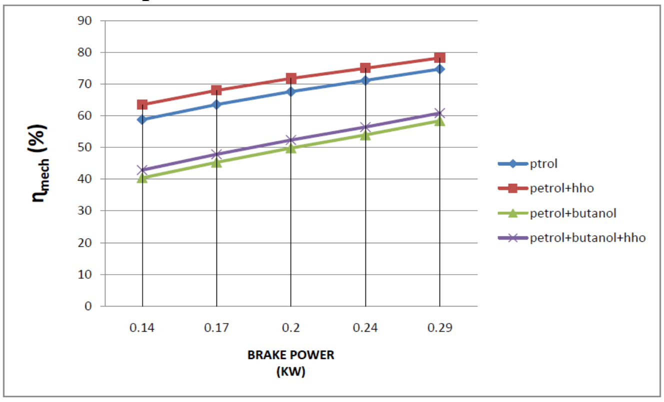
After performing experiment on 4-stroke single cylinder petrol engine and from experiment table we can plot the graph and compare them for different fuel used as petrol, petrol-hho, blend of petrol butanol and blend of petrol-butanol with hho gas as fuel supplement for fuel consumption, brake power, mechanical efficiency as follow:



Figur-3.1: Brake power Vs. Fuel consumption graph

As we can see from the graph of Brake power vs. Fuel Consumption, as increase the brake power on engine, fuel consumption is increase. We got lower fuel consumption for petrol-hho fuel.

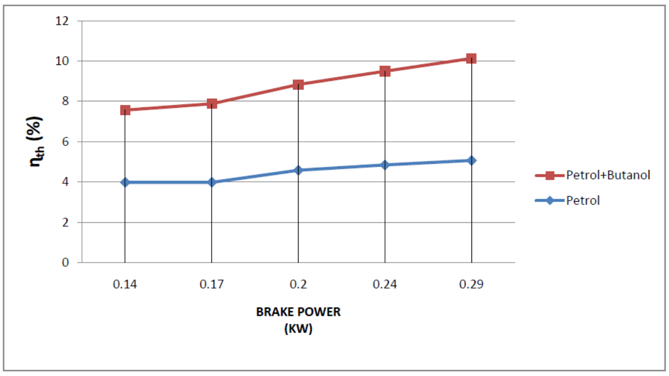
- **Below figure show the graph of Mechanical Efficiency Vs. Brake power.**



Figur-3.2: Mechanical efficiency Vs. Brake power

As we can see from the graph of Brake power vs. Mechanical Efficiency, as increase the brake power on engine, mechanical efficiency is increase. We got higher mechanical efficiency for petrol-hho fuel.

- **Below figure show the graph of Thermal Efficiency vs. Brake power**.



Figur-3.3: Thermal efficiency Vs. Brake power

As we can see from the graph of Brake power vs. Thermal Efficiency, as increase the brake power on engine, Thermal efficiency is increase. We got higher Thermal efficiency for petrol-hho fuel.

4. CONCLUSION

By performing experiment on single cylinder 4-stroke petrol engine with using fuel as petrol, petrol-hho, petrol blend with butanol, petrol-hho blend with butanol we conclude following :

1. The performance characteristics of the single cylinder 4 stroke petrol engine supplementing HHO Gas will improve.
2. Thermal efficiency will improve due to butanol.

4.1 FUTURE SCOPE

As we know that automobile vehicle are necessary for transportation this days. So it's necessary to improve performance of vehicle to expand the lifespan of fossil fuel.

1. Butanol-diesel blend fuel can be used in diesel vehicle.
2. HHO kit can be used in diesel engine.

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