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Effects of Brown Gas Performance and Emission in a SI Engine

D.V.N.Lakshmi1, T.R.Mishra2 & R.Das 3 S.S.Mohapatra4

Abstract: The world is facing declining liquid fuel reserves at a time when energy demand is exploding. As the supply decreases and costs rise, In order to achieve a secure and stable energy supply that does not cause environmental damage, renewable energy sources must be explored and promis-ing technologies should be developed. Considering various gaseous fuels, Brown‟ s gas pro-duced by the electrolysis process of water has high potential for cost effective and emission as-pects. It is identified as the one of the best partial alternate gaseous fuel to be enriched with in-take air in a spark ignition engine or compression ignition engine. The present investigation in-volves the usage of Brown‟ s gas in SI engines. The experiment was carried out in a 100 cc sin-gle cylinder air cooled engine at 1500 rpm for various loads. The performance characteristics such as Brake thermal efficiency, specific fuel consumption and emission characteristics like Carbon monoxide (CO), and Oxides of Nitrogen (NOx) are studied. The results are compared with petrol engine and found that the Brown‟ s gas enriched operation gives better results com-pared to conventional engine operation.

Keywords: *Brown Gas, Brake Thermal Efficiency, Total Fuel Consumption, NOx Emissions*

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Introduction

The search of sustainable alternative fuels for petrol engine has recently become important due to rising price of petrol, dep-leting the petroleum reserves and the environmental problems. So alternative of this is very necessary. In the use of gasoline fuels harmful emission products (CO, NOx, and HC) are left over as an exhaust in to the environment. By using exhaust gas circulation and using some cata-lytic converter these emissions can be reduced to some extent [2-4]. Due to raising prices of petrol can be thought of an alternative fuels for petrol engines which help reduce cost of fuel. One of the alternative fuels for this is hydrogen which enhances the engine efficiency and zero emissions also .But the main disadvantage is if we are using hydrogen as fuel the generation cost is more. Brown gas as a renewable fuel resource can be produced through the expendi-ture of energy to replace increasingly the depleting sources of conven-tional fossil fuels. The hydrogen fuel when mixed with air produces a combustible mixture which can be burned in a conventional spark ignition engine at an equivalence ratio below the lean flammability limit of a gasoline/air mixture. The flammability range of the hydrogen fuel is from 4% to 75% by volume whilst the value for gasoline fuel is from 1% to 7.6% by volume at atmospheric pressure. The resulting ultra lean combustion produces low flame temperatures and leads directly to lower heat transfer to the walls, higher engine efficiency and lower ex-haust of NOx emission. Using hydrogen fuel rather than gasoline ori-sooctane fuels for short periods during cold starts and warm-up pe-riods, avoids problems of cold fuel evaporation. This paper focuses on studyingthe effect of emissions from a SI engine which is hydrogen fuelled. The model is first tuned with the experimental results ob-tained from the experimental program. Good agreement with the expe-rimental fuel consumption data, NOx emissions for gasoline and hydrogen fuels is observed. The model is used to study and to provide data on the effects of various emissions like CO, CO2, hydrocar-bons and NOx emissions using a Multi-Gas Analyzer of an engine oper-ating on the above fuel mentioned.

1.1. Production of Brown gas :

Oxy-hydrogen is an enriched mixture of hydrogen and oxygen bonded together molecularly and magnetically (Brown, 1978). Oxy-hydrogen gas is produced in a common-ducted electro-lyser and then sent to the in-take manifold to introduce into combustion chamber of the engine. Oxy-hydrogen gases will combust in the combustion chamber when brought to its auto-ignition or self ignition temperature. For a stoichiometric mix-ture at normal atmospheric pres-sure, auto-ignition of oxy hydrogen gas occurs at about 570°C (1065°F). The minimum energy required to ignite such a mixture with a spark is about 20 micro joules. At normal temper-ature and pressure, „oxy- hydrogen gas ‟ can burn when it is between about 4 and 94% hydrogen by volume. When ignited, the gas mixture converts to water vapour and releases energy. The amount of heat re-leased is independent of the mode of combustion, but the temperature of the flame varies. The maximum temperature of about 2800°C is achieved with a pure stoichiometric mixture, about 700°C hotter than a h ydrogen flame in air. Oxy-hydrogen gas has very high diffusivity. This ability to disperse in air is considerably greater than gasoline and it is advantageous in mainly two reasons. Firstly, it facilitates the formation of homogeneous air fuel mixture and secondly, if any leak occurs it can disperse at rapid rate. Oxy hydrogen gas is very low in density. This re-sults in a storage problem when used in an internal combustion en-gine.

Method of Oxy-Hydrogen Gas Generation :

Electrolysis is the general method which is used for the generation of oxy-hydrogen gas. This method makes use of the basic principle of fara-days law. An electrical power source is connected to two electrodes, or two plates typically made from some inert metal such as platinum or stainless steel which is placed in the water. In a properly designed cell, hydrogen will appear at the cathode (the negatively charged electrode, where electrons enter the wa-ter) and oxygen will appear at the anode (the positively charged electrode). Assuming ideal faradic efficiency, the amount of hydrogen generated is twice the number of moles of oxygen and both are directly proportional to the total electrical charge conducted by the solution. Fol-lowing are the reactions that normally take place at cathode and anode:

Cathode (reduction): $2\ H_2O + 2e^- \rightarrow H_2 + 2\ OH^-$
Anode (oxidation): $4\ OH^- \rightarrow O_2 + 2\ H_2O + 4\ e^-$
Overall reaction: $2\ H_2O \rightarrow 2\ H_2\ (g) + O_2\ (g)$

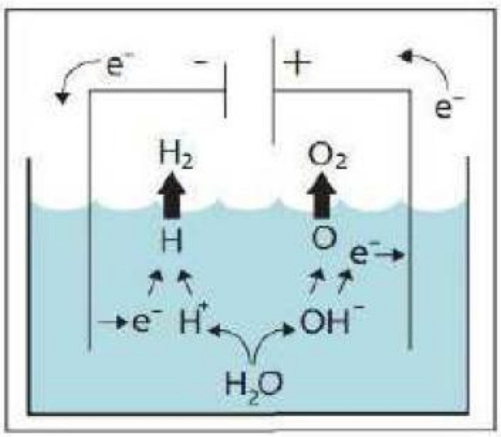

Fig.1.Electrolvzer

The electrolyzer shown in Figure 1 is based on the common-duct series-cell electrolyzer concept originally developed and patented by William Rhodes, Ernest Spirig, Yull Brown and later refined by Bob Boyce, George Wiseman, etc. It uses an alkaline (NaOH, KOH) electrolyte to split distilled water into hydrogen and oxygen components very efficiently. The produced hy-drogen and oxygen gasses are not separated to separate containers, but kept mixed. The pro-duced oxy- hy-drogen gas is a stoichiometric mixture of hydrogen (2 parts vol.) and oxygen (1 part vol.) and can be combusted in vacuum. The combination of series-cell topology is very efficient, because it allows the cells to operate as close to their optimal cell voltage (1.47V) as possible. The electrolyzer runs fairly cool, at about 30- 50 °C depending on the current and elec-trolyte. The electrolyzer shown in this report has about 80-90% total efficiency when all things are considered (am bient temperature, ambient pressure, accurate measurement of gas volume and current) and powered by straight DC. Pulsing (PWM) or modulation of the input voltage waveform could increase the performance further.

Fig.2 Side and top view of HHO generator

Experimental set-up:

The set up involves fuel metering device, portable multi gas exhaust emission analyzer, tachome-ter, brake drum dynamometer arrangement, stopwatch and other support equipments for meas-urement of different characteristics. Brown gas is produced from the electrolysis circuit which is supplied to the 4-stroke SI engine before the carburetor simultaneously with the gasoline supply. The fuel metering device in the form of measuring tube is used to calculate amount of gasoline (for certain period of time) supplied to the 4-stroke engine. The exhaust gas analyzer is coupled with the silencer of the motor Vehicle for exhaust gas analysis.

The exhaust temperature measurement device is used to measure the exhaust temperature of the exhaust gases. Digital tachometer is used to measure the engine RPM at different fuel supply. Stop watch is used to measure the time-period for certain amount of fuel consumption and for torque measurement a rope brake dynamometer is attached to the rear wheel.

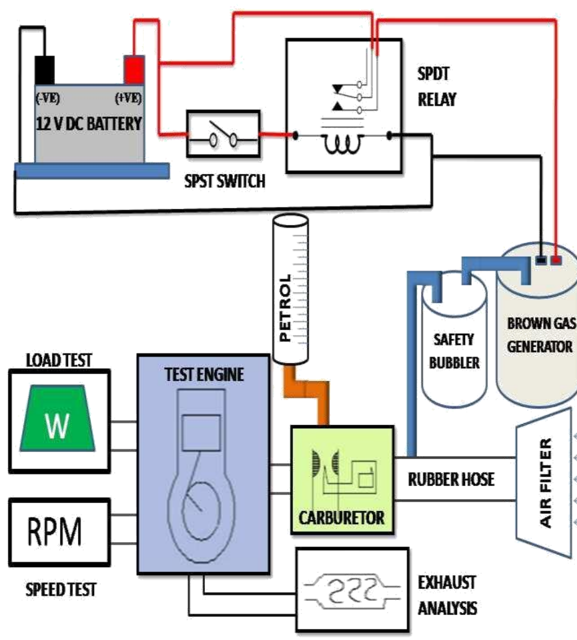

Fig.3.Block Diagram of Petrol Engine boosted with

The Engine:

The engine is made by "Hero Honda Company Ltd." lic ensed with having 100 CC single cylinders SI engine. The important specification of engine and its sub-system are

- Bore diameter : 52.4 mm Stroke
- length : 57.8mm
- Swept volume : 97.2cc
- Compression ratio :9.1:1
- Power : 7.60HP(5.5kw) @8000rpm
- Torque : 6.5 Nm @8000 rpm
- Fuel feeding : by carburetor

- Ignition : Electronic type
- Cooling : Air
- Gear box : 4-speed
- Power/Weight ratio :0.0697 Hp/Kg

3. Results and discussion:

3.1 Performance Characteristics:

Experiments were conducted for engine performance and emission analysis for a 100cc spark ignition engine. Brake Thermal Efficiency indicates the fraction of heat supplied that is transformed into engine shaft work. Fig 4 shows the variation of load with Brake thermal efficiency values for gasoline and gaso-line with Brown"s gas fuel. Graph shows the steep increase in the Brake thermal efficiency for gasoline with Brown"s gas. It indicates that the engine performance increases by addition of brown gas.

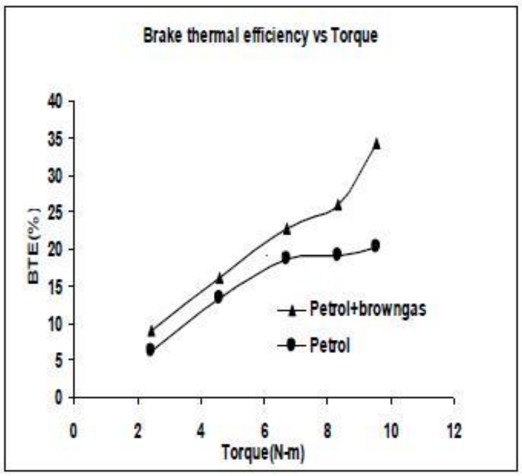

Fig.4.Comparision of brake thermal

Total fuel consumption:

Total fuel consumption obviously reduces in the brown gas enriched engine as shwn in Fig.5 because we have reduced the fuel supply by adjusting the carburetor screw,as a result the engine can have better mi-lage. Specific Fuel Consump-tion (SFC): Specific fuel Consumption is the fuel flow rate per unit of power. Fig 5 shows the curves for Specific fuel Con-sumption at various loading conditions for gasoline fuel and Brown"s gas enriched fuel. There is a decrease in the Specific Fuel Consumption of Brown"s gas enriched fuel when com-pared to that of gasoline

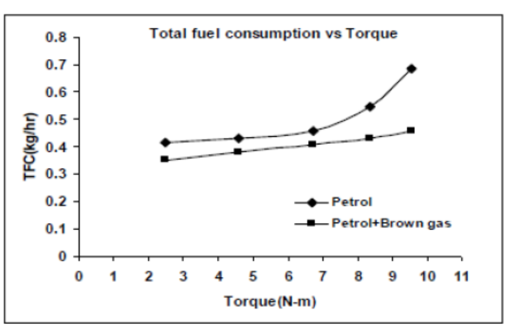

Fig.5.Comparision of Total specific fuel

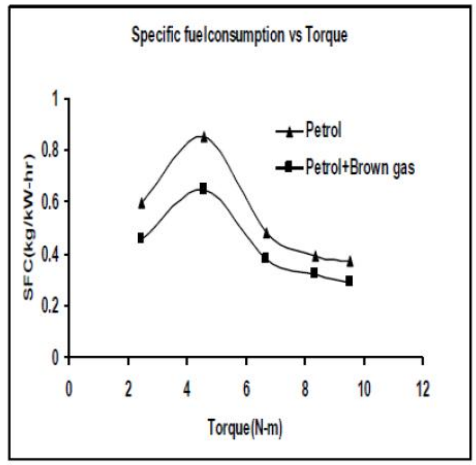

Fig.6.Comparision of Specific fuel

CO emissions: Carbon Monoxide emissions are generated in an engine when it is operated with a fuel-rich equivalence ratio. These emissions can be reduced by operating the en-gines at leaner ratios. Brown"s gas fueled engine can be op-erated at leaner ratios, thus resulting in reduced level of CO emissions. Fig 7 shows the reduction in Carbon Monoxide emission level for gasoline with Brown"s gas fuel compared to that of gasoline fuel. This is because of the operation of the engine at lean ratios.

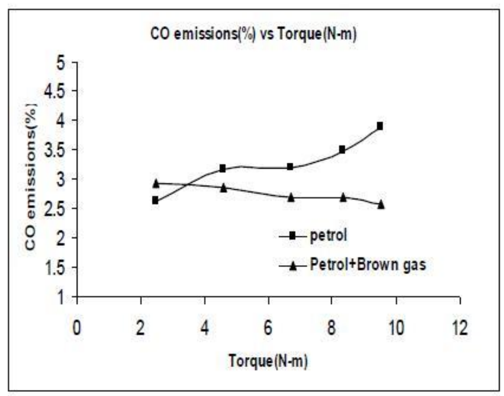

Fig.7.Comparision of CO emissions

The NOx emissions reduced when the engine is enriched with brown gas as shown in Fig.8.There is a decrease in the level of nitrogen oxide emissions for Brown's gas enriched fuel.

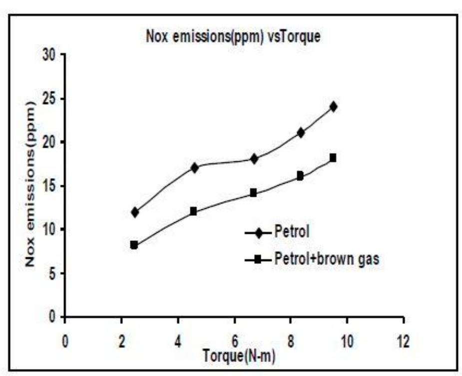

Fig.8.Comparision of NO_x emissions

Conclusions: Experimental investigation of the effect of brown gas on the emission parameters and performance test on 100 CC single cylinders Hero Honda SI engine has been carried out. HHO gas has been generated by using HHO generator. The exhaust analysis was done by us-ing exhaust gas analyzer. From the experimental work the following conclusions were made

- Brake thermal efficiency of brown gas engine enriched operation gives higher than `normal conventional S.I.Engine. At full load brake thermal efficiency of a brown Brake gas boosted engine operation gives 30% more than normal conventional engine.
- The concentration of Nox has been reduced to almost 25%when brown gas petrol engine was used
- Carbon monoxide emissions are reduced by using brown gas

This work proves that using brown gas enriched internal combustion engines is advantageous compared to gasoline engines.

Acknowledgement

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