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Power gas An Example Of The Emerging Novel Gaseous Fuel For SI Engine

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ABSTRACT

In this paper systematic study on the novel gaseous fuel 'Powergas' for SI engine has been presented. Search for alternative fuel for internal combustion engine is one of the major research areas in this age of energy crises. 'Powergas' a synthetic fuel is said to be an effective alternative for gasoline and natural gas. Powergas is mainly consists of hydrogen and carbon monoxide, derived from Aqua-fuel. Though it has lower calorific value than gasoline and natural gas, its combustion characteristics, clean burning properties, cost effectiveness can make it suitable alternative. Powergas shows low performance characteristics like less brake mean effective pressure (BSFC) operating on same compression ratio compare to gasoline and natural gas. Performance can be improved by using high compression ratio. Engine downsizing can be used for improving performance of Powergas. Total hydrocarbons in exhaust are very minimal in case of powergas with compare to natural gas and gasoline. It also drastically reduces carbon monoxide emission. High level of hydrogen concentration in powergas there is increase in level of peak temperature of combustion which has impact on concentration of oxide of nitrogen (NOx). Because of presence of high carbon monoxide in the powergas emission of carbon dioxide is also high compare to gasoline. Using powergas as fuel with minimum coefficient of variance some modification are needed in existing SI engine such as increase in compression ratio and spark advance for better performance. Reducing NOx emission exhaust gas recirculation should be done. Substitutions of current material with hydrogen compatible material, NOx reduction according to norms are challenges for Powergas. After researching powergas proved to be better alternative fuel in future .

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I. INTRODUCTION

IC Engine is one of the most developed technologies in human history .Over the last century use of IC engine in automobile sector increased drastically. This creates large impact on consumption of fossil fuel and also creates environmental impacts because of pollution produced in IC engine. These concerns have stimulated researchers into more ecofriendly alternative fuels that can replace the use of fossil fuels to a full or partial extent. "Powergas" is example of these alternative fuels. "Powergas" a synthetic gaseous fuel originally derived during the processing of Aqua-fuel.
The Aqua-fuel process encompasses an electric discharge on carbon rods submerged in water. The discharge decomposes the carbon rods and the water molecules and creates plasma composed of mostly ionized hydrogen, oxygen, and carbon atoms. The atoms combine in various forms, and are cooled down in the water surrounding the discharge. The exact composition of the gas depends on the production site, the time history of the decomposition and the ambient conditions .The major constituents of the synthetic gas after formation are hydrogen H_2, carbon monoxide CO, and carbon dioxide CO_2. It may also contain trace amount of hydrocarbons, oxygen O_2, nitrogen N_2, and water vapor.

The gases are collected above the water surface, after drying, and compressed and stored in a cylinder. The synthetic gas resulting from the Aqua-fuel process was originally identified by the patent owner William H. Richardson Jr. The synthetic gas is known by several different names among researchers. „Powergas" is the product and trade name used in New Zealand by Mr. Chris Newman, who has maintained an association with Mr. Bill Richardson since 1994. Readers are directed to the literature [1,2] for detailed information regarding Aqua-fuel.

Table 1 Composition of aqua fuel

	NASA	**IBR**
Hydrogen	46.47	48
Carbon dioxide	9.34	2
Ethylene	0.05	-
Ethane	0.01	-
Acetylene	0.63	-
Oxygen	1.17	5
Nitrogen	3.82	-
Methane	0.18	-
Carbon Monoxide	38.37	44
Misc. structures	-	1
Total	**100.02**	**100**

Table.1 shows the composition analysis from NASA and the Institute for Basic Research (IBR) for Aqua-fuel or Magnegases. This latter is another name for a fuel produced from the Aqua-fuel process. Based on the „Powergas" composition, which is assumed in the current review paper is (52% CO, 44% H2 and 4% N2), the lower calorific value of the fuel is 15.3 MJ/kg. This compares with gasoline (44 MJ/kg) and natural gas (40 MJ/kg) used in this work.Gas composition can have a significant impact on the Performance and emission characteristics of an engine by Affecting the flame speed, ignition, and knock characteristics and therefore, the spark timing and air/fuel ratio are required to be optimized carefully for improved engine performance. This study extends the understanding of the impact of the gas composition on engine performance and emissions in comparison to the conventional fuels gasoline and natural gas (NG).[3]

ADVANTAGES PROPERTIES OF AQUAFUEL

1) Powergas has less density tan air is lighter than air AquaFuel does not self–combust because of its low content of Oxygen

2) Miner modification in the carbonator is required to existing SI engine to run on powergas.

3) Powergas has astonishingly low pollutant content in its exhaust when compared to other fuels, such as gasoline and methane, etc. Hence no pollution control equipment is needed for burning AquaFuel;

4) The main gas produced in burning Powergas is carbon dioxide as it is the case of methane, whose precipitation into a solid form is under study

5) Powergas is different than the mixture of Hydrogen and Oxygen emitted from ordinary electrolysis .It is stable, permanent gas.

6) Powergas can be stored in ordinary tanks either as in gaseous form or in its liquid form;

7) Powergas can be produced in any desired amount, whether small or large, and anywhere, whether on land or at sea;

8) Powergas is economic, easier and more practical to produce compare to gasoline, methane or pure Hydrogen;

9) Powergas uses much less Oxygen than other forms of fuels because of its high internal content of Oxygen in various compounds, thus providing a significant contribution to the reduction of depletion of Oxygen

10) Powergas has a light, yet very characteristic and peculiar odor. This odor has considerable practical and safety values because other gases which are naturally odorless require the addition of odor via chemicals for safety purposes.[4]

In this technological survey we are focus on study of various parameters for optimizing the SI engine fueled by powergas which have significant impact on combustion, performance and emission characteristics

1) composition

2) Air fuel ratio
3) Compression ratio

1) Composition

Tough powergas is synthetic gaseous product of electrolysis of water using carbon rod the composition of gas is dependent on many factor such as rate of reaction ,content of aqua fuel and time history of production site By varying composition of powergas has impact on its combustion propertiesHydrogen is the one of the key component of the power gas which has very clean burning properties, wide flammability limit and high flame propagation speed. . Hydrogen very high laminar flame propagation speed nearly eight times of natural gas .Higher Hydrogen content in powergas reduce the duration of combustion reaction and thereby reducing heat loss improves the efficiency of IC engine Extending the lean burn limit without misfiring at lean mode is also one of the major advantage of hydrogen by virtue of which further improvement in fuel economy is possible On other hand increasing concentration of the hydrogen beyond certain limit effect on combustion stability. It also lead to knocking tendencies. Increase in hydrogen also increase in cylinder temperature which increase NOx emission Carbon monoxide is another important constituent of power gas generally it is noncombustible gas which take very high activation energy for combustion reaction .but Hydrogen act as a catalyst for combustion of carbon monoxide and significantly improve rate of reaction Research study shows that increase in carbon monoxide stabilize the combustion reaction It also control Knocking characteristics of fuel by smoothing P-Θ curve. Equal volume percentage of the carbon monoxide and Hydrogen shows good Heat release rate and higher heating value compare to other concentration Small addition of methane also have significant positive impact on the combustion phenomena

2) Air fuel ratio

Stoichiometric air fuel ratio is one of the important parameter For comparing two different fuel As we already discussed the calorific value of power gas is 14MJ/kg which is very less compare to gasoline-42MJ/kg and natural gas40MJ/kg This lead to loss of BMEP and power output of engine but we can"t compare two fuel only base on calorific value Due to presence of oxygen chemical composition of powergas there in less external oxygen is needed for fuel combustion results in lower stoichiometric air fuel ratio. lower stoichiometric ratio of powergas amount of fuel admitted in per cylinder is increased which can compensates the lack of low energy content of fuel.Presence of hydrogen in powergas improves the lean burning limits because of its high laminar flame propagation speed. Various speed, injection timing and mass burn fraction are compared for powergas fuelled SI engine. The engine operation was restricted at λ=1.5-3.25 due to limitations associated to injector pulse width at lower λ and engine stability during lean operation at the lower end. The maximum IMEP was observed to be

9.08 bars at 2400 rev/min with λ=1.5.

The lean limit of CNG fuelled in the same engine was reported to be in the range of λ = 1.6 to 1.8 depending on the degree of stratification . However, syngas was shown to present a wider operational λ range as compared to CNG in the lean operation side. Fig 1 shows the variation of ignition advance in crank angle degree (CAD) with λ for different engine speeds. The result indicates that the optimum ignition timing was advanced with an increase in λ for all engine speeds. Similar trend of the ignition advance with increase λ was reported for natural gas-hydrogen mixture combustion. The increase in ignition advance can be attributed to the decrease in burning velocity as the mixture gets leaner [7,8]

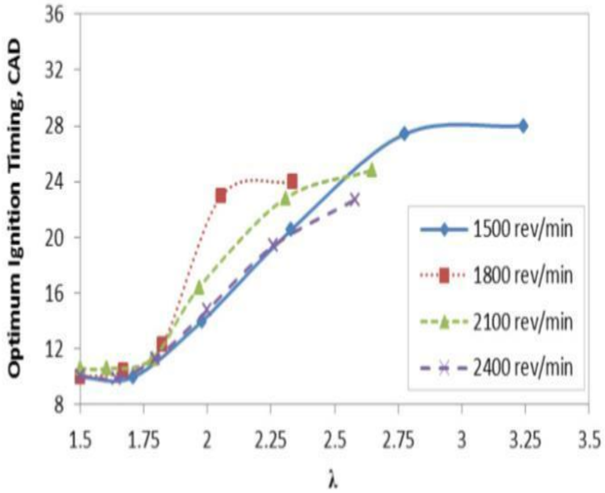

Fig.2 Optimum Ignition timing Vs λ at different speed

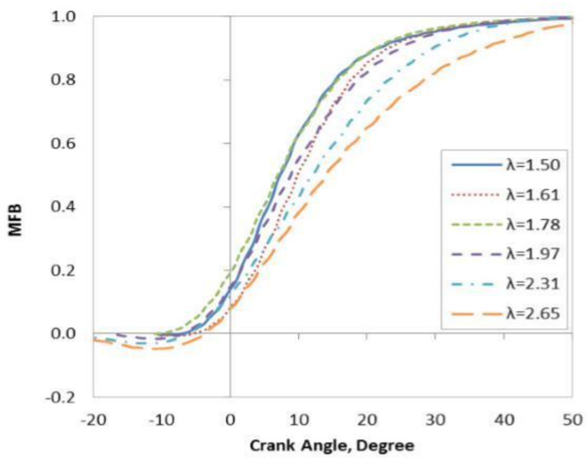

Fig.3 Mass fraction burn (MFB) Vs crank angle

3) Compression Ratio

Due to gaseous nature of fuel power gas using in SI engine It occupies more volume in cylinder .and because of lower stoichiometric ratio quantity of gas inject per stoke is also quite high hence its greatly reduce the volumetric efficiency of Si engine.co compensate this loss of power we have to increase the compression ratio of engine.

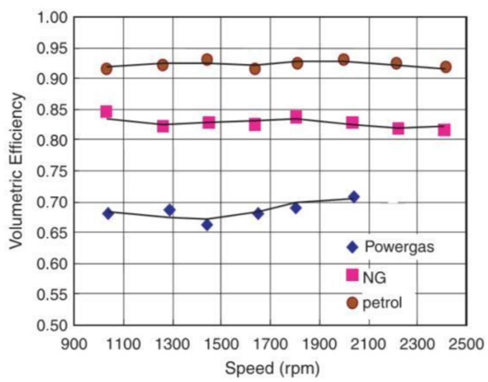

Fig.5 Volumetric efficiency Vs engine speed

Fig. 6 shows that increasing compression ratio up to 11:1, the brake torque for „Powergas" improved compared to the other fuels. When operating at around 1500 rpm,

„Powergas" produced about 18% less torque output than NG. This is a considerable improvement over the 30% less torque at the lower compression ratio. However, the bsfc remained almost the same at this operating condition as at compression ratio of 8:1.

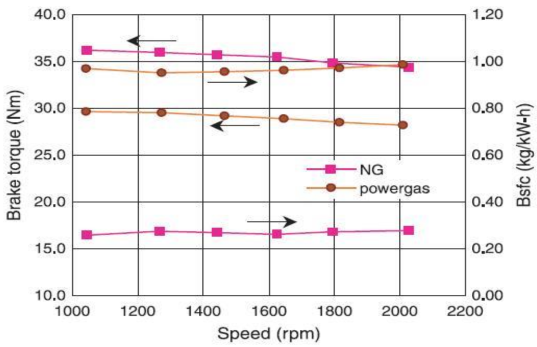

Fig.6 brake torque & BSFC Vs engine speed

Performance Characteristics

The performance parameters like brake torque, and Bsfc function of engine speed .For powergas as baseline fuel we have to change the spark timing .for constant equivalence ratio it is found that maximum braking torque is obtain at spark timing 4 degree before top dead center (BTDC).This is much less than gasoline 12-15 BTDC at close to stoichiometric point (1.02-1.08)and Natural gas 24-30 BTDC at lean mixture(0.81) This may because of hydrogen consist within fuel reduce ignition delay . for „Powergas" gasoline and natural gas a standard constant compression ratio of 8:1 is maintained for comparing performance. The brake torque in case of each fuel gradually declined with rise in engine speed For power gas reduction of brake torque with engine speed is significant compare to other two fuel.. At about 1500 rpm, „Powergas" produced 30% lower brake torque output compared to gasoline and 23% lower output brake torque than Natural gas. This decrease in torque is may be attributed to the less heating value per unit volume of the „Powergas"-air mixture (2.63 MJ/m3) as per equivalence ratio assumed for gasoline-air mixture heating value is(w3.42 MJ/m3) and for natural gas and air mixture it is (w2.88 MJ/m3). [6]

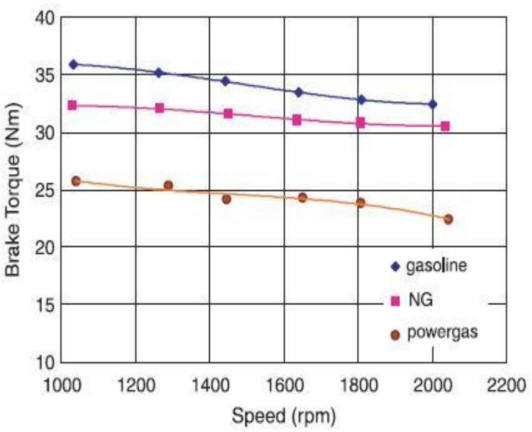

Fig.7 Brake torque VS engine speed

Volumetric efficiency is normally less for gaseous fuels in comparison of conventional liquid fuels. It was also substantially attributed in the case of „Powergas" fuelling (Fig. 5). Indicated torque output is proportional to volumetric efficiency, and as „Powergas" causes a lower volumetric efficiency, its torque output also decreases.Brake specific fuel consumption (BSFC) for natural gas was almost constant for NG as engine speed was increased, but showed a mild increase for gasoline and „Powergas" .For a particular operating engine speed, very high specific fuel consumption compared required for powergas compared to the other two fuels. At around 1500 rpm, „Powergas" required about 2.7 times more fuelling than gasoline and about 3.4 times more than NG. The stoichiometric air/fuel ratio for „Powergas" was determined to be about 4.25:1 Thus „Powergas" has a much lower stoichiometric A/F ratio than for the NG (w15.5) or gasoline (w14.6) since it contains mainly CO and H2. Because of the high flame speeds, ignition timing, for the engine, operated on fuel containing significant proportion of H2, is usually found to optimize at close to the top dead center[8]. Optimum spark timing, MBT, was found for „Powergas" to be at about 48btdc and that for gasoline ranges from 12 to 158btdc for the whole range of speeds. This clearly confirms a very rapid combustion process of „Powergas" compared to the other conventional fuels.

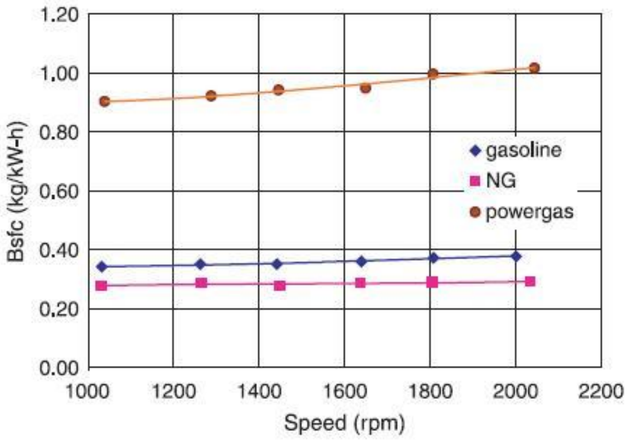

Fig.8 Brake specific fuel consumption Vs engine speed

Engine Emission

When Engine operating on „Powergas" the Total

Hydrocarbon Emission (THC) were very low at 0–20 ppm Which is negligible compare to other two fuel. This is may because of absence of any hydrocarbons in the Powergas. The THC emissions for gasoline are in between 90 to 225 ppm and that for natural gas is in between 20 to 106 ppm. However, the CO2 emission was found to be the highest for „Powergas" among the three fuels. Reason of this is high concentration of Carbon monoxide CO in its composition and Powergas may contain some minor amount of CO2 also. For the „Powergas" operation, CO emissions were found to be very much lower than the other two fuels under almost similar operating conditions, which was an indication of complete combustion.

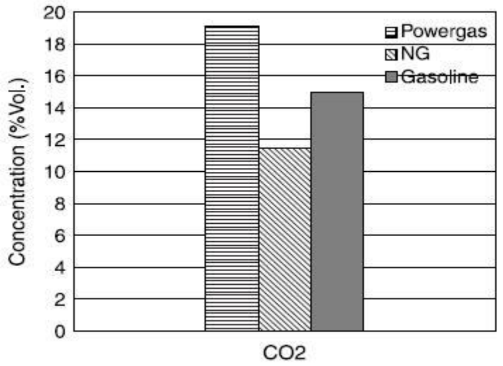

Fig.9 CO2 emission concentration of different fuel

The NOx emissions for the three fuels at about 1500 rpm and at MBT timing with WOT condition The NOx emission for „Powergas‟ was found to be very high compared to the conventional fuels. This is due to the higher temperature and relatively shorter combustion duration, which is discussed more fully below. „Powergas‟ contains mainly CO and H2 and they have relatively high flame speed and flame temperatures. This is investigated further by ISIS computer simulation. The effect of engine speed on NOx emissions was found to be negligible for „Powergas

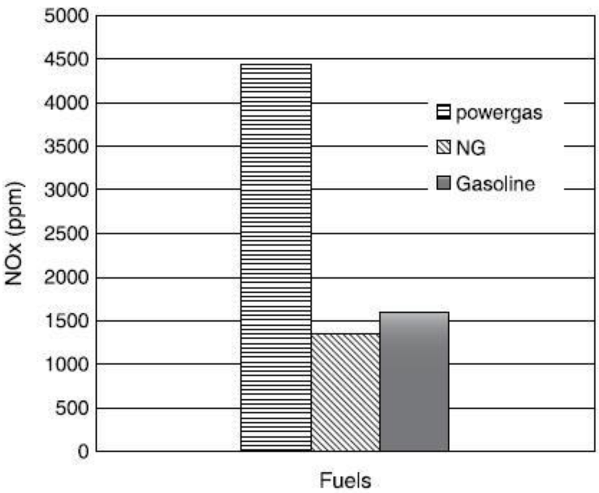

Fig.10 NOx emission concentration for different fuel

CONCLUSIONS

1) The primary objective of this study was to introduce the new synthetic gaseous fuel „Powergas‟ to a spark ignition engine and to observe the effects of the fuel on the engine performance and emissions compared to the fuels gasoline and NG.

2) „Powergas‟, being composed of mainly CO and H2, required very retarded spark timing and experimentally it was found to be at 4BTDC .

3) „Powergas‟ produced the lowest power output among the three fuels. At a constant speed (such as about 1500 rpm), „Powergas‟ produced about a 30 and 23% lower brake torque output compared to gasoline and NG respectively. The decrease in torque is mainly due to the lower heating value per unit volume of „Powergas‟ and also due to the decrease in volumetric efficiency of the engine

4)BSFC increased in the case of „Powergas‟ fuelling and for a particular operating speed (at around 1500 rpm), it required about 2.7 times more fuelling than gasoline and about 3.4 times more than NG fuel. Because of its composition, „Powergas‟ has a very low stoichiometric A/F ratio (4.25) compared to gasoline (A/F14.6) or natural gas (A/F15.5) fuels. However, an improvement by around 22% in power output was observed when the engine was operated at a higher compression ratio (11:1) compared to its value at compression ratio of 8:1 when compared to similar results for natural gas fuelling. However, the BSFC remained unchanged.

5) Very low THC emissions (0–20 ppm) were measured on

„Powergas‟ operation compared to either gasoline (90–225 ppm) or natural gas (20–106 ppm) fuels. This may be
due to the absence of any hydrocarbons in „Powergas‟.

6) CO2 concentration was the highest for „Powergas‟ operation among the three types of fuel. This is perhaps its higher concentration of CO in its composition and also the fuel may contain some minor amount of CO2. The fuel gas produces lower CO emissions than the other fuels under almost similar operating conditions.

7) NOx emissions are found to be much higher in the case of „Powergas‟ operation compared to other fuels. This is due to the higher combustion temperature and relatively shorter combustion duration. „Powergas‟ contains mainly CO and H2 and both of them have relatively high flame speed and flame temperatures. Reducing NOx below emission norms is an challenge in case Powergas for controlling EGR and after treatment devices can be implemented

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