A Review on Process Feasibility of Gaseous Fuel And Biodiesel in a Dual Fuel Mode IC Engines

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***Abstract* — Alternative fuels for IC engines are gaining lot of interest due to increased fuel consumption. Promising alternative fuels for internal combustion engines are liquefied petroleum gas (LPG), compressed natural gas (CNG), hydrogen, acetylene, producer gas, biogas, alcohols and vegetable oils. Lot of research is been carried out on Biodiesel to use it has an alternative fuel in IC engines. Experimental investigation have been carried out on a single cylinder, direct injection, and compression ignition engine run on Dual fuel mode with gaseous fuel as an injected primary fuel and Biodiesel injected as secondary gaseous fuel to obtain data on engine performance and exhaust emissions. Dual fuel operation results in lesser thermal efficiency when compared to neat diesel operation. Biodiesel aspiration reduces smoke, soot formation, and exhaust temperature; and increases NO_x emission. The emission of carbon mono oxide and carbon dioxide was lower under all operating conditions when compared to diesel operation. This is an attempt to study Dual fuel operation of acetylene and biodiesel in IC engines.**

Keywords— Bio-diesel; Alternative Fuel; Acetylene;Dual fuel mode.

I. INTRODUCTION

Among the internal combustion engines, compression ignition (CI) engines are widely used. These engines give superior power output and consistent performance at all loads. Diesel is the prime fuel for CI engines. The number of diesel engines is continuously increasing every year because of high efficiency, enhanced fuel economy and low emissions. Diesel engines are preferred over spark ignition engines in almost all heavy-duty applications . Therefore, the world's demand for diesel fuel increases every year. In the search of alternative fuels for diesel engines many fuels were experimented and successfully replaced. Alternative fuels for IC engines are gaining lot of interest due to increased fuel consumption .Promising alternative fuels for internal combustion engines are liquefied petroleum gas (LPG), compressed natural gas (CNG), hydrogen, acetylene, producer gas, biogas, alcohols and vegetable oils. It is essential to look for energy sources which are more secure and produce less greenhouse gas emissions.

Bio-diesel, an earth friendly choice of consumers and renewable sources of alternative fuel occupies a great volume of the worlds fuel sector. Due to its clean emission characteristics, availability of continued and increasing use of petroleum and its limited resources enhances the production of bio-diesel. Considering all economic and environmental benefits, production of bio-diesel is growing quickly as an alternative fuel of petroleum diesel around the world. Bio-diesel or bio fuel is generally defined as ester-based fuels (fatty esters) made from vegetable oils or from animal fats through a simple transesterification process. Vegetable oils are vital energy sources though sometimes vegetable oils create various problems in engine components. This problem may be occurred due to their different volatility and molecular structure from diesel fuel as well as high viscosity compared to diesel fuel. Intensive research is going on throughout the globe for a suitable diesel substitute. Biodiesel fuels produced from different vegetable oils are bio degradable and non-toxic alternative renewable fuels for diesel engines. In general, they are blended with diesel fuels and the blends are used in diesel engines without any modification. It is known that gaseous fuels will result in very low levels of pollutants and can be effectively utilized in diesel engines by converting them to run in Dual fuel mode.

A. Acetylene Production and Properties

Acetylene is chosen as an alternative fuel because it is renewable in nature, it seems to posses similar properties as that of Petrol Diesel (table 1) and can be used as an alternative fuel in internal combustion engines. Acetylene was discovered in 1836 in England by E.Davy. It is a colorless gas with a garlic smell produced from calcium carbonate (lime stone), which is abundant and renewable in nature in a lime kiln at 825ºC which yields calcium oxide (lime) by liberating CO_2. Calcium oxide is heated along with coke in electric furnace to produce calcium carbide. Finally calcium carbide is hydrolyzed to liberate acetylene. Acetylene has a very wide flammability range, and minimum ignition energy is required for ignition since the engine can run in lean mode with higher specific heat ratios leading to increased thermal efficiency. It has higher flame speed and hence faster energy release and at stoichiometeric mixtures, acetylene engines could closely approach thermodynamically ideal engine cycle. High self ignition temperature of acetylene allows larger compression ratios than diesel engines , But high flame speed, wide flammability limits will cause premature ignition leading to Knocking. However reashers suggest that this problem can be solved by reducing the inlet valve opening time, and it will led to less percentage of fuel coming to combustion chamber in SI engine. In CI engine it is preferred to reduce the injection time period.

B. Working of Dual fuel mode

In Dual fuel Mode the gaseous fuel ,called primary fuel is either inducted along with intake air or injected directly into the cylinder and compressed. However, it does not auto-ignite due to its very high self-ignition temperature. Ignition of homogeneous mixture of air and gas is achieved by injection of small quantity of diesel called pilot fuel near the end of the compression stroke. The pilot diesel fuel auto-ignites first and acts as a deliberate source of ignition for the primary fuel air mixture. The combustion of the gaseous fuel occurs by flame initiation by auto-ignition of diesel at un specified location in the combustion chamber. This ignition source can develop into propagation flame, similar to that of spark ignition(SI) engine combustion. Thus, Dual fuel engine combines the features of both SI and CI (compression ignition) engine. Usually primary fuel is blended with percentage composition of secondary fuel and performance, emission characteristics are measured. This is then compared with the performance, emission characteristics of primary fuel at full load.

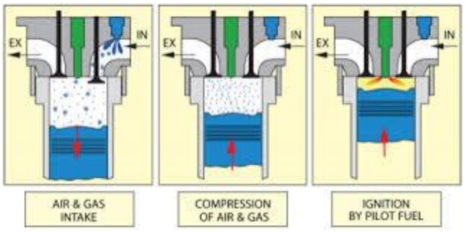

Figure 1: Working of dual fuel mode

II. RESEARCH WORKS

A. ACETYLENE AS ALTERNATIVE FUEL

Research workers like P.K. Sharma et al. explained the method to employ acetylene as an alternative energy source for IC engines. They have conducted experiments on SI engine using acetylene as a primary and alcohol as a secondary fuel. Final results showed that alcohol can be introduced so as to reduce the cylinder temperatures of the engine.

TABLE 1: SPECIFICATION OF THE ENGINE SET UP USED BY P.K,SHARMA

Equipment	Specification
Engine	Single Cylinder 4-stroke Petrol Engine
Rated Power	3.7 KW, 1500 RPM
Bore-Stroke	80mm x 110mm
Compression Ratio	8:1 to 14;1
Cubic Capacity	553 CC

Nagarajan G and Lakshamanan studied about the performance and also the emission quality of a compression ignition engine suitable for multi fuel operation, by timed manifold injection to induct acetylene at different flow rates. Results show that best possible condition as manifold injection with 10° ATDC with the injection interval of 90°crank angle. Fixed quantity of 3L/m of acetylene is supplied to the inlet manifold in dual fuel mode. The results on the internal combustion engines with a primary fuel as diesel under different working loads during experiments were encouraging. The diesel engine working on dual or multi fuel system is noticed to give a lesser thermal efficiency at full load. The experiments conducted by Nagarajan and Lakshamanan on acetylene aspirated engine reported optimistic results. It was really interesting under a dual fuel system operating at higher loads. The experiment was performed on a single cylinder engine with direct injection system at rated power at different loads. The air aspirated with acetylene resulted with lower thermal efficiency. But the amount of smoke declined, CO and HC emissions were comparable to the baseline diesel engine. The accelerated combustion rate and higher temperatures NOx formations are significantly increase as acetylene was inducted into the cylinder. As the flame travelled very rapidly the peak pressure rises in the case of the acetylene aspirated engine. It is experimentally proved that the emissions of such engines are quite encouraging since the smoke, hydrocarbon and carbon monoxide levels are noticed to be lower. However the efficiency of the engine is sacrificed in such case. A stationary air-cooled diesel engine with a rated power of 4.4kWatt 1500 rpm was used for the study.

TABLE 2: SPECIFICATION OF THE ENGINE SET UP USED BY NAGARAJAN G AND LAKSHAMANAN

Equipment	Specification
Engine	4 Stroke Air cooled CI Direct Injection
Rated Power	4.4KW 1500 RPW
Bore-Stroke	87.5mm x 110mm
Compression Ratio	17.5:1

B. ON BIODIESEL AS ALTERNATIVE FUEL

Bai-fu Lin used Vegetable oil methyl ester (VOME) fuels produced from eight commonly seen oil bases were used as test fuels in an unmodified, single cylinder direct injection (DI) diesel engine to conduct a series of engine tests to investigate the effects of VOME fuels on a DI diesel engine. The VOME fuels used for testing were as follows: soybean oil methyl ester (SOME), peanut oil methyl ester (PNOME), corn oil methyl ester (COME), sunflower oil methyl ester (SFOME), rapeseed oil methyl ester (ROME), palm oil methyl ester (POME), palm kernel oil methyl ester (PKOME), and waste fried oil methyl ester (WFOME). The experimental results, such as brake specific fuel consumption (BSFC), engine power, and smoke, NOx and Total Hydrocarbon (THC) emissions for each VOME test fuel were first compared with Petroleum Diesel (PD), and then compared to each of the other VOME test fuels. Furthermore, the effects of different fuel properties and compositions for each test fuel associated with the engine performance and exhaust emissions were discussed. Finally, combustion characteristics, such as the heat release rate (HRR) and the in-cylinder combustion pressure (ICCP) were to demonstrate the effects of VOME fuels on DI diesel engine performance and exhaust emissions. This study used a single cylinder, four-stroke, water-cooled, DI diesel engine to conduct a series of engine tests. The engine cylinder bore was 88 mm, the piston stroke was 96 mm, and the compression ratio was 17.9. The rated output of the engine was 8.1 kW at 2400 rpm. Additionally, the injection pressure and injection timing of the fuel system are set at 19.6 MPa and 17 degree crank angle before top dead center (17□ CA BTDC), respectively.

TABLE 3: PHYSICAL AND CHEMICAL PROPERTIES OF VARIOUS ALTERNATIVE FUELS

Properties	**Gasoline**	**Diesel**	**Turpentin**	**Hydrogen**	**Acetylene**
Formula	$C_4$to C_{12}	C_8 to C_{25}	$C_{10}H_{16}$	H_2	C_2H_2
Molecular	105	200	136	1	26.04
Density kg/m3	780	830	860-900	.08	1.092
Specific gravity	0.78	0.83	0.86	0.0696	0.920
Boiling point ^{0}	32-220	180-340	150-180	-252.8	-84.4
Latent heat of vaporization kJ/kg	350	230	305	0.904	801.9
Lower heating value kJ/kg	43890	42700	44000	120000	48225
Flash point ^{0}c	-43	74	38	-	32
Autoignition temperature ^{0}c	300-450	250	300-330	572	305
Flammability limit %volume	1.4	1	0.8	4	2.3

TABLE 4: GLIMPSE OF AREAS COVERED BY PRIOR RESEARCH WORKS

Alternative fuels used in various studies	**Details of research information/authors**	**Significant areas covered in prior research work**	**Issues not addressed**
Jatropha (Jatropha curcas)	Nitin Shrivastava Anil Kumar Dubey	- Performance, emission studies at B20 B40 blends Cooled EGR technique to reduce emissions. -Properties of Jatropha oil, Jatropha biodiesel and degumming Jatropha oil. -Properties of Jatropha–Palm biodiesel.	-Use of pure Jatropha diesel blends. -Selection of a Jatropha–Diesel blend suitable for diesel engine.
Eight different vegetable oils	Bai-fu Lin	Performance, exhaust and combustion analysis	Best one among them
Kranja (Pongamia Pinnata)	Gaurav Dwivedi Lijo P. Varghese R.K. Singh	-Engine performance analysis. -Lower concentration of straight Karanja vegetable oil with diesel fuel. -Lubricity properties of lower percentage Karanja blend. -Fuels spray parameters and atomization of the injected fuel.	-Use of pure Karanja oil (TBO) with diesel. -Selection of a particular suitable blend.
Neem	E.F Aransiola K. Anbumani	-Emission studies Neem and Jatropha biodiesel. -Highlighted 20% blend as a diesel substitute. -Combustion and emission studies with single and Dual fuel mode of operation. -Emission and combustion studies for pure Neem biodiesel.	Use of TBO (Neem)
Mahua	A Haiter Lenin N. Kapilan	-Performance, emission and combustion analysis of B25 B50 B75 B100 blends of mahua bio-diesel - Studies on mahua oil and LPG mixture/mahua bio-diesel and LPG mixture/diesel and LPG mixture. -Performance and emission studies	--TBO of mahua with diesel fuel. -Selection of percentage of mahua oil in the mixture for satisfactory results.
Acetylene	P.K. Sharma. Praveen Shrestha	-Feasibility of acetylene in IC engine -Production of acetylene	Compatible to petrol or diesel engines
Used Transformer Oil	Pritinika Behera, S.Murugan	Performance, emission and combustion analysis of used transformer oil with acetylene	Petrol engine

IV. CONCLUSION

From the above prior research works we can conclude that Acetylene is renewable in nature, it seems to posses similar properties as that of Petrol, Diesel and can be used as a primary fuel in Dual fuel mode of operating IC engine. There are various Biodiesel produced from different production techniques. Even though number of investigators in the area of bio diesel have carried out extensive works and are well documented. However not much work as been carried out on the Dual fuel consisting of Bio diesel and acetylene in IC engine. Hence there is a sufficient scope for further studies in the area of process feasibility of bio diesel and acetylene in IC engine.

REFERENCES

[1] Prabin K. Sharma.: "Use of Acetylene as an Alternative Fuel in IC Engine" proceeding of Rentech Symposium Compendium, Volume 1, March 2012.
[2] J. B. Heywood, Internal Combustion Engine Fundamentals ,McGraw-Hill, Inc., New York, 1988.
[3] Ganesan V. Internal combustion engine. 3rd ed Singapore : McGraw Hill Book Company; 2007
[4] Lin Bai Fu ,Huang Jyun-Han, Huang Dao-Zi. " Experimental study of effects of Vegetable oi methyl ester on DI diesel engine performance characteristics and pollutant emissions''.
[5] Lenin A Haiter, Ravi R, Thyagarajan K. "Performance characteristics of a diesel engine using mahua biodiesel as alternative fuel".

[6] B. Rajendra Prasath*, P.Tamilporai, Mohd.F. Shabir. " Analysis of combustion, performance and emission characteristics of low heat rejection engine using biodiesel".

[7] Kaniz Ferdous, M. Rakib Uddin, Maksudur R. Khan and M. A. Islam, "Biodiesel from Pongammia pinnate: Base Catalyzed Transesterification" ,

[8] Bobade S N "Detail study on the Properties of Pongamia Pinnata (Karanja) forthe Production of Biofuel"

[9] Nitin Shrivastava*, S.N. Varma, Mukesh Pandey "Performance and exhaust emission of a diesel engine fuelled with Jatropha biodiesel and its blends"

[10] Pritinika Behera, S.Murugan "Performance, emission and combustion analysis of used transformer oil with acetylene"