Experimental study of acetylene enriched air in di diesel engine powered by biodiesel-diesel blends

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ABSTRACT

Due to widely depletion of fossil fuel, environment threat, and non-renewable energy resources led to a significant effort to develop and propose alternative transportation fuels. India has enormous potential for production of biofuels like Biodiesel that can be derived from various vegetable oils. It is oxygenated, sulphur-free, renewable fuel and biodegradable can be utilized in conventional diesel engines without major modification. The use of biodiesel as a fuel in conventional diesel engines causes high smoke emission and low thermal efficiency due to their more viscosity compared to neat diesel. Various methods are used to encounter this problems. Some of these methods are fuel blending and Acetylene enriched air on improve fuel economy and reduction of exhaust emission in diesel engine. In this work, Tamanu methyl ester (TME) and its 80%, 60%, 40%, and 20% blends (volume basis) with diesel were used as an alternative fuel in diesel engine. The performance and emissions characteristics were investigated and compared with neat diesel. The experimental results exhibit that TME in single fuel mode low performance and high smoke emission compared to diesel. Dual fuel mode with Acetylene enriched air further decreased the emission of CO, HC, and smoke with TME diesel blends as primary fuel at all outputs. With acetylene enriched air, due to high burning rates, NOx level significantly increased. It is concluded that acetylene enriched air can significantly improve performance of TME blends with a small penalty on NOx level.

Keywords: Dual fuel engine; Acetylene; Tamanu Methyl Ester; Performance; Emission

INTRODUCTION

Right from the invention of steam locomotives back in the 18th century automobiles depend mostly on fossil fuels for their prime movers. Usage of petroleum products has increased up to 120% in the past decade. So Engine research is mainly focused on finding renewable energy resources. In countries like India which have abundant agricultural resources biofuels from non-edible oil seeds has been of good interest. Some diesel locomotives of Indian railway have already started using jatropha oil in various blends with diesel as their fuel.

MATERIALS AND METHODS

Plant materials: Vegetable oils can be directly used in compression ignition engines without any modification. The primary problem associated with using pure vegetable oil as a fuel in a compression ignition engine is caused by viscosity.

Solvent extraction: By Transesterification the viscosity of the fuel can be reduced and fuel could be used in compression ignition engine. Biodiesel (Methyl ester) from various non-edible oils were studied in the past 50 yrs. The major problems associated with using biodiesel in diesel engine are its higher viscosity, poor spray characteristics and nozzle clog along with higher NO_xemissions. To improve the characteristics of biodiesel and to bring its performance near diesel, methods like Blending with alcohols, Blending with diesel, water emulsification, low heat rejection technique, exhaust gas recirculation, using it with gaseous fuels in dual fuel mode are followed. Tamanu Biodiesel is used in our work as pure biodiesel and 20%, 40%, 60% and 80% blends with diesel. The properties of the blends were studied. The performance and emission characteristics of these fuels in the diesel engine were studied. Acetylene is used in dual fuel mode with biodiesel-Diesel blends as pilot fuel in the study.T. Lakshmanan et al used acetylene by inducting it in the intake of the diesel engine with diesel as pilot fuel in dual fuel mode along with timed induction and found that there is a marginal decrease of HC, CO and NO_x emissions.Rakopoulos et al observed reduced smoke emission in diesel engine running with waste transformer oil (WTO) when dual fuelled with acetylene which is due to the reduced ignition delay of WTO. Wulff et al. used acetylene and ethanol in dual fuel mode in a CI engine and observed improved thermal efficiency than diesel engine with low emission than neat diesel. In 1836 acetylene was first introduced by Zheng. It has wide flammability range hence lowest ignition energy required for ignition. Its flame travels at higher speeds and hence shows faster energy release. Due to the homogeneous mixtures acetylene engines can run on higher engine cycle efficiency. Hence acetylene can be used to reduce smoke and other emission in diesel engines running with diesel-Biodiesel blends when run on dual mode operation.

Table.1. Properties of TME, Blends, Diesel, and Acetylene

Properties	Diesel	TME	TME20	TME40	TME60	TME80	Acetylene
Density (kg/m^3)	840	904	852.8	865.6	878.4	891.2	1.092
Flame velocity (m/s)	0.3	-	-	-	-	-	1.5
Cetane No	45	43	44.6	44.2	43.8	43.4	-
Auto Ignition Temp. (° C)	280	-	-	-	-	-	312
Calorific Value (MJ/kg)	44.8	41.3	44.1	43.4	42.7	42	48.22

Experimental Setup: Acetylene is inducted through intake of the engine to improve the performance and reduce emission levels Diesel-TME blends. The engine is loaded by an electrical dynamometer with resistance loading. The engine is water cooled and splash lubricated. The fuel is filled in the fuel tank which is at a height of 2 m from ground and fed through gravity. The time taken from a known volume of fuel flow is measured and Total fuel consumption and Specific fuel consumption are calculated. Acetylene gas which is stored in a high-pressure cylinder at 160 bar is reduced to 1bar by using a pressure regulator. A small amount of Acetylene is allowed

through a control valve to adjust the flow rate of Acetylene. Acetylene flows through a mass flow controller, which varies the flow of Acetylene which is measured in liters per minute. The Acetylene passes through a flame arrestor which is used to suppress fire hazards in the system. Acetylene from the cylinder after passing through the flame arrestor is inducted through the gas nozzle, which is fitted in the inlet manifold. The engine was started with diesel as the fuel and then Acetylene was introduced into the intake manifold by using a gas nozzle and it is brought to steady state conditions. The baseline Diesel reading was observed and tabulated. Engine was run with Diesel-TME blends as pilot fuel and Acetylene was inducted through the inlet manifold. Performance and emission characteristics were measured for five different loads.

RESULTS AND DISCUSSIONS

Performance charactertics: Variation of brake thermal efficiency with brake power for different diesel blends of TME is shown in fig. 2. The graph reveals that 24% improvement of brake thermal efficiency than neat TME at full load with 4 lpm acetylene enrichment. The brake thermal efficiency increase with higher enrichment of acetylene but they are inadequate due to lack of oxygen. A higher brake thermal efficiency of 29.69 % is achieved by Diesel at full load. The brake thermal efficiency of TME20 and TME for acetylene enriched air is 28.87% and 25.12% respectively. This may be attributed to better mixing of acetylene with air.

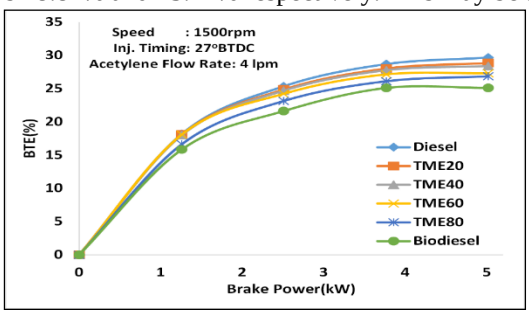

Figure.2.Variation of Brake thermal efficiency with Brake power

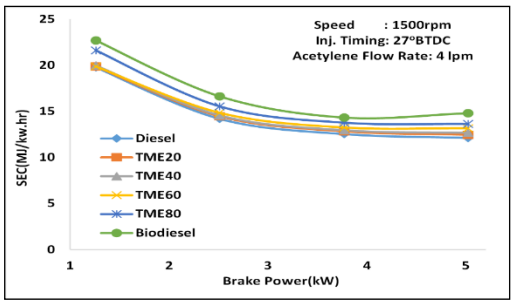

Figure.3.Variation of Specific energy consumption with brake power

The specific energy consumption of TME20 is inferior to that of all other TME blends at full load condition is shown in Fig 3. This may be due to heating value, fuel density, and viscosity of the fuels. TME20 has higher calorific value than TME 80, TME 60 and TME40, but lower than neat diesel. It shows that specific energy consumption decrease as acetylene enrichment. This may be due to premixing of acetylene with air. It achieved by high diffusivity and uniform mixing of acetylene with air results in improve combustion of fuel. The SEC of TME20 decreases from 19.87 MJ/kWh to 12.46 MJ/kWh; when 4 lpm of acetylene enriched air is introduced in the combustion of biodiesel, it slightly increases by 8.06% compared to neat diesel.

Emission characteristics: Figure 4 displays graphical representation of NOx occur combustion assisted by acetylene enriched air, supplied to engine at 4 lpm of mass flow rate with various TME blends at various load conditions. The formation of NOx is due to higher combustion temperature and present oxygen concentration in the combustion chamber. When the mass flow rate of acetylene enriched air of 4 lpm with TME20 is injected at full load condition, NOX emission increases from 80 ppm to 480 ppm compared to neat diesel, it shows in an increase of 11%. This is due to high temperature produced by high flame velocity of acetylene enriched air mixture.

The variation of Carbon monoxide of TME blends and neat diesel at acetylene energy shares can be shown in Fig. 5. It appears that 43% reduction of CO emission in TME blends than the neat diesel at rated brake power. In presence of oxygen in biodiesel helped in increase oxidation of the fuel and hence promotion of CO converted to CO_2. CO emission was recorded as 0.12%, 0.113%, 0.105%, 0.122% and 0.11% with diesel, TME20, TME40, TME60, TME80 and neat TME respectively at full load condition. Due to lower volatility of TME and high calorific vale of acetylene enriched air.

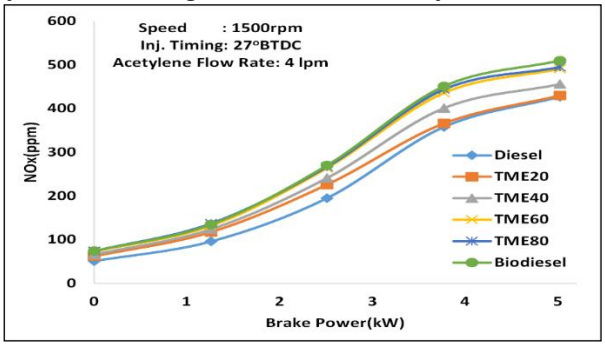

Figure. 4. Variation of NOx level with brake power

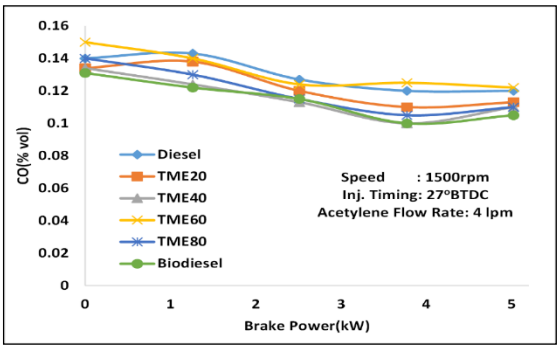

Figure. 5. Variation of Carbon monoxide emission with brake power

CONCLUSIONS

A single cylinder diesel engine was operated power by Tamanu methyl ester and its diesel blends in dual fuel mode along with acetylene as secondary fuel. The results of experimental are concluded as follows:

- The Brake thermal efficiency of TME- diesel blends in dual fuel operation is slightly lower than neat diesel at full load condition, as an effect of constant flow rate of acetylene in the intake manifold.
- Dual mode operation of acetylene with TME shows slightly higher specific energy as compared to neat diesel.
- CO emission of TME and its blends have lower than the diesel operation. It is also noticed that there is an appreciable reduction in NOx level at full loads.

It is concluded that small amount acetylene induction resulted in an increase in thermal efficiency, when compared to neat diesel. CO emission was less than the diesel. However, a penalty of increase in the NOx level is noticed in the exhaust. Hence, biodiesel is evidenced to be an ability as a fuel for partially or complete alternate of diesel fuel.

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