Blending impacts of biogas and dimethyl ether (DME) on Compressed Ignition engine

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ABSTRACT- *Now a day, emission rules are becoming strict around the world. Also the fossil fuel is getting depleted at faster rate, compelling to develop an emission free engine. Even though diesel engine has higher thermal efficiency, still it is not free from NOx and soot emissions. Many research groups have attempted to develop diesel combustion technologies with superior efficiency and ultra-low exhaust emissions levels such as homogeneous charge compression ignition (HCCI)[1,2], low temperature combustion (LTC) [3], and dual fuel combustion [4]. Moreover, environment-friendly alternative fuels including biodiesel [5], dimethyl ether (DME) [6,7] bioethanol [8,9] and biogas [10] have been studied and attempts have made to apply them to diesel engine systems. Understanding the issue of contamination and detecting the disturbing rate of increment of contamination in environment, the Government of India has made an empowering stride towards the utilization of LPG as an automobile fuel. Essentially Biogas which is gotten from natural waste is additionally considered as great other option to petroleum powers.*

Keywords: Biogas, Dual-fuel combustion, Dimethyl ether(DME), Emission and exhaust reduction, indicated mean effective pressure(IMEP),alternate fuel, ignition delay.

1. INTRODUCTION

In general, biogas is an alternative fuel produced by anaerobic fermentation of organic material, and the main sources for biogas are residuals from beverage production, animal waste, vegetable waste, as well as wastes from the food and fodder industry [11]. The main component of biogas is methane (CH_4, 50-70%), but it also includes carbon dioxide (25-50%), hydrogen (1-5%), nitrogen (0.3-3%), and hydrogen sulphide [12]. In a compression ignition engine system, biogas is usually applied to diesel engines with dual-fuel injection systems. Nathan et al. [13] and Bedoya et al. [18] investigation showed that biogas dual-fuel combustion in HCCI (homogenous charge compression ignition) mode has a thermal efficiency (45%) closer to diesel combustion with comparatively low NOx emission. They also reported that biogas dual fuel combustion at low equivalence ratio reduced HC and CO emission. Raine and Mustafi [14] showed that the stable operation of a diesel engine using natural gas and biogas is possible, and the particular matter (PM) and NOx can be reduced by biogas dual fuel combustion by 70% and 37%, respectively using biogas-diesel dual fuel engine systems. We studied biogas-DME dual-fuel engine, focusing on blending ratio of biogas and DME.

The way to utilize biogas and DME as a substitute fuel can isolate into three focuses as takes after:

i) As the global energy crisis is approaching at alarming rate, biogas can play a vital role in strengthening the nation's energy security.
ii) Increase in consumption of biogas leads to economic development and additional markets for agricultural products. This creates new jobs in rural communities and keeps money circulating in rural economy. Manufacturing a fraction of fuel at home increases our nation's energy independence.
iii) 1 biogas plant can save up to 32 litres of kerosene and 4 tons of firewood every year. The organic chemical plant also contributes indirectly to the protection of soil.
iv) DME has high cetane number (55) and less modification required in dual-fuelled engine
v) DME releases comparatively less NOx and COx. It's sulphur free and useful in preventing ignition delay.

2. EXPERIMENTATION AND METHODOLOGY

Tab.1 Specification of single-cylinder diesel engine .

ITEMS	SPECIFICATION
Engine type	Direct injection diesel engine
Bore x stroke	75.00 mm x84.5 mm
Displacement volume	373.3 cc
Fuel injection system	Bosch common rail
Valve type	DOHC 4 valve
Compression ratio	17.8
Injector no. of hole & hole diameter and spray angle	6 & 0.128 mm & 156 degree

3. EXPERIMENTAL SET UP

In a dual-fuel engine using biogas, the biogas is introduced into the combustion cylinder through an intake port with air, whiles the ignition source such as diesel and dimethyl ether (DME) are directly injected into the combustion cylinder through common rail injection system. . A single-cylinder diesel engine was used for this study, and it has a co A DC dynamometer (55 kWh) was used for controlling engine speed. The injection timing and injection quantity of the fuel injector were controlled by a timing pulse generator (Blue Planet, TPG-28MP) and an injector driver (TEMS, TDA-3300) synchronized with two signals from the crank angle and camshaft angle sensor.

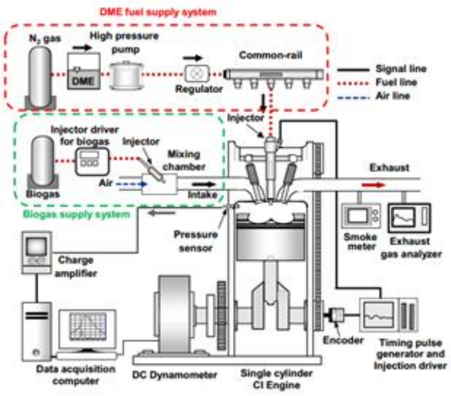
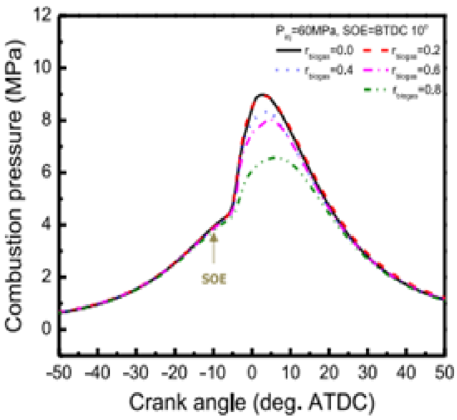


Fig 1. Schematic diagram of Diesel engine and emission analyser

4. RESULT AND DISCUSSION

4.1 Effect of biogas mixing ratio on combustion characteristics



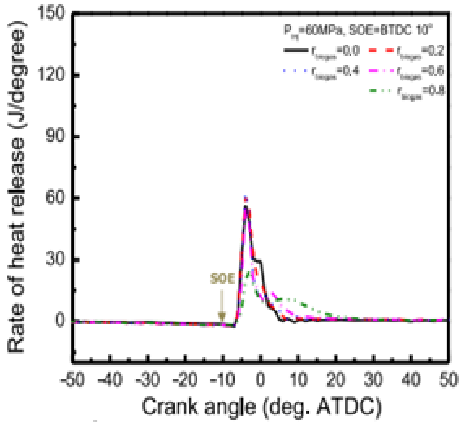


Fig 2. SOE=BTDC 10^0

It was concluded that combustion pressure and heat released for various mixing ratio of biogas and DME the ratio varies from 0.0 to 0.8 for the crank angle 10 to 40 degree. it was observed that an increase in mixing ratio caused a decrease in peak ROHR value and its gradient, which results in a decrease in burning rate in the biogas-DME mixture combustion in the combustion cylinder because the mixture has higher octane fuel (Octane number of biogas: 130); hence, the ignition was delayed and the velocity of flame propagation became slow.

4.2 IMEP characteristics for various injection timing

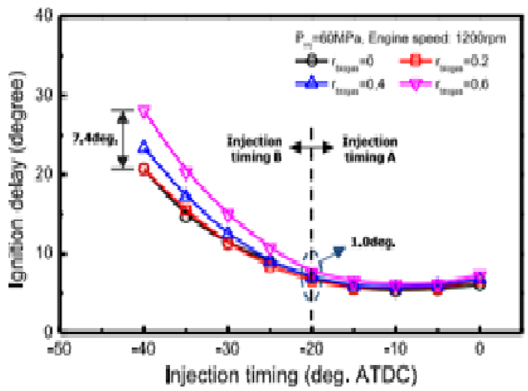


Fig 3. Ignition Delay Vs Injection Timing

The IMEP dependence on mixing ratio of biogas showed an opposite relationship to that between the IMEP and injection timing for the region of "Injection timing A" and "Injection timing B". As the mixing ratio of biogas increases, the IMEP in "Injection timing A" decreases, while that in "Injection timing B" increases. These behaviours were due to the change in formation pattern of the mixture based on the geometry of the combustion chamber and the injection timing; hence, it influenced the ignition delay and the start of ignition characteristics.

4.3 Impact of biogas blending proportion on emission characteristics

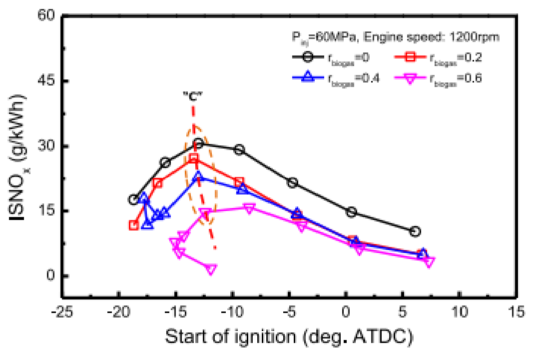


Fig 4. ISNO Vs Start of Ignition

As can be confirmed from the graph NOx emissions were decreased. The reason for the reduction of NOx with increasing mixing ratio of biogas is due to CO2 in the biogas, which makes achieving high in-cylinder temperature difficult[18,25]. Further, the effect of biogas mixing on NOx emissions became clear as the SOI advanced. Moreover, it can be found that the biogas-DME dual fuel combustion with a mixing ratio biogas of 0.2 - 0.6 emitted lower NOx than pure DME combustion.

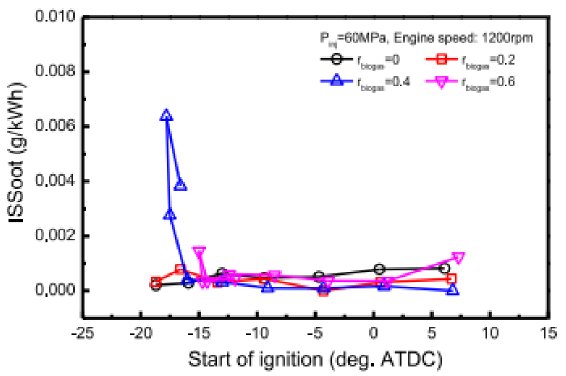


Fig 5. ISSoot Vs Start of Ignition

From the graph we can conclude that soot emission was almost zero because DME has no carbon-to-carbon direct bonding and has a high oxygen content of about 34.8%. Soot is never emitted in pure DME and biogas mixed with DME combustion even through the biogas was introduced trough the intake port with air into the combustion cylinder.

4.4 Fuel utilization attributes as a capacity of infusion timing and biogas blending proportion.

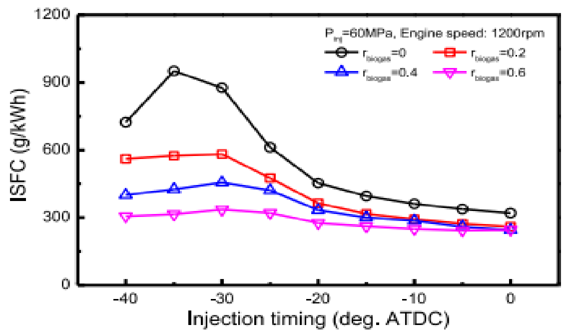


Fig 6. ISFC Vs Injection timing

We know that power is proportional to the IMEP, displacement of the engine, and engine speed and the mass flow rate is proportional to the injection amount and the engine speed. Therefore, the fuel consumption is proportional to the ratio of the injection quantity and the IMEP. In this study, the total injection quantity was determined to meet the same energy density in each test condition, hence, it was found that it decreased with increasing biogas mixing ratio (LHV DME: 28.7 MJ/kg, LHV biogas: 55.4 MJ/kg).

5. CONCLUSION

On the basis of test following conclusion were drawn:-

i. Increase in blending ratio resulted in decrease in peak combustion pressure. Also heat release rate gets decreased.
ii. The injection timing and ignition delay showed linearity irrespective of blending ratio of biogas and DME.
iii. When the injection timing was same, with the increase in concentration of biogas resulted in decrease of IMEP in "region A" and increase in "region B" .However IMEP showed linearity with SOI.
iv. NOx emissions diminished as the biogas blending proportion expanded for all test condition. Also the soot emissions level in biogas-DME dual fuel diesel engine was almost zero.

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