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Sustainable Power Generation using Methanol Fuelled Spark Ignition Engine with Oxygen Enriched Air for a fertiliser Industry

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Abstract

The oxygen in the intake air of the engine fuelled with methanol was enriched from 23% (by mass) with base oxygen to 26.5%, 38.7% and 60.4%. The brake thermal efficiency of the engine increased drastically with the oxygen enriched air. The peak pressure and cumulative heat release increased with the enrichment. Carbon monoxide (CO) and hydrocarbon (HC) emissions decreased substantially. However, nitrogen oxides (NOx) emission increased drastically with 38.7% of oxygen but it decreased by 31.5% with 60.4% oxygen enriched air which is lower than base oxygen. A notable conclusion emerged from the study is that a methanol fuelled engine with the oxygen enriched air (60.4%) could emit very lower emissions (CO, HC, NOx) along with improved thermal efficiency compared to base oxygen (23% by mass). The by product oxygen in a fertiliser industry could be utilised for this enrichment of intake air for a methanol fuelled genset engine for power generation. A methanol fuelled genset engine with the oxygen enriched air could run with higher efficiency and ultra-low emissions.

Introduction

Methanol is an economically attractive and environment friendly alternative fuel. The layout for sustainable methanol production and its utilisation for power generation in a fertiliser industry is shown in Figure 1.

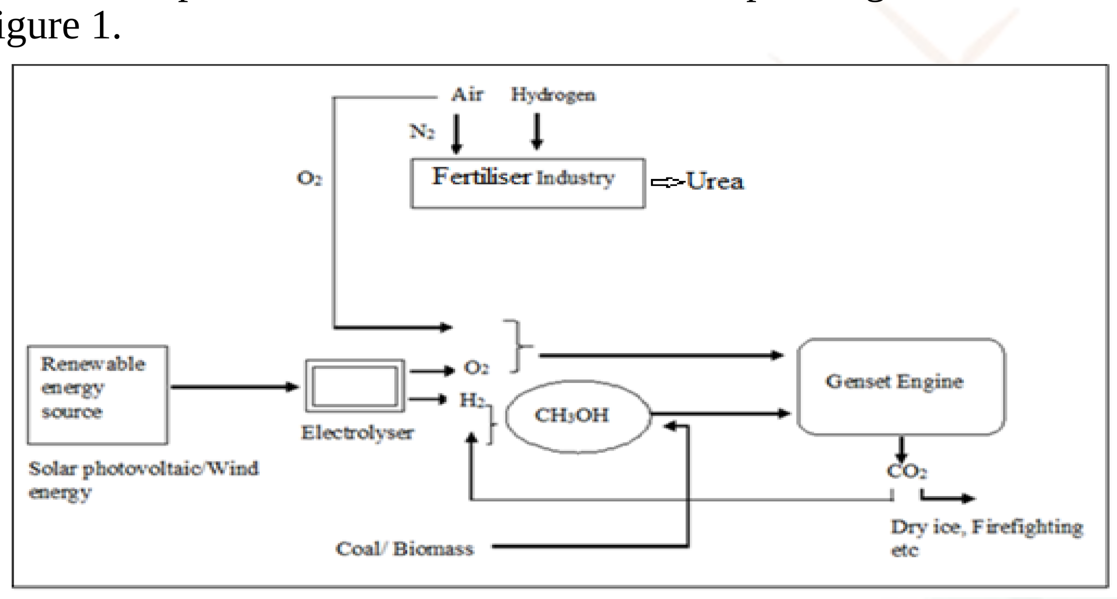
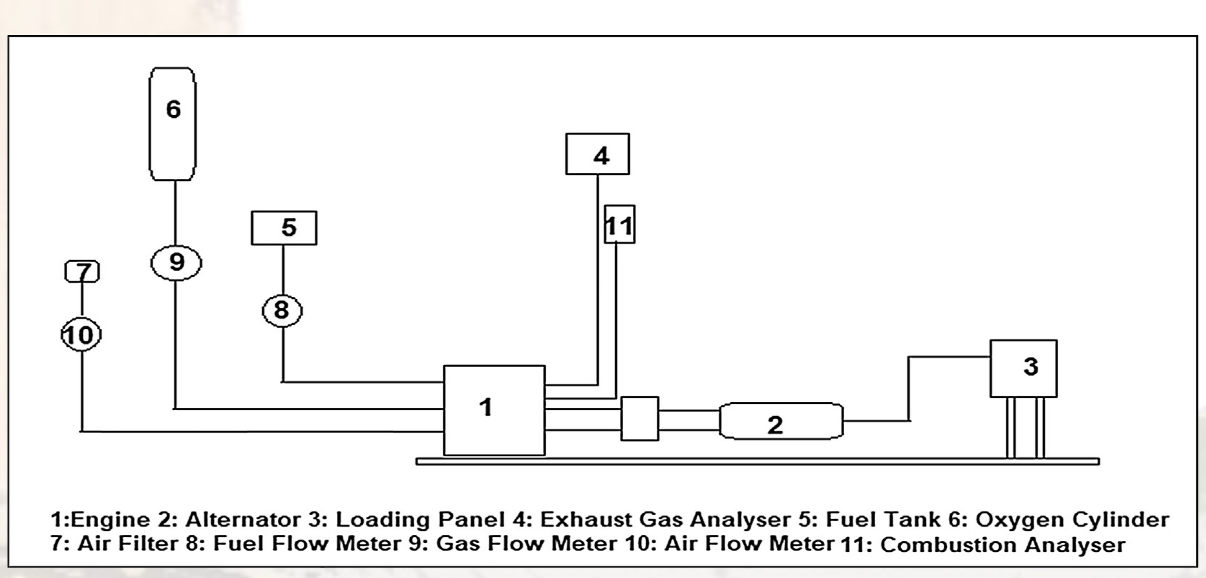


Figure 1. Sustainable power generation

The fertiliser industry requires nitrogen in huge amount for the production of ammonia and urea. The by product oxygen is produced after separation of nitrogen from air. The oxygen could be utilised for enrichment of intake air for a methanol fuelled genset engine for power generation.

Materials and Methods

A single cylinder four stroke spark ignition engine having compression ratio of 7.2:1 was used for conducting the experiment. The output shaft of the engine was connected with an alternator with rated power of 2.1kVA at 50 Hz and 220 V. The fuel was supplied through carburetor with throttle controlled by mechanical governor directly connected with crank shaft which revolved with 3000 ± 50 rpm.. An incandescent bulb panel was used for loading. Experiments were conducted at a constant load of 1 kW. Ignition timing was constant at 20 deg. before top dead center. Oxygen (99.99% pure) was supplied through a high-pressure cylinder connected through pressure regulator with the engine. Its supply was increased in three steps accompanied by decrease in air flow rate. The oxygen enrichment was done in consecutive three steps; from 23% (by mass) base oxygen to 26.5%, 38.7% and 60.4%. The schematic diagram of test set up is given in Figure 2.



Conclusions

- Brake thermal efficiency is higher with all enriched air (26.5%, 38.7% and 60.4%) compared to base oxygen (23% by mass) due to higher in-cylinder temperature and pressure and increased constant volume combustion. The change in brake thermal efficiency with 38.7% and 60.4% oxygen enrichment is about 9.9% and 20.5% respectively.
- Cumulative heat release with 60.4% oxygen enrichment increased by 1.27 times than the base oxygen whereas combustion duration decreased about 57.8%
- CO and HC emissions decreased drastically due to better oxidation of fuel and intermediate products with oxygen enriched air. CO and HC emissions with 60.4% oxygen enrichment decreased about 48.59% and 30.9% respectively.
- NOx emission with 26.5% and 38.7% oxygen enrichment increased about 80.7% and 112.2% respectively due to high in-cylinder temperature. But, with 60.4% oxygen enriched air, NOx emission decreased drastically and it is lower than base oxygen due to decrease in nitrogen content in the inducted air.

Industrial Significance

The total demand of ammonia in India is forecasted to reach 25.49 million tonnes per annum (MTPA) by 2022. It implies that 20.99 MTPA of nitrogen would be required for ammonia production. Therefore, oxygen as a waste product is available about potential about 6.26 MTPA which is in huge amount. The gensets fuelled with methanol and oxygen can be used for power generation which can meet the requirement of a fertiliser industry. This technology could also be used for power generation in the industries such as Ethylene, Oil and Gas Refineries, Food processing etc where surplus oxygen is available as a tangible or waste product.

Technology Readiness Level: TRL 5. The laboratory scale testing has been completed and the testing of the engine with the enriched air is being done as a pilot scale.

Results

Fig. 3 to Fig. 9 shows the effect of oxygen enriched air on combustion, performance and emission characteristics of a methanol fueled engine.

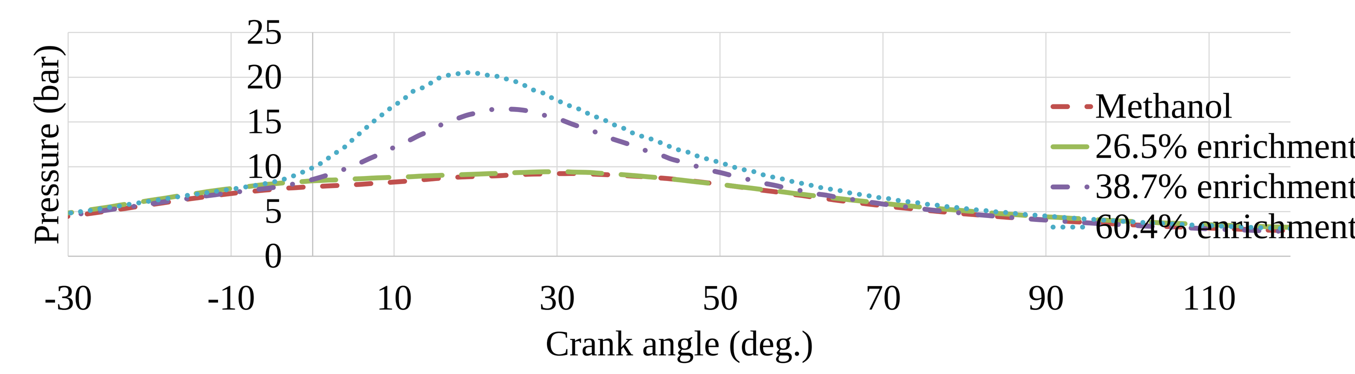


Figure 3.

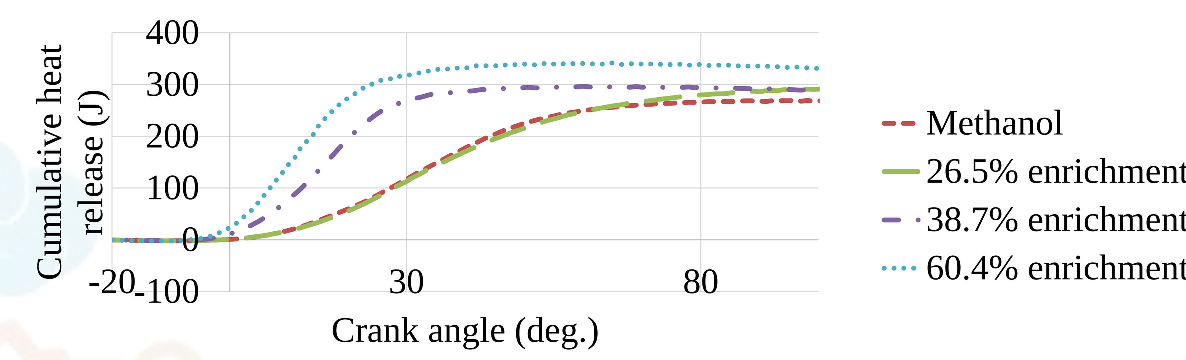


Figure 4.

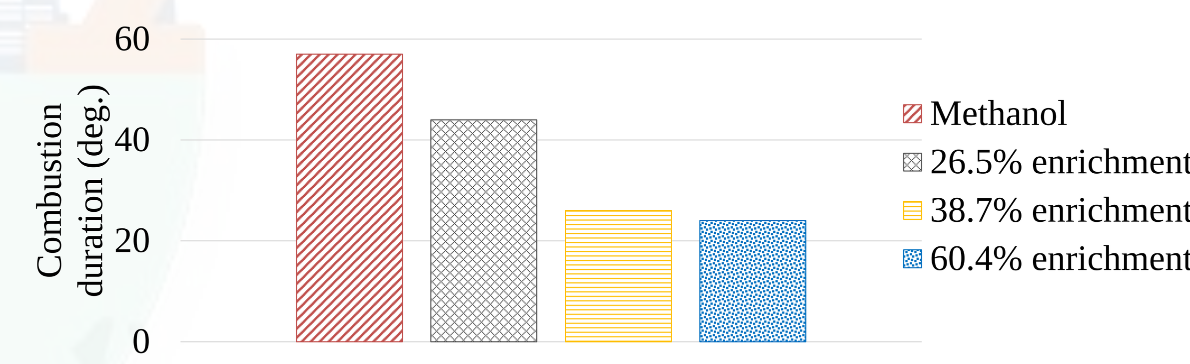


Figure 5.

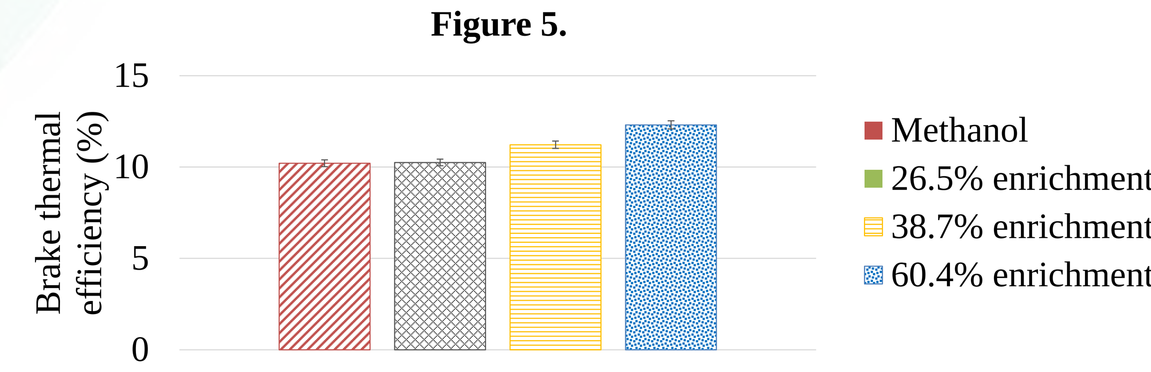


Figure 6.

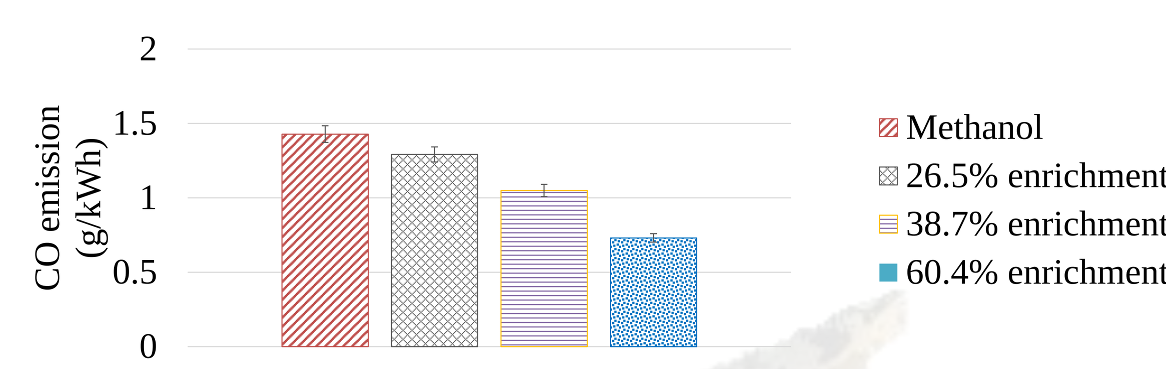


Figure 7.

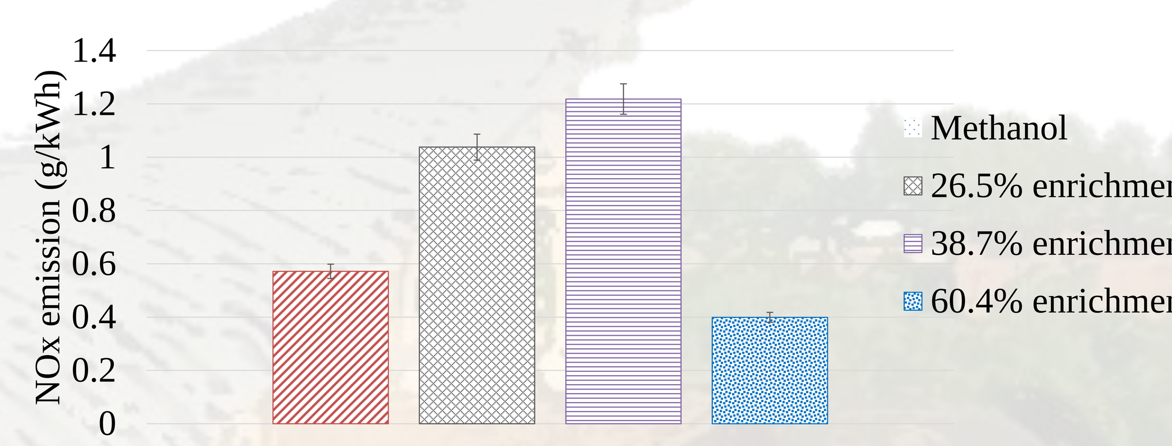


Figure 8.

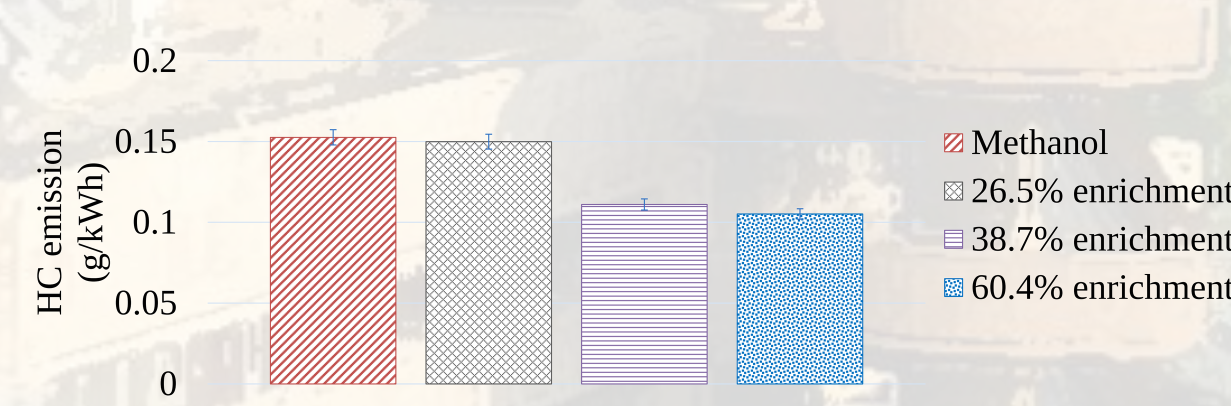


Figure 9.

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