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Experimental Investigation of Performance and Emission Characteristics of CI Engine Using CNG And Neem Oil Blend

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Abstract: Fuel crisis and environmental concerns have led to look for alternative fuels of bio-origin sources such as vegetable oils. The objective of this work is to evaluate duel fuel operation of CI diesel engines with simplest possible change of hardware. Here the effort has been made to determine the performance and emission characteristics of CNG and neem blends in CI engine. The maximum achievable neem biodiesel replacement by natural gas was found to vary with engine loads. The experiments are carried out for five different flow rates starting from minimum to maximum flow rate position. The engine showed very similar performance compared to diesel operation near up to 90% of rated load with up to 54% replacement of diesel by CNG being possible. The maximum flow rate position is one at which the engine starts knocking.

Exhaust gas analysis showed that with higher diesel replacement the level of CO_2 generation decreased and CO emission was found to increase. The late burning of the mixture with higher diesel replacement levels of CNG had caused more fuel to remain partially unburned increasing the formation of CO and decreasing the proportion of CO_2. This would contribute to the reduction of efficiency at light loads.

From the Comparison of results obtained with all above flow rate, CNG1 (4% CNG + 96% Neem oil), CNG3 (8% CNG + 92% Neem oil), CNG5 (12% CNG + 88% Neem oil) are found optimum.

Key words: Small diesel engine, Duel fuel, Neem oill and CNG blend.

INTRODUCTION

Increase in petroleum prices, threat of global warming has generated an interest in developing alternative fuels for engine. Technologies now focusing on development of plant based fuels, plant oils, plant fats as an alternative fuel. Bio-diesel is described as fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats. Bio diesel can be produced from feed stocks that are generally considered to be renewable.

The dual fuel engine is a diesel engine that operates on gaseous fuels while maintaining some liquid fuel injection to provide a deliberate source for ignition. Such a system attempts usually to minimize the use of the diesel fuel by its replacement with various gaseous fuels and their mixtures while maintaining satisfactory engine performance. There are some problems associated with the conversion of a conventional diesel engine to dual fuel operation. [1]

At light load, the dual fuel engine tends to exhibit inferior fuel utilization and power production efficiencies with higher unburned gaseous fuel and carbon monoxide emissions, relative to the corresponding diesel performance. Operation at light load is also associated with a greater degree of cyclic variations in performance parameters, such as peak cylinder pressure, torque, and ignition delay, which have narrowed the effective working range for dual fuel applications in the past.

The objective of this work is to quantitatively evaluate dual fuel operation of small diesel engines with the simplest possible change of hardware, which could be suitable for applications where loads are changing less frequently or an engine attendant is already employed. For using natural gas a cross-flow gas mixing chamber was added to the air intake. All the diesel and biodiesel settings including fuel injection timing were kept at the factory defaults to retain instant interchangeability to diesel-biodiesel operation, in case natural gas is unavailable.

Natural gas could be fed from line supply for urban users or a low pressure CNG package (LPCNG) developed by the author for rural or remote users. The maximum achievable diesel replacement by natural gas was found to vary with engine loads. The engine showed very similar performance compared to diesel-only operation near up to 90% of rated load with upto 88% replacement of diesel by natural gas being possible. [2]

MATERIAL AND METHODOLOGY

Neem Oil

Neem (Azadirachta indica) is a tree in the mahogany family Meliaceae which is abundantly grown in varied parts of India. The Neem grows on almost all types of soils including clayey, saline and alkaline conditions. Neem seed obtained from this tree are collected, de-pulped, sun dried and crushed for oil extraction. The seeds have 45% oil which has high potential for the production of biodiesel [3]. Neem oil is generally light to dark brown, bitter and has a rather strong odour that is said to combine the odours of peanut and garlic. It comprises mainly of triglycerides and large amounts of triterpenoid compounds, which are responsible for the bitter taste. It is hydrophobic in nature and in order to emulsify it in water for application purposes, it has to be formulated with appropriate surfactants.

Neem oil also contains steroids (campesterol, beta-sitosterol, stigma sterol) and a plethora of triterpenoids of which Azadirachtin is the most widely studied [3].

Compressed Natural Gas

Typical composition of Natural Gas is 2.18% Nitrogen, 92.69% Methane, 3.43% Ethane, 0.52% Carbon Dioxide, 0.71% Propane, 0.12% Iso-Butane, 0.15% n-Butane, 0.09% Pentane and 0.11% Hexane.

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Gross calorific value = 38.59 MJ/m3,
Net calorific value = 34.83 MJ/m3,
Stoichiometric A/F ratio = 16.65: 1,
Net calorific value of diesel fuel=42.70 kJ/kg,
Relative density of diesel fuel=0.844.

Table 1: Properties of Diesel and Neem Seed Oil

Property	Diesel	NSO
Density (kg/m^3)	850	926
Calorific Value (kJ/kg)	43400	39000
Kinematic Viscosity (Cst@40°C)	3.5	38
Flash Point (°C)	68	245
Fire Point (°C)	107	268

EXPERIMENTAL SET UP

Table 1 shows the specification of the test engine. The engine was tested at constant rated speed of 1500 rpm throughout its power range using different blends like N20,N40,N60,N80, N100 The conventional gas fumigation technique was used for mixing the natural gas with the intake air through a cross flow mixing chamber added before the intake manifold. A calibrated gas flow-meter was used to measure the natural gas consumption rate. The engine was tested at 20%, 40%, 60%, 80% and 100% of the actual rated load in dual fuel mode. For each setting, diesel was used as the pilot fuel for starting auto ignition while, natural gas from line supply was used as the main fuel. For each power level the proportion of natural gas replacing diesel was gradually increased by manually opening a control valve to determine the maximum possible diesel replacement using natural gas with satisfactory engine performance.

Table 1: Engine Specification

Manufacturer	Kirloskar Engines Ltd.India,
Model – AG -10	TV-SR II
Engine	Single cylinder, DI
Bore/Stroke	87.5mm/110mm
Compression ratio	16.5:1
Speed	1500rpm
Rated power	5.2kW
Working cycles	Four
Injection pressure	200 bar/23 deg TDC
Type of sensor	Piezo electric

Fig 1: Photograph of the experimental setup

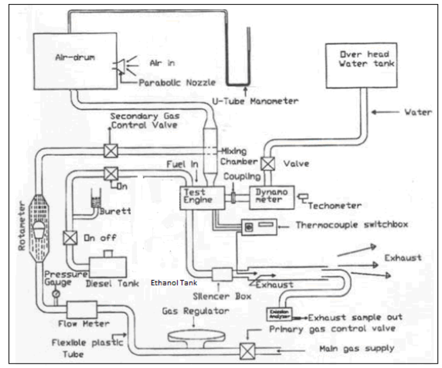

Fig 2: Schematic Diagram of the experimental setup showing different systems.

RESULT AND DISCUSSION

Brake Thermal Efficiency

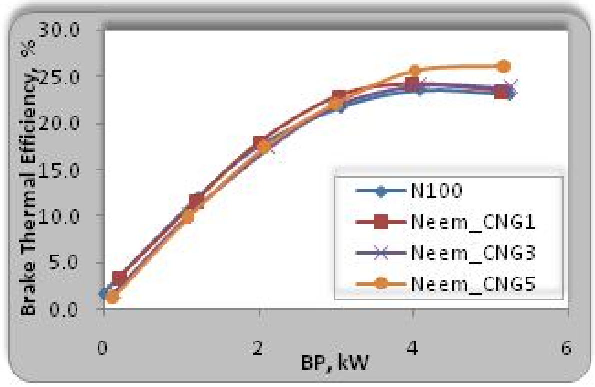

Fig 3: Variation of brake thermal efficiency with brake power for neem oil and neem-CNG dual fuel operation

Fig 3 shows the Variation of brake thermal efficiency with brake power for neem oil and neem-CNG dual fuel operation. The brake thermal efficiency is lower for neem oil as compared to CNG being used as the pilot fuel. This is due to poor mixture formation as a result of the low volatility and high viscosity and density of neem oil. At full load, the brake thermal efficiency with neem oil is about 23.1 at 0% CNG admission, where as it is 24.4%, 31.14%, and 39.82% with 4%(CNG1), 8%(CNG3) and 12%(CNG5) of CNG injection respectively. It rises with both fuels with an increase in amount of CNG inducted. Maximum efficiency for neem oil and 4%(CNG1), 8%(CNG3) and 12%(CNG5) of CNG as pilot fuels are 23.1%, 25.6%, 35.19%, and 45.13% respectively. These maximum efficiencies occur at 75% of full load. The increase in brake thermal efficiency is attributed mainly due to the higher ignition delay, which allows more time for pre-flame reaction in CNG air mixture, which on initiation of combustion results in higher rate of heat release. As the amount of CNG admitted is increased, the pilot fuel quantity reduces.

Exhaust Temperature

Fig 4 shows the Variation of exhaust temperature with brake power for neem oil and CNG-neem dual fuel operation. Exhaust gas temperature is higher for neem oil than that of neem-CNG operation at higher loads. By charge cooling effect of CNG, exhaust temperature decreases. Minimum exhaust temperature occurs at the maximum brake thermal

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efficiency of CNG sharing indicating clear burning of CNG and neem. The maximum exhaust temperature for 4%(CNG1), 8%(CNG3) and 12%(CNG5) of CNG as supplement fuels are respectively 510°C, 482°C, and 454°C, against 494°C of neem at full load.

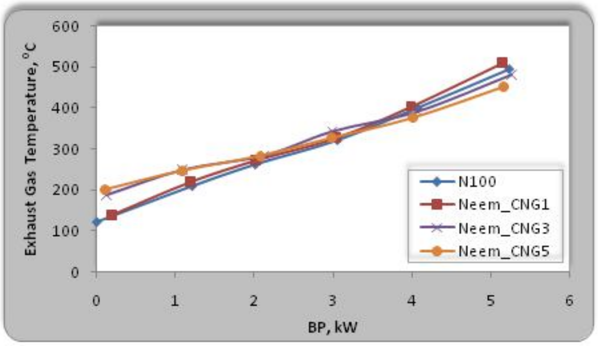

Fig 4: Variation of brake exhaust gas temperature with brake power for neem oil and neem-CNG dual fuel operation

Volumetric Efficiency

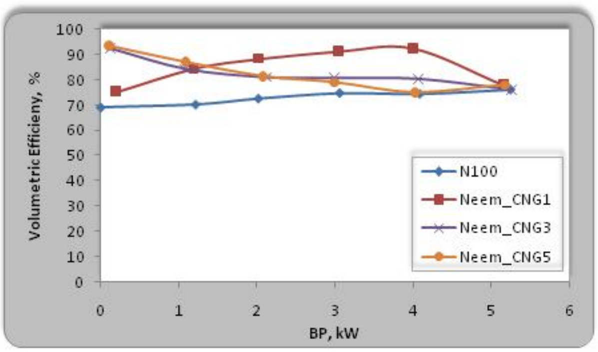

Fig 5: Variation of volumetric efficiency with brake power for neem oil and neem-CNG dual fuel operation

Fig 5 shows the Variation of volumetric efficiency with brake power for methanol-neem oil and methanol-diesel dual fuel operation. The volumetric efficiency with neem oil is lower than that of neem-CNG operation. It may be noted that the temperature of the retained exhaust affects the volumetric efficiency. A high temperature exhaust leads to a low volumetric efficiency. The retained exhaust gas heats the incoming fresh air and lowers the volumetric efficiency. However, with CNG admission the volumetric efficiency is increased with both the pilot fuels. The increase in volumetric efficiency is also due to the cooling of intake charge by vaporization of CNG. At higher amounts of CNG admission the volumetric efficiency is again reduced probably due to the rise in exhaust gas temperature.

Carbon monoxide

Fig 6 shows the Variation of carbon monoxide emission with brake power for neem oil and neem-CNG dual fuel operation. Carbon monoxide emission of neem oil is higher than that of neem CNG operation. At full load, the CO emission of 4 %(CNG1), 8 %(CNG3) and 12 %(CNG5) of CNG as supplement fuels are respectively 0.21%, 0.15%, and 0.10% against 0.3% that of neem oil operation. As the amount of CNG injection increases the CO emission decreases. This is attributed to clean burning of CNG with lower neem oil and CNG mixture.

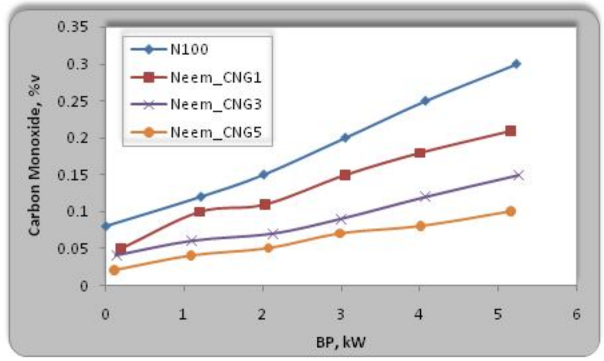

Fig 6: Variation of carbon monoxide emission with brake power for neem oil and neem-CNG dual fuel operation

Un-burnt Hydrocarbon

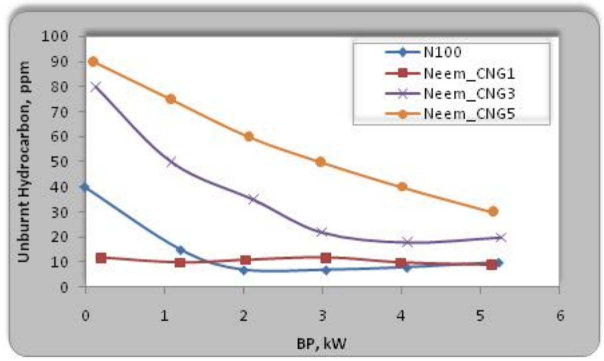

Fig 7: Variation of unburnt hydrocarbon emission with brake power for neem oil and neem-CNG dual fuel operation

Fig 7 shows the Variation of un-burnt hydrocarbon emission with brake power for neem oil and neem-CNG dual fuel operation. Un-burnt HC emission for neem-CNG is higher than that of neem oil operation. Un-burnt HC emission increases with increase in amount of CNG in mixture. At full load operating condition, un-burnt HC emission of neem oil and 4%(CNG1), 8%(CNG3) and 12%(CNG5) of CNG as supplement fuels are respectively 10, 9, 20, 30ppm.

Combustion Characteristics

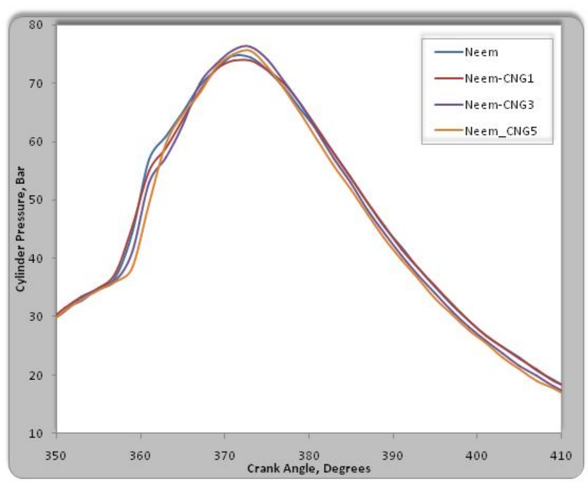

Fig 8: Variation of cylinder pressure with crank angle for neem oil and neem-CNG dual fuel operation

The experimental results showed that the neem-CNG dual fuel operation produced lower cylinder pressure compared to that of neem oil as shown in Fig 8. The cylinder pressure of neem oil can reach nearly 74.4 bars as for the CNG1, CNG3 and CNG5 approximately 75.75, 76.25, 75.58 bars respectively. The neem oil also should adjust its ignition timing for about 7 to 18 degree more advanced than that of neem-CNG operation. The reason is that neem oil has a low flame speed. It needs more time to reach the peak pressure just after TDC. Three different neem-CNG mixtures produced different values of peak cylinder pressures. The higher the CNG mixture, the higher the pressure produced in the cylinder. This phenomenon happens due to rapid mixing and clean burning of CNG fuel.

CONCLUSION

The following conclusion can be drawn from this work:

1. The CNG fuelled engine produced more power and pressure cylinder than that of neem oil operation. The increase in brake thermal efficiency is attributed mainly due to the higher ignition delay, which allows more time for pre-flame reaction in CNG air mixture, which on initiation of combustion results in higher rate of heat release.
2. The neem-CNG operation produced lower emission of CO, CO2 for all operating conditions.
3. In the overall, the neem-CNG dual fuelled engines have a great possibility to be comparable to that of neem oil, since it has clearly advantages in reducing the emissions and cheaper price. Nevertheless, to reach the optimum performance, the CNG fuelled engine required some modification that may be studied further.

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REFERENCES

[1] Scott Jensen, Converting Diesel Engines to Duel Fuel The Pros and Cons of Common Gas Engine Types, Energy Conversions Inc.1/12/06
[2] Ahmad N., Babu M. K. G. and Ramesh A., “Experimental Investigations of Different Parameters Affecting the Performance of a CNG-Diesel, Dual-Fuel Engine”, SAE Technical Series, Paper No. 2005-01-3767, October 2005.
[3] Ganguli, S. (2002) 'Neem: A therapeutic for all seasons', Current Science, Vol. 82, pp.1304
[4] Balasubramanian V., Sridhara K. and Ganesan V., “Performance Evaluation of a Small Agricultural Engine Operated on Dual Fuel (Diesel + Natural Gas) System” SAE Technical Series, Paper No. 951777, September 1995.
[5] Karim G.A., “An Examination for Some Measures for Improving the performance of a Gas Fueled Diesel Engine at Light Loads”, SAE Technical Series, Paper No. 912366, Vol 100, pp. 888-902, 1991.
[6] A. C. Hansen, Q. Zhang, and P. W. L. Lyne, “ Ethanol-diesel fuel blends—a review ,” *Bioresource Technology*, vol. 96, no. 3, pp. 277–285, 2005.
[7] P. Satgé de Caro, Z. Mouloungui, G. Vaitilingom, and J. C. Berge, “Interest of com Semin, Abdul Rahim Ismail, Rosli Abu Bakar, Gas Fuel Spray Simulation of Port Injection Compressed Natural Gas Engine Using Injector Nozzle Multi Holes, European Journal of Scientific Research ISSN 1450-216X Vol.29 No.2 (2009), pp.188-193.
[8] O M I NWAFOR, Knock characteristics of dual-fuel combustion in diesel engines using natural gas as primary fuel, MS received 13 November 2001; revised 13 May 2002
[9] Bechtold R. L. “Alternative Fuels Guide Book”, Published by : Society of Automotive Engineers, Inc., Warrendale, USA, ISBN No. 0-7680-0052-1, 1997. G.A. Rao, A.V.S. Raju, K. Govinda Rajulu and C.V. Mohan Rao
[10] Ishiyama T., Shioji M., Ikegami M. and Mitani S., “Improvement of Performance and Exhaust Emissions in a Converted Dual-Fuel Natural Gas Engine”, SAE Technical Series, Paper No. 2000-01-1866, June 2000.
[11] Amarendar Rao G, Sita Rama Raju AV, Mohan Rao CV and Govinda Rajulu K (2008) Experimental investigation of a single-cylinder, four-stroke diesel engine operating on the dual-fuel mode (LPG + Diesel). Intl. J. Scientific Computing. pp: 2(2), 145
[12] Srinivasa Rao BR, Samaga BS and Mohanan R (2005) Combustion studies on LPG-diesel dual-fuel engines. Proc. 19th Natl. Conf. Intl. Combustion Engines & Combustion. Annamalai Univ., Chidambaram. pp:125-130.
[13] Poonia MP, Ramesh A and Gaur RR (1999) Experimental investigation of the factors affecting the performance of a LPG-diesel dual-fuel engine. SAE Intl. 1999-01-1123, 1999
[14] Ganguli, S. (2002) 'Neem: A therapeutic for all seasons', Current Science, Vol. 82, pp.1304