Renewable Energy 34 (2009) 1877–1884

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

Technical Note

Combustion characteristics of a 4-stroke CI engine operated on Honge oil, Neem and Rice Bran oils when directly injected and dual fuelled with producer gas induction

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A R T I C L E I N F O

Article history:
Received 21 July 2008
Accepted 28 December 2008
Available online 8 February 2009

Keywords:
Honge oil
Neem oil
Rice Bran oil
Producer gas
Injection timing
Injection pressure
Carburetor

A B S T R A C T

Energy is an essential requirement for economic and social development of any country. Sky rocketing of petroleum fuel costs in present day has led to growing interest in alternative fuels like vegetable oils, alcoholic fuels, CNG, LPG, Producer gas, biogas in order to provide a suitable substitute to diesel for a compression ignition (CI) engine. The vegetable oils present a very promising alternative fuel to diesel oil since they are renewable, biodegradable and clean burning fuel having similar properties as that of diesel. They offer almost same power output with slightly lower thermal efficiency due to their lower energy content compared to diesel. Utilization of producer gas in CI engine on dual fuel mode provides an effective approach towards conservation of diesel fuel. Gasification involves conversion of solid biomass into combustible gases which completes combustion in a CI engines. Hence the producer gas can act as promising alternative fuel and it has high octane number (100–105) and calorific value (5–6 MJ/Nm^3). Because of its simpler structure with low carbon content results in substantial reduction of exhaust emission. Downdraft moving bed gasifier coupled with compression ignition engine are a good choice for moderate quantities of available mass up to 500 kW of electrical power. Hence bio-derived gas and vegetable liquids appear more attractive in view of their friendly environmental nature. Experiments have been conducted on a single cylinder, four-stroke, direct injection, water-cooled CI engine operated in single fuel mode using Honge, Neem and Rice Bran oils. In dual fuel mode combinations of Producer gas and three oils were used at different injection timings and injection pressures. Dual fuel mode of operation resulted in poor performance at all the loads when compared with single fuel mode at all injection timings tested. However, the brake thermal efficiency is improved marginally when the injection timing was advanced. Decreased smoke, NO_x emissions and increased CO emissions were observed for dual fuel mode for all the fuel combinations compared to single fuel operation.

1. Introduction

The environment is greatly polluted by transport vehicles through emissions such as CO, CO_2, NO_x, SO_x, unburnt or partially burnt HC and particulate. The chief contributors to urban air pollution and major source of green house gases (GHGs) are fossil fuels and they are considered to be the major cause for the global warming. The cost of crude petroleum is sky rocketing and is presently $142 per barrel. World petroleum consumption was 1.5 million bbl/d (768 trillion dollars/day) in 2007. The estimated World petroleum consumption is 900,000 barrels per day (bbl/d) in 2008. India's current monthly oil import is averaging at $7.7 billion (Rs. 33,000 crore) and at this rate our annual oil import bill will touch $112 billion (Rs. 470,000 crore). In view of this high demand/cost of fossil fuels associated with higher emissions it is necessary to search suitable alternative to diesel oil. Vegetable oils being renewable, non-toxic, biodegradable with low emission profiles are suitable alternative fuels to diesel. [1–7]. Various non-edible oils such as, Honge, Rice bran and Neem oils are being investigated for their suitability as diesel engine fuels [5–7]. Many researchers have performed tests on CI engine with different vegetable oils at different injection pressures and injection timings [8]. The botanical name of Honge, Rice Bran and Neem oils is Pongamia *Pinnata* or *Pongamia glabra*, *Oryza sativa* and *Azadirachta indica* respectively. It is

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doi:10.1016/j.renene.2008.12.031

Table 1
Properties of Diesel, Honge, Rice Bran and Neem oils [5,24].

Properties	Diesel	Honge oil	Rice Bran oil	Neem oil
Viscosity @ 40 °C (cst)	2–5	56	46.815	20.50
Flash point °C	56	230	285	34
Calorific value in Kj/kg	45,000	35,800	43,135	39,501
Specific gravity	0.840	0.927	0.927	0.941
Density Kg/m^3	840	927	927	912
Volatility	Fast			
Colour	Light brown	Yellowish	Brownish	Dark green
Type of oil	–	Non-edible	Edible/non-edible	Non-edible
Pour point (°C)		−2 to −5		
Cloud point (°C)	13	15		
Cetane number	45–55	40		

extracted from the seeds of Honge, Rice and Neem tree. Higher viscosity, lower volatility and polyunsaturated character of neat vegetable oils pose serious engine operational problems [1–3]. Preheating [9], blending [10] and transesterification [11], Super-critical methanolysis [12] are different methods of reducing viscosity of vegetable oils.

India being predominantly agricultural country requires major attention for the fulfillment of energy demands of a farmer. The complete substitution of oil imports for the transportation and agricultural sectors is the biggest and toughest challenge for India. Biomass gasifier projects for decentralized power supply in India and their financial evaluation have been undertaken. [13]. In view of this, promotion of biomass-based power generation in the country is being encouraged. Producer gas can act as a promising alternative fuel, especially for diesel engines by substituting considerable amount of diesel oil. Dual fuel compression ignition engines have been employed in wide range of application to utilize gaseous fuel resources and minimize exhaust emissions without excessive increase in cost from that of conventional diesel engines [14]. Several researchers have undertaken works related to conservation of diesel fuel in dual fuel engines using various vegetable oils. Dual fuel combinations of Producer gas–Honge oil, Producer gas–Rice Bran oil and Producer gas–Neem oil have been extensively studied for rural applications [15–17]. This feature is very convenient for electricity generation in more remote areas or areas inaccessible for long periods over the year. The major problem with producer gas operated gas engines is power derating. A power drop from 40% to 70% can be expected [15]. From derating and fuel flexibility point of view, dual fuel engines are highly acceptable. Modification of existing diesel engine for dual fuel operation with producer gas is simple and power derating is limited to 20–30%.

The present work is undertaken to investigate feasibility of popular alternative fuels in the form of non-edible oils of Honge, Rice Bran and Neem oils in single fuel mode and combinations of these oils with producer gas in dual fuel mode. Experiments were conducted to optimize parameters in terms of injection timings and injection pressures for each fuel combinations selected. Honge oil gave better overall performance associated with reduced emissions in both single and dual fuel mode. Dual fuel mode of operation for all the fuel combinations resulted in poor performance at all the loads and injection timings compared to single fuel operation. However dual fuel operation with all the fuel combinations resulted in lower smoke, NO_x and increased CO emissions.

2. Fuel properties

The properties of Honge oil, Rice Bran and Neem oils and producer gas were determined in our college laboratory and are summarized in Table 1.

3. Experimental set up

Schematic diagram of the engine test rig is shown in Fig. 1. The engine tests were conducted on four-stroke single cylinder direct injection water cooled compression ignition engine. The specification of the engine is given in Table 2. The engine was always operated at a rated speed of 1500 rev/min. The engine was having a conventional fuel injection system. The injection nozzle had three

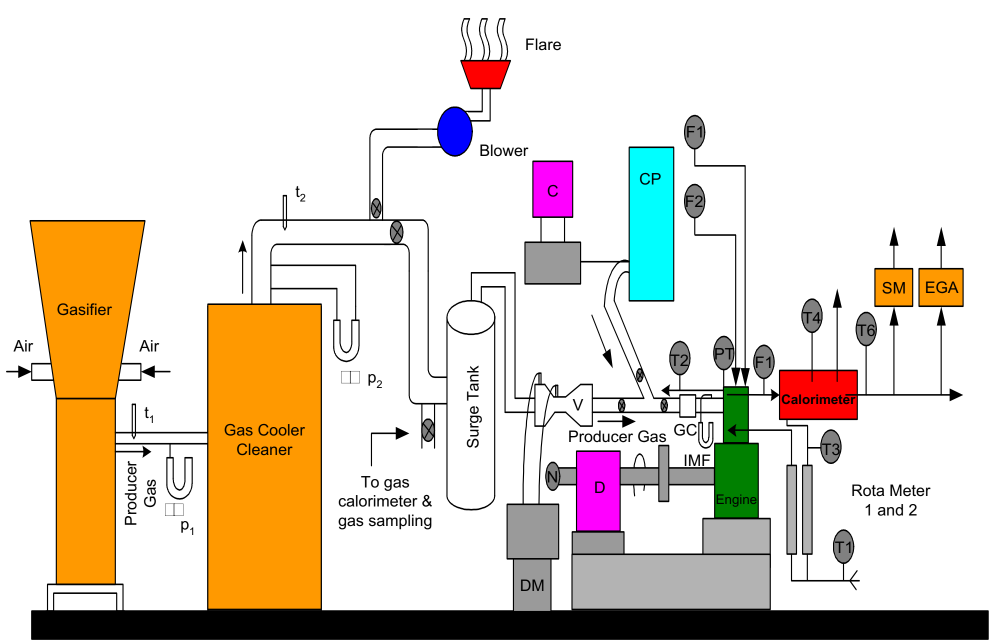

Fig. 1. Schematic diagram of the Experimental set up T_1, T_3 – Inlet Water Temperature, T_2 – Outlet Engine Jacket Water Temperature, T_4 – Outlet Calorimeter Water Temperature, T_5 – EGT before Calorimeter, T_6 – EGT after Calorimeter, F_1 – Fuel Flow DP (Differential Pressure) unit, F_2 – Air Intake DP unit, PT – Pressure Transducer, N-RPM Decoder EGA-DELTA 1600S-Exhaust 5 Gas Analyser, SM – Hartridge Smoke Meter, GC – Gas Carburetor, DM – Digital Manometer, C – Computer, CP – Control Panel, D-Electric Dynamometer, IMF – Inlet Manifold Pressure, ΔP_1 – Pressure drop across gasifier, ΔP_2 – Pressure drop across cooling cleaning system, V – Venturimeter.