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Performance of single cylinder diesel engine with karabi seed biodiesel

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This paper presents performance of single cylinder diesel engine using blends of karabi seed biodiesel. Potassium hydroxide was used as catalyst to facilitate estarification process. It has been observed that karabi seed biodiesel can effectively be used as diesel fuel substitute in existing diesel engine without any engine modification.

Keywords: Diesel engine, Karabi seed biodiesel

Introduction

Biodiesel is derived from vegetable oils modifying their molecular structure through a transesterification process[1]. Vegetable oils on long run tend to choke fuel filter because of high viscosity and insolubility. Heating and blending of vegetable oils reduce viscosity and improve volatility of vegetable oils but its polyunsaturated structure remains unchanged. Blending of vegetable oils with diesel reduces viscosity. Transesterification is an effective way to overcome all problems associated with biodiesel. Bora & Nath[2] found that existing diesel engine could be operated with up to 30% nahor biodiesel blend (B30N). Use of mixed biodiesel in a conventional diesel engine indicated that performance characteristics of engine with mixed biodiesel operation are comparable to those with pure diesel operation[3]. Significant improvement in engine performance and emission characteristics for biodiesel-fuelled engine compared to diesel-fuelled engine, and improvement in brake thermal efficiency (BTE), brake specific fuel consumption (BSFC) reduction, and exhaust smoke opacity reduction has been observed for biodiesel[4].

This study presents performance and emission characteristics of diesel engine using karabi seed biodiesel and its blends with diesel.

Methodology

Collection of Seeds

Fruits of Karabi tree (*Nerium oleander* Linn.) were collected from different villages of Assam during September-October 2007. Seeds are composed of hard shell (Fig. 1a). After drying seeds, outer hard shell is removed from fully matured seeds. A light brown colored core comprising of usually four units of inner lighter seeds is obtained. Using screw press, oil (58.5%) (Fig. 1b) was extracted from seeds and filtered by filter paper.

Biodiesel Production, Characterization and Quality Analysis

Esterification reactor (capacity, 5 l), used for producing biodiesel in laboratory, consists of constant stirrer mechanism, electric heater and stainless steel container. In transesterification process, mixture of oil, methanol and potassium hydroxide (KOH) as catalyst was stirred at constant speed and reaction temperature also maintained constant. Physico-chemical properties of karabi biodiesl (B100) and 20% karabi biodiesel blend (B20) were compared with that of diesel (Table 1). Most of fuel properties of B100 and B20 are comparable with that of petro diesel.

Engine Selection

A kirloskar made, single cylinder, air cooled, direct injection, DAF 8 model diesel engine was used. It has following specifications: rated speed, 1500 rpm; rated power, 8/5.9 bhp/kW; bore x stroke, 95 x 110 mm; displacement volume, 779.704; compression ratio, 17.5:1; cubic capacity, 0.78l; fuel injection timing, 26° BTDC (Before Top Dead Centre); and injection opening pressure, 200 bar. Engine was coupled to a 5 kVA electric generator. An AVL Digas analyzer was used to measure CO, CO_2 and NOx by non-dispersive IR gas analyzer. Hydrocarbons were measured with heated flame ionization detector. Smoke was measured using AVL 437

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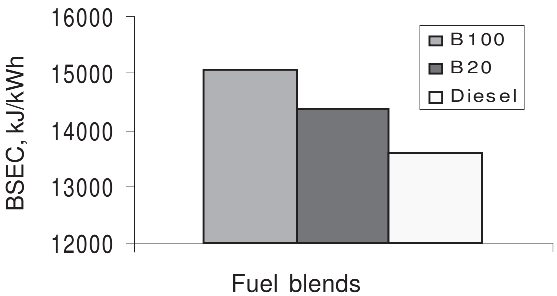
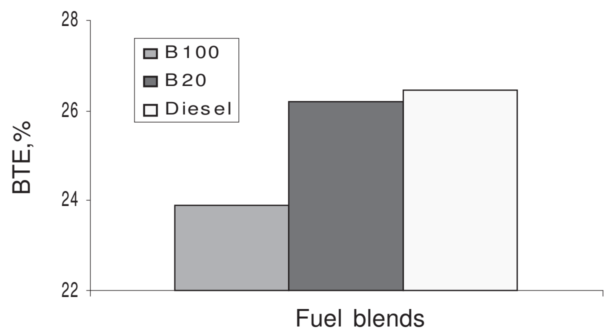
a)

b)

Fig. 1—Karabi fruit: a) seeds with outer coat; b) seed oil



a)



b)

Fig. 2—Engine performance at full load: a) BSFC; b) BTE

Table 1 — Physico-chemical properties of Karabi seed biodiesel and diesel

Property	Diesel	Karabi seed biodiesl (B100)	20% Karabi seed biodiesl (B20)	Test methods
Density, kg/m^3	834	860	838	ASTM D 4052
Kinematic viscosity$^{40°C}$, cSt	2.6	4.2	3.0	ASTM D 445
Cetane Number	48	50	48	ASTM D 613
Flash point, °C	66	110	72	ASTM D 93
Fire point, °C		120	79	
Cloud point, °C	- 8	- 4	- 7	ASTM D 2500
Pour point, °C	- 16	- 10	- 12	ASTM D 97
Ash content, %	< 0.01	0.003	0.002	ASTM D 482
Copper strip corrosion	1	1	1	ASTM D130
Moisture content, % wt	-	0.005	Nil	Karl Fisher Titrator
Ester content, % mass	-	> 98	-	GC method
Free glycerol, % mass	-	0.01	-	ASTM D 6584
Total glycerol, % mass	-	0.19	-	ASTM D 6584

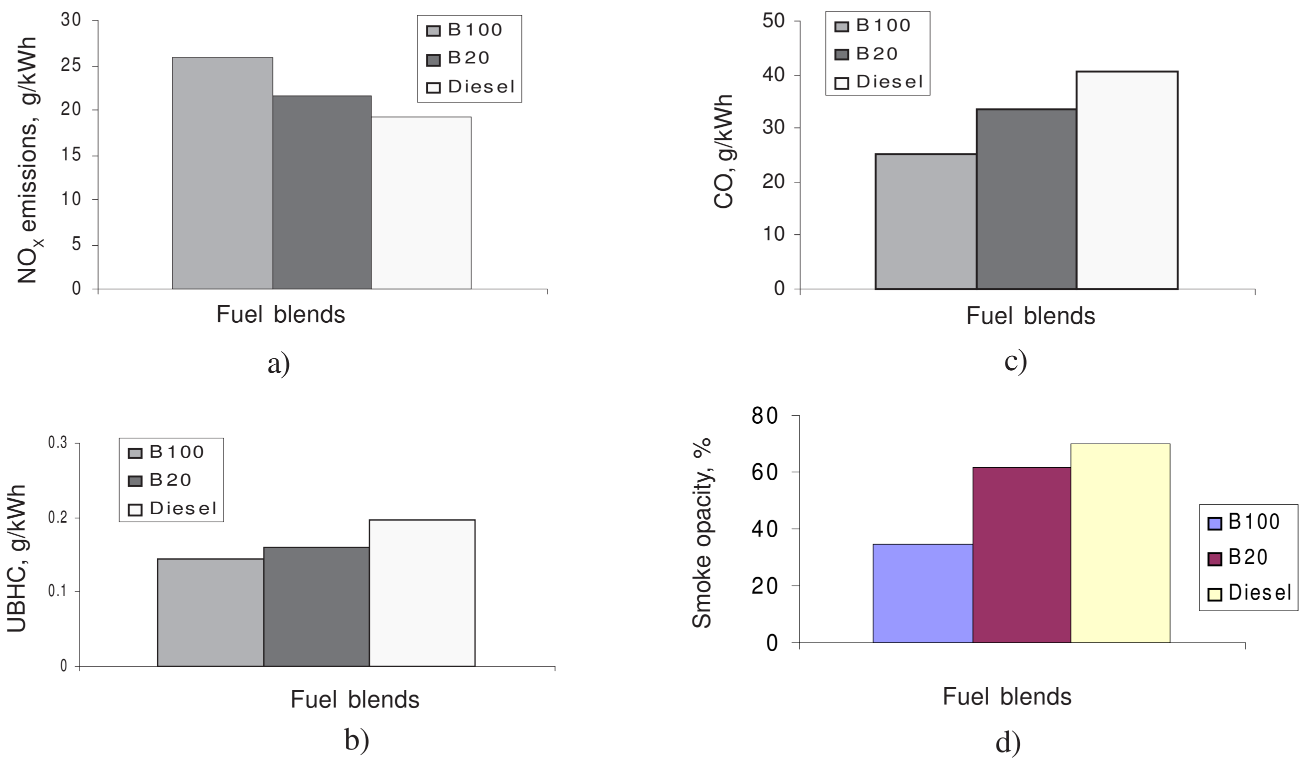


Fig. 3—Engine emissions at full load: a) NOx; b) UBHC; c) CO; d) smoke

smoke meter. Readings taken during each set of experiments were used for calculation of BSEC, thermal efficiency and other engine characteristics.

Results and Discussion

Engine Performance

Engine performance with karabi biodiesel (B100) was evaluated in terms of BSFC and BTE at full load condition. Engine speed was kept constant for test fuels. BSEC (Fig. 2a) has been found more for all biodiesel fuels compared to diesel, may be due to lower calorific value and higher density of biodiesel fuel. B20 fuel shows better BTE (Fig. 2b) than B100 fuel, may be due to availability of O_2, which helps in complete combustion of fuel. Drop in BTE with B100 can be attributed to poor fuel combustion due to relatively high viscosity and poor volatility.

Engine Emissions

Oxides of nitrogen (NOx), carbon monoxide (CO), unburned hydrocarbon (UBHC) and smoke opacity were measured for exhaust emissions at full load and constant engine speed of 1500 rpm. All observations recorded were replicated thrice to get a reasonable value. B100 shows maximum NOx emissions (Fig. 3a), may be due to advancing of injection timing caused by more rapid transfer of pressure wave from fuel injection pump to fuel injector causing fuel injector to open earlier. Faster pressure wave is due to a higher bulk modulus of compressibility and consequently a higher speed of sound in biodiesel fuel or blend relative to diesel fuel. Advancing injection timing in a diesel engine advances phasing of combustion process resulting in a longer period of time where temperatures are conducive to NOx formation and a greater opportunity to form NOx. Amount of UBHC in exhaust depends on engine operating conditions, fuel spray characteristics and interaction of fuel spray with air in combustion chamber. UBHC emissions for B100 are found to be better than diesel at full load (Fig. 3b), may be due to better combustion characteristics of karabi biodiesel. Diesel engines always operate on lean side of stoichiometric. Therefore, CO emissions from diesel engines are low as compared to petrol engines. B100 emitted least CO emissions (Fig. 3c) in comparison with B20 and diesel. Increase in CO levels at higher loads was due to rich mixture, resulting in incomplete combustion. Smoke levels (Fig. 3d) of B100 and B20 were significantly lower that that of diesel fuel, due to oxygen content in biodiesel helping better combustion.

Conclusions

Fuel properties of karabi biodiesel were within limits specified by ASTM D 6751-02 standard. BSFC increased and BTE decreased with increase in proportion of biodiesel in blends. Smoke level, UBHC and CO in exhaust emissions reduced, whereas NOx increased with increase in percentage of karabi biodiesel in blends. Karabi seed biodiesel can effectively be used as diesel fuel substitute in existing diesel engine without any engine modification.

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