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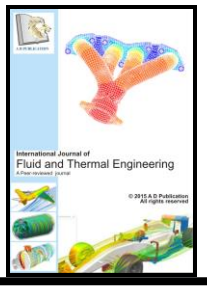

Experimental investigation for performance of single cylinder Diesel Engine by using Tallow-biodiesel

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A B S T R A C T : In the era of continuous revolutions from the evolution of the wheel to evolution of the IC engine, there is constant increase in fuel demand. Biodiesel is being tested as the replacement as it solves the problem of fuel deficiency and environmental degradation. The objective of the present study is to investigate the performance and emission parameter of diesel engine by using Tallow biodiesel. The experimental study is carried out on single cylinder 4 stroke diesel engine of compression ratio 15.5:1. Performance parameters such as brake thermal efficiency, brake power, BSFC and emission parameter such as exhaust gas temperature, CO, NOx were measured at different percentage of tallow biodiesel blending with diesel for different load condition. From the experimental results, it is observed that 20% blending of tallow biodiesel improve Brake power, Brake thermal efficiency as well as reduced BSFC as compared to neat diesel. However it is found that exhaust gas temperature, CO and NOx formation increases as blending of biodiesel increases as compared to neat diesel. It is conclude that up to 20% of tallow biodiesel can improve engine performance without much increase in emission gases.

Keywords: Tallow biodiesel, Diesel engine performance, Emission parameter.

1. Introduction

Innovation of internal combustion engine was one of the greatest evolutions of nineteenth century that change the human life. Various engineers and scientist have contributed for development of IC engine. Principle of modern diesel engine comes from the result of internal combustion engine proposed by Carnot in 19th century. It has made traveling time shorter and comfortable. Fast depletion of fossil fuels is urgently demanding an exhaustive research effort to find out the viable alternative fuels for meeting sustainable energy demand with minimum environmental impact. Biodiesel and alcohol are considered as alternative fuels. Various states government has shown immense interest in effective alternative fuels. The 'National Biofuel Policy' has set an indicative target of 20% blending of biofuels, both for bio-diesel and bio-ethanol, is proposed.

Biodiesel refers to a non-petroleum-based diesel fuel consisting of short chain alkyl (methyl or ethyl) esters, made by Transesterfication of vegetable oil or animal fat (tallow), which can be used (alone, or blended with conventional petro diesel) in unmodified diesel-engine vehicles. One of the main parts of agriculture is animal husbandry which produces many bio-residues like horn, hoof, and tallow. Beef tallow is one of these residual materials produced in slaughterhouses, and primarily is utilized in soap production industry. However, when this industry is overloaded, the extra fats are usually incinerated or disposed in a sanitary landfill, which can pollute the environment. Therefore, the integrated use of bio-residues produced in slaughterhouses can prevent pollution induced by accumulation of these residues in natural resources. The animal fats differ from some vegetable oils, such as soybean or colza oil, with respect to their chemical properties. The composition of these oils presents a large amount of unsaturated fatty acids; however, in animal fats such as beef tallow, there are a large amount of saturated fatty acids.

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Nomenclature

BP	Brake power
BTE	Brake thermal efficiency
BSFC	Brake specific fuel consumption
EGT	Exhaust gas temperature

Senthil Kumar et al (2005) investigated preheating of animal fat at five different temperatures and tested it as a fuel in CI engine. In their investigation, animal fat is preheated to 30°C, 40°C, 50°C, 60°C and 70°C before it is injected into combustion chamber of an engine. Wyatt et al (2005) analyzed biodiesel production and properties of lard, beef tallow and chicken fat by base-catalyzed Transesterification. Nitrogen oxide (NOx) emission tests were conducted in single cylinder direct injection diesel engine using animal fat-derived esters and soybean oil biodiesel as 20% by volume (B20 blend) with diesel. John Panneer Selvam et al. (2012) investigated performance and exhaust emissions parameter of direct injection diesel engine with methyl esters of beef tallow as neat biodiesel (B100) and its blend (B5, B25, B50 and B75) with diesel fuel. The test result indicates that there is a slight decrease in brake thermal efficiency and increase in specific fuel consumption for all the blended fuels when compared to that of diesel fuel. The drastic reduction in carbon monoxide, unburned hydrocarbon and smoke density were recorded for all the blended fuels as well as with neat biodiesel. Piyushi Nautiyal et al. (2017) study systematic characterization of tallow biodiesel to find its suitability for diesel engines. The chemical nature and composition of tallow biodiesel as determined by NMR, FTIR and GC analyses are closely related to established biodiesel properties. Nikul K Patel et al (2017) investigate the performance for a direct-injection four in line cylinder I C engine using Leptadenia Reticulatta Methyl Ester (LRME) as fuel. The investigation on performance of an engine with LRME and its blends indicates LRME is good alternative to I C engine. In present experimental study, Tallow biodiesel is used. The performance of diesel engine varies with operating condition and it is important to identified suitable operation condition for efficient engine operation. There are various parameter effect on the performance of diesel engine needs to calculate and investigate during operation of the engine.

2. Experimental Test-facility

2.1 Biodiesel blends:

Biodiesel blend contains both Tallow biodiesel and diesel. B20 refers to a fuel which contains 20% of biodiesel and 80% of diesel. Similarly with increment in percentage of biodiesel refers to B40 to B80. Pure diesel is designated as B00. The selected fuels were blended on volume basis (v/v). First the known volume of diesel was taken in the measuring beaker and required quantity of biodiesel was added and stirred manually for 10 to 15 min. The nomenclatures given for blends are presented in Table-1.

Table-1: Details nomenclature of Biodiesel blends with petro Diesel prepared

Sr. no	Fuel type	Nomenclature
1	0% Tallow Biodiesel + 100% Diesel	B00
2	20% Tallow Biodiesel + 80% Diesel	B20
3	40% Tallow Biodiesel + 60% Diesel	B40
4	60% Tallow Biodiesel + 40% Diesel	B60
5	80% Tallow Biodiesel + 20% Diesel	B80

2.2 Experimental setup:

Experimental set up consist of four main integrated systems: (1) a single cylinder four stroke diesel engine (fig.1a), (2) an engine loading system (fig.1b) and (3) various measuring instrument (4) digital display (fig.1c) (4) multiple gas analyzer (fig.1d). All integrated systems attached to engine, is shown in line diagram figure 2. This test is conducted on a single cylinder four stroke diesel engine of 95mm bore and 115mm stroke. Diesel engine is coupled with electrical generator of 5kW and Engine output is measured by using ammeter and voltmeter.

Exhaust gas temperature is measured by thermocouple. Multiple gas analyzer is connected with exhaust pipe of engine. Engine is also loaded by variable resistance load panel. Burette is mounted on the fuel tank which uses to measure the rate of fuel consumption. Engine specification is mentioned below Table-2:

Table-2: Engine specification

Sr. no	Engine	Specification
1	Model	Swaraj PV-4
2	Type	4- Stroke water cooled
3	Fuel	Diesel
4	Cylinder	1
5	Displacement volume	780cm3
6	Bore	95mm
7	Stroke	110mm
8	Compression ratio	15.5:1
9	Rated output	5.9kW

Figure 1(a) Single cylinder four stroke diesel engine

Figure 1(b) Engine loading system

Figure 1(c) Measurement panel

Figure 1(d): multiple gas analyzer

Figure 1 Diesel Engine test-setup

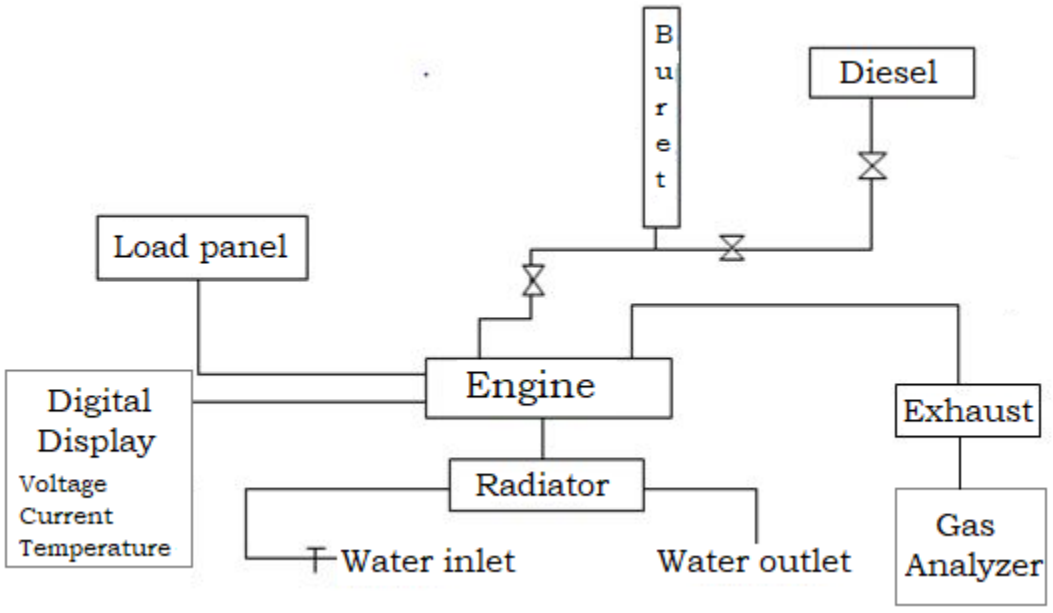

Figure 2: Schematic diagram of Experimental setup

2.3 Experimental procedure

Experiment was carried out on four stroke water cooled diesel engine. The engine was run at no load and at different load conditions and the various observations were evaluated in terms of BP, BSFC,BTE and emission of exhaust gas were measured at different loads for different blends of biodiesel. The digital exhaust gas analyzer detected the following parameters of the exhaust gas; CO, NO, NO_2 Exhaust gas temperature. Various observations were evaluated by measuring of time taken for 20ml fuel consumption, exhaust gas temperature, Current and voltage.

3. Result and discussion:

3.1 Performance analysis

3.1.1. Brake power:

The power developed by the engine at the output shaft is called break power. BP increases with increase in load. But it decreases with increment in bland percentage. Maximum BP is observed for B20 at 80% of load. Highest BP observed is 3KW. It is 850W higher than diesel at full Load. Effect with load on BP is shown in figure 3

3.1.2. Brake thermal efficiency:

It is the ratio of power developed by the engine and the energy release per unit time due to complete combustion of fuel. Maximum BTE is 18.33% evaluated at 80% of load for B20. Brake thermal efficiency decrease as the percentage of biodiesel increases. Maximum increase in BTE is observed at 40% of load which is 4.05% more than diesel. BTE with variable load is shown in figure 4.

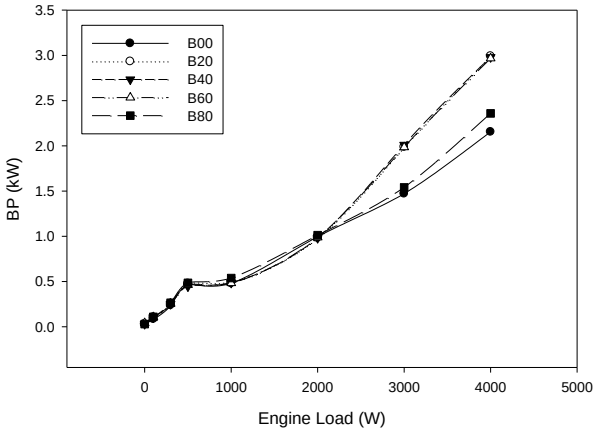

Figure 3: Brake power vs Engine load

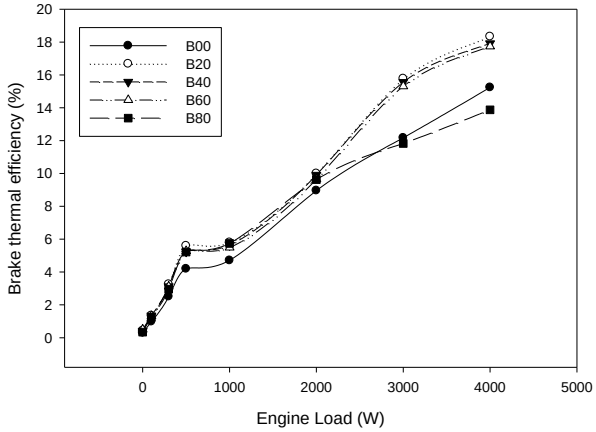

Figure 4: Brake thermal efficiency vs Engine load

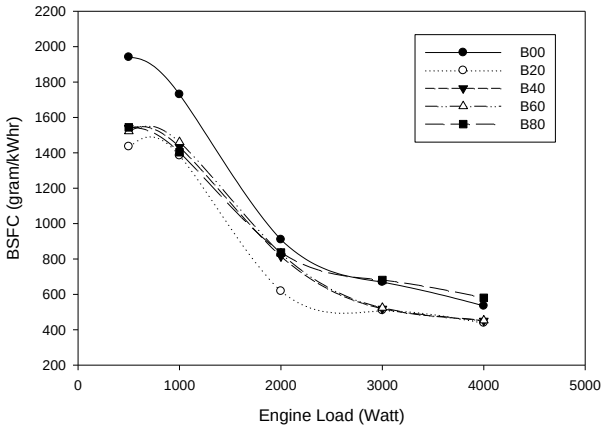

Figure 5: BSFC vs Engine Load

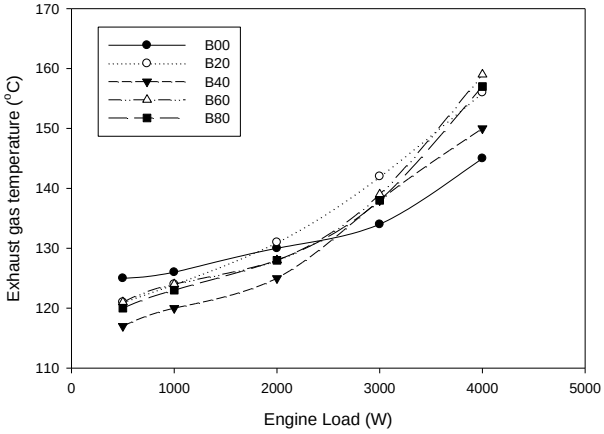

Figure 6: Exhaust gas temperature vs Engine Load

3.1.3. Brake specific fuel consumption:

BSFC is the rate of fuel consumption divided by the power produced. Variation of BSFC with load is shown in figure 5. BSFC decrease with increase in load. BSFC is observed more for diesel compared to Biodiesel. Brake specific fuel consumption for the B20 is lowest among all blend. At full load condition BSFC for B20 is 96.48 gm/Kwh lower than that of diesel.

3.2. Emission analysis

3.2.1. Exhaust gas temperature:

EGT, measures the temperature of gases leaving a vehicle's exhaust manifold. Exhaust gas temperature is increases with increasing load on engine. This is due to higher fuel consumption of the engine at higher load. There is 8% increase in temperature compared to diesel at full load. Temperature observed for B40 has 4.7% less than diesel. Figure 6 shows the variation of exhaust gas temperature with diesel and blends of biodiesel at different load.

3.2.2. NOx emission:

NOx emission can be calculated with the help of NO and NO_2. Figure 7 describes variation of NOx with different blend at different load. It is observed that NOx emission increases with increase in load. B20 produces more emission compared to other blending. . It is observed that B40 has lowest emission than others at full load.

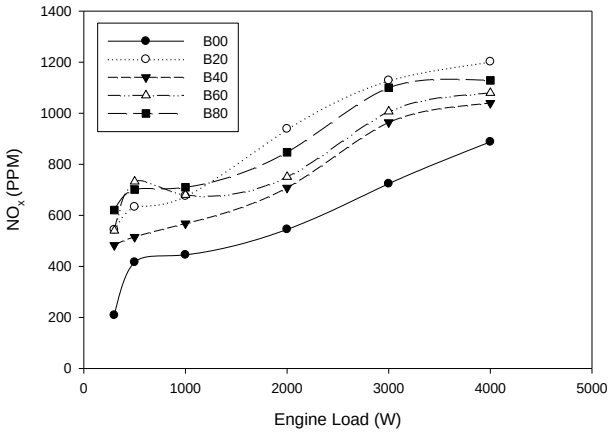

Figure 7: NO_x vs Engine Load

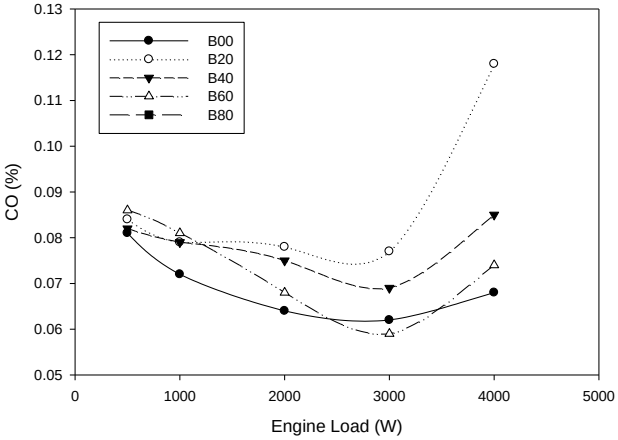

Figure 8 : CO vs Engine Load

3.2.3. CO emission

Carbon monoxide emission is observed minimum for B20 than all other blends. Minimum emission is observed at 20% of load on engine. The load increased, CO emission decreased initially and further it increased as the load increased. Variation in CO emission with different blends of biodiesel at varying load is shown in figure 8.

4. Conclusions

In the present work, the performance and emission evaluation of single cylinder four stroke diesel engine using neat diesel and Tallow biodiesel for different blends and variable loading are carried out.

Brake Power is observed maximum for B20 blend at 80% of load which is 3KW. It is 850W higher than diesel at full Load. Bake thermal efficiency is a maximum for B20 blend at 80% of load which is 18.33%. Maximum variation in BTE is observed at 40% of load which is 4.05% higher than diesel. Brake specific fuel consumption for the B20 is lowest among all blend. In case of B20 the BSFC is around 17% less than diesel fuel at full load. Exhaust gas temperature is increases with increasing load on engine. There is 8% increase in temperature compared to diesel at full load. Carbon monoxide emission is observed minimum for B20 than all other blends. Minimum emission is observed at 20% of load on engine. Nitrogen oxide emission increases with increasing load on engine. It is observed that B40 has lowest emission than others at full load. Nitrogen dioxide emission decreases with increase in load.B40 has minimum emission than all other blends. The optimum condition for performance of engine using biodiesel is blend of 20% biodiesel and 40% load on engine. Whereas desiring lowest emission, optimum condition is to use B40 blend.

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