International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 08, August-2018

PERFORMANCE AND EXPERIMENTAL ANALYSIS OF C.I ENGINE FUELLED WITH TALLOW OIL ALONG WITH ANTIOXIDANT ADDITIVE

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ABSTRACT:
In this research work, performance and emission analysis of a single cylinder direct injection diesel engine with pure diesel and blend of diesel and methyl ester of tallow oil in different proportions of B10, B20 and B30.The B20 blend gives better results compare to other blends and also adding different proportions (300ppm, 600ppm, 1000ppm) of p- phenylenediamine additive to B20 blend. The addition of antioxidant to blend improves fuel combustion which helps to reduce the emissions of engine. p-phenylenediamine showed greater capability to increase the stability of B20. The test was conducted on single cylinder diesel engine under conditions of constant speed and varying load. Brake thermal efficiency of diesel is 27.3% at 2.31kW BP and 26.3% at 2.88kW BP where as brake thermal efficiency of B20+600ppm additive gives 27% at 2.31kW BP and 26% at 2.88kW BP. The results show that B20 and B20 with antioxidant additive produced higher brake specific fuel consumption compare to diesel. Adding additive to biodiesel blend results decrease of HC, CO, and NOx emissions compare to diesel. Thus, B20 blend with added antioxidant can be used in diesel engines without any engine modifications.

Keywords: Tallow Biodiesel, Antioxidant, Performance, Emission, NOx reduction.

1. INTRODUCTION

Recently biodiesel is catching the attention as an alternative source of energy in the world mainly because of its lesser pollutant nature to environment as compared to diesel fuel. The major problems in the world are environmental pollution and global warming. The reason behind these problems is raising use of fossil fuels. At present biodiesel is produced mainly by edible vegetable oils and non-edible vegetable oils. Currently, greater amount of edible oils are used to compare to non-edible oils for biodiesel production which makes edible oils costly for daily use. So using edible oil as biodiesel feedstock is not appropriate. On the other hand, non-edible oils are easily available and can be cultivated in nonagricultural land and also can be derived from fats. Also, they can't be used in daily life as frequently as edible oils which makes them cheaper. Diesel fuel is used for transportation, power generation and many other applications like industrial and agriculture uses. The major problem associated with the use of diesel fuel is production of harmful gases like CO (Carbon monoxide), CO_2 (Carbon dioxide), NO_x (Nitrogen oxides) and UHC (Unburnt hydrocarbons). That is why the requirement of an alternative fuel other than diesel arises to fulfill the energy demand and save the environment. At present, use of non-edible oil also known as 2nd generation feedstock for biodiesel production is under development. The main problem of the non-edible vegetable oil is high viscosity, high free fatty acid (FFA) content and production of carbon deposit. To reduce the viscosity and density, we use transesterification process. The properties of biodiesel are similar to that of diesel.

2. MATERIALS & METHODS

Test Fuel:
In the present investigation conventional diesel fuel, tallow biodiesel and p-phenylenediamine were used. The fuels tested were pure diesel (B0), blends of 90% diesel and 10% tallow biodiesel (B10), 80% diesel and 20% tallow biodiesel (B20), 70% diesel and 30% tallow biodiesel (B30) and B20 with 300, 600, 1000 ppm of p- phenylenediamine. Fuel properties that are important from engine performance and emission point of view such as density, viscosity, calorific value, cetane number of the above fuel blends were determined and shown in the table

Table 2.1Properties of Diesel, Tallow biodiesel blends

S.No	Property	Units	Diesel (D100)	Tallow Biodiesel(B100)	B10	B20	B30
1	Density	kg/m^3	826	873	855.8	861.1	868.6
2	Viscosity @40^oC	m^2/s	3.1	4.2	3.42	3.56	3.71
3	Calorific Value	kJ/kg	43150	40930	41082	39940	38340
4	Flash Point	^oC	68	174	73	87	98
5	Fire Point	^oC	80	221	89	95	107
6	Cetane Number		47	58	48.2	49.5	49.9

Table 2. 2 Properties of Diesel and tallow biodiesel blend with PPD

Property	Units	B20+300ppm	B20+600ppm	B20+1000ppm
Density	kg/m^3	869	876	885
Viscosity @40^oC	m^2/s	3.61	3.75	3.84
Calorific Value	kJ/kg	40030	40190	40210
Flash Point	^oC	88	91	95
Fire Point	^oC	97	100	105
Cetane Number		49.9	51.8	50.3

P-Phenylenediamine additive:

In this study we use PPD as additive. The chemical formula for PPD is $C_6H_4(NH_2)_2$. p-phenylenediamine is accurately weighed using a high precision electronic weighing balance and added to measured quantity of tallow biodiesel blend (B20).

3. EXPERIMENTAL SETUP

3.1 Engine Setup

The experimental setup comprises of a diesel engine with rope brake dynamometer. The engine used in conducting experiment is a constant speed Kirloskar engine, four stroke, single cylinder, direct injection diesel engine. The engine is a water-cooled engine. The load applied on the engine is mechanical loading type. The engine is mounted on concrete bed with suitable connections for water cooling and lubrication.

3.2 Engine Specifications

S. No	Configuration	Model
1	Make	Kirloskar
2	Power	5HP
3	Speed	1500 rpm
4	No of cylinders	One
5	Compression ratio	16.5:1
6	Stroke length	110mm
7	Bore	80mm

Table 3. 1 Engine Specifications

Figure 3. 1 Experimental set up

3.3 Test Method

Experiment is carried out using diesel and tallow biodiesel. Initially engine was operated on pure diesel for few minutes at rated speed of 1500 rpm. The diesel fuel was replaced with ternary blends (B10, B20, and B30). The test was conducted by varying 0 to 100% of load on the engine. In the next phase experimental investigation was carried out by adding p-phenylenediamine additiveby various proportions (i.e300ppm, 600ppm and 1000ppm) for best blend B20 for reducing NOx emissions. Using a dynamometer and gas analyzer performance and emission characteristics were taken.

4. RESULTS AND DISCUSSIONS

4.1 PERFORMANCE ANALYSIS

4.1.1 Brake Thermal Efficiency (BTE):

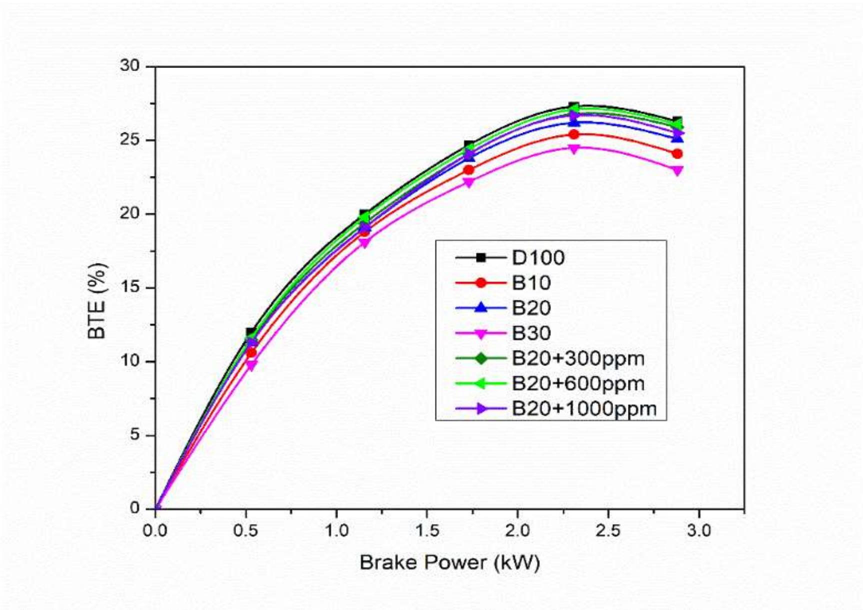

Figure 4. 1Variation of BTE with Brake Power

Brake thermal efficiency is defined as the ratio of brake power to the heat input to the engine. Fig4.1 shows BTE increases with increasing brake power. The maximum value of BTE observed for pure diesel, B10, B20, B30, B20+300ppm, B20+600ppm, B20+1000ppm was 27.3%, 25.4%, 26.2%, 24.5%, 26.8%, 27.1%, 26.7% at 2.31 kW Brake power. The lower BTE is due to the lower calorific value and having high viscosity. The addition of antioxidant PPD shows increase in BTE at all loads due to higher cetane number and mass flow rate. The advancement in combustion of B20 with antioxidant additives, together with the presence of excess O_2 has resulted in better combustion and hence the BTE is increased. The brake thermal efficiency of B20+600ppm closer to the diesel fuel.

4.1.2 Brake Specific Fuel Consumption (BSFC):

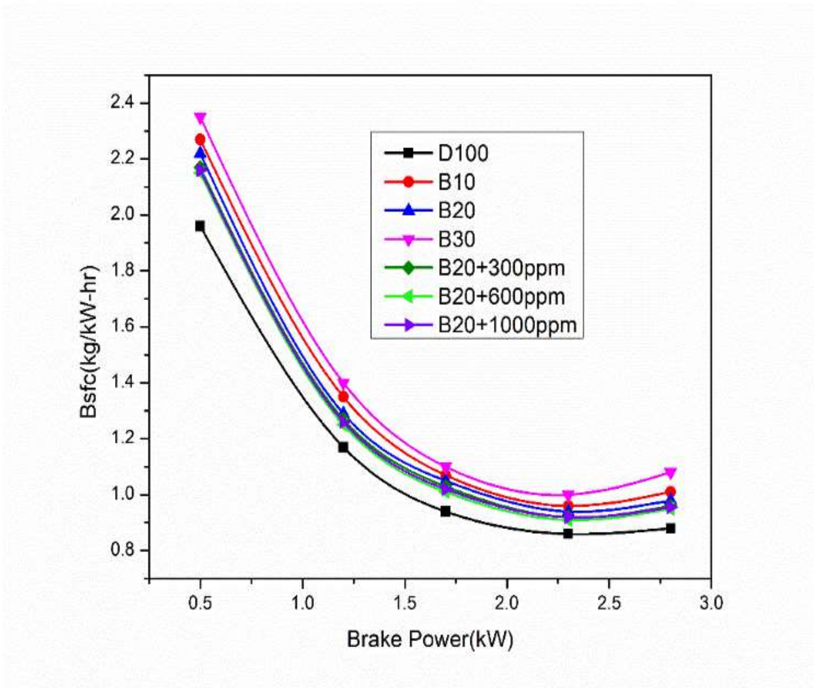

Figure 4. 2Variation of BSFC with Brake Power

Brake specific fuel consumption is defined as ratio of total fuel consumption to brake power. Fig4.2 shows the variation of brake specific fuel consumption with load. The BSFC of blends and B20 with antioxidant additives higher than that of diesel fuel. The BSFC for B20+600ppm additive decreases by5.2% than B20 at 2.3 kW BP.

4.2 EMISSION ANALYSIS

4.2.1 Carbon monoxide (CO):

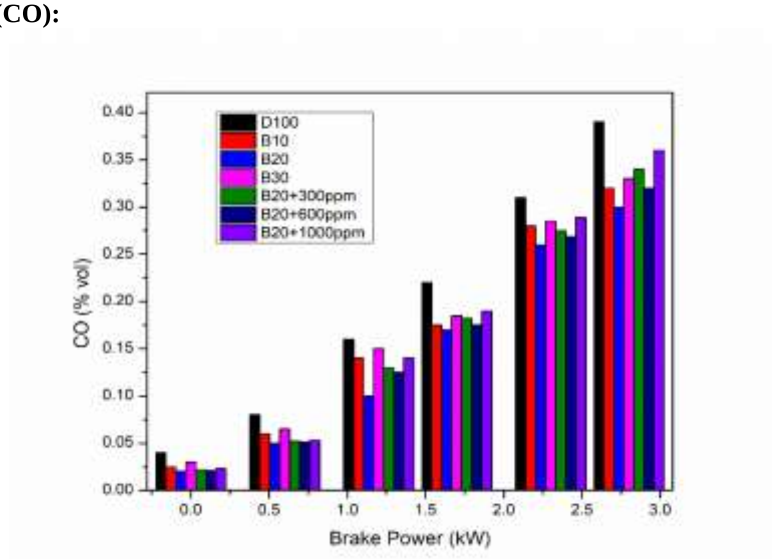

Figure 4. 3Variation of CO Emission with Brake Power

Fig4.3 shows the variation of CO with brake power. A low flame temperature and too rich fuel air ratio are the major causes of CO emissions from diesel engines. Increasing in CO emissions results in loss of power in engines. Biodiesel blends contain high oxygen by mass and high cetane number of fuel which promotes complete combustion, and thus leads to reduction of CO emissions. The CO emission of B20 fuel without antioxidant additive shows a decreasing trend due to the oxygen content in the tallow biodiesel. The addition of antioxidant additive to B20 blend shows increase in CO emission compare to B20 at all loads. The CO emissions of B20+600ppm fuel decreased by 13.2% at 2.3kW BP.

4.2.2 Hydrocarbon (HC):

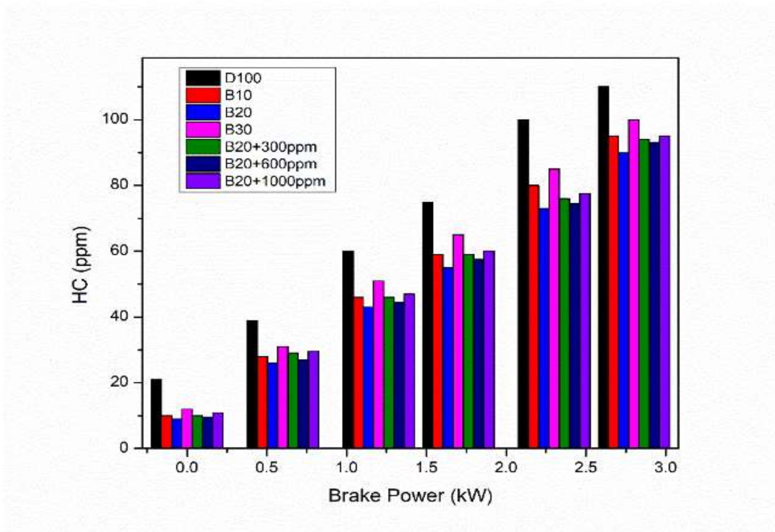

Figure 4. 4Variation of HC Emission with Brake Power

The presence of unburned fuel in engine results hydrocarbon emissions. Fig4.4 shows the variation of HC with engine Brake power. HC emissions increases with increasing load on the engine. The HC emissions are mainly due to the over mixing of fuel and air. B20 shows the reduction in HC emissions of 27% compare to diesel at 2.31 kW BP. Addition of antioxidant shows increase in HC compare to B20 and the values of HC emissions were below the level of pure diesel.

4.2.3 Oxides of Nitrogen (NOx):

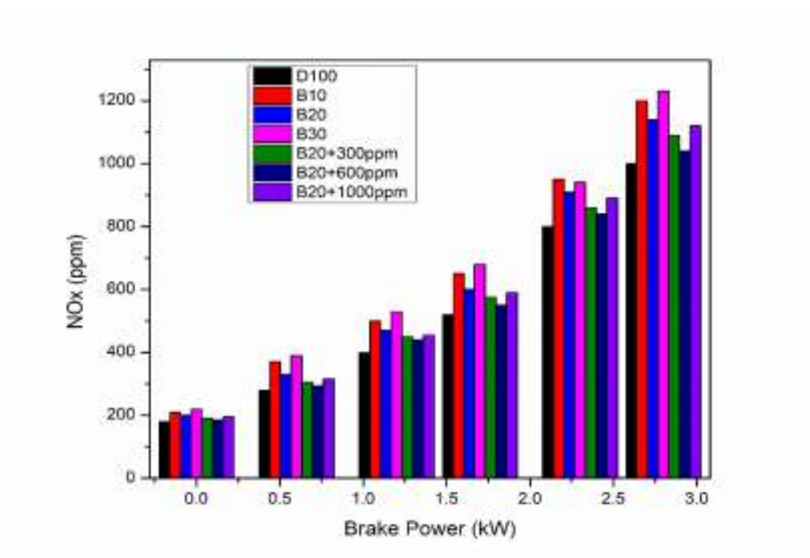

Figure 4. 5Variation of NOx Emission with Brake Power

Fig4.5 shows that NOx emissions increase with the increasing load on the engine. The biodiesel concentration increases in diesel the NOx emissions increases due to rich oxygen content of fuel as well as rich oxygen provides complete combustion due to this exhaust gas temperature increases. The NOx emission concentration with added antioxidant decreases up to 600 ppm then it increases. B20 with 600ppm concentration reduces NOx by 8.77% compare to B20 blend. NOx emission is decrease due to the reduction in formation of free radicals when the antioxidant additive added to blend.

5. CONCLUSIONS

The main aim of the study was to investigate the performance and emission analysis of tallow biodiesel with additive as fuel in diesel engine. Based on the results, the following conclusions can be drawn.

- The addition of antioxidant additive increased the kinematic viscosity, density and flash point.
- Brake thermal efficiency increases by 3.5% at B20+600ppm than B20. The earlier combustion of B20 with additive and the presence of enough oxygen result in better combustion and hence BTE increases.

- The addition of antioxidant additive result lower BSFC compared to B20 blend.
- The addition of antioxidant additive produced an increase in CO and HC emissions than B20 but these are in acceptable limit.
- B20 produced an increase in NOx emission compared to diesel. The addition of antioxidant additive produces a reduction in NOx emission.

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