Performance and Emission Analysis of Waste Animal Fat Methyl Esters Blends on Naturally Aspirated Single Cylinder Engine

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ABSTRACT

With emergent energy demands along growing concerns over health and ecological issues, have motivated consideration of biomasses derived alternative fuels, such as biodiesel for IC engines. In the current study transesterified waste animal fat was investigated for performance and emission characteristics and compared with mineral diesel. Experiments was performed on a single cylinder four stroke CI engine with constant injection pressure on Kirloskar TV1 having power 3.60 kW @ 1500 rpm. Using these constraints BTE and BSEC are computed. Exhaust emission behavior of such alternative fuels is vital in order to assess suitability for further utilization to compare these uHC, CO, NO_x and smoke emission were also measured for all the test fuels. Emission reports indicate higher NO_x and lesser CO emissions compared to mineral diesel. The characteristics found to be equivalent with ASTM Standards which is a favorable fuel requirement.

Key words: Biofuel, renewable Energy, Waste Animal Fat Methyl Ester.

INTRODUCTION

Energy is most substantial portion for any nation's frugality. With the day by day depletion of oil reserves and the new stringent environmental laws in force made the world moving towards a better, cleaner and safer option like renewable energy resources. In India renewable energy power generation is 90,399.11 MW in 2020 which was 24% of the total power generation in

the country (Annual Reports for New and Renewable Energy Sector, 2019-2020). On other hand India can possibly create vitality by sun powered, hydro, wind and bio-starting points yet their utilizations are constrained in India (Basic Indian Statistics Petroleum & Natural Gas, 2019-20).

The major form goods transportation in India like more than 90% of trucks play on this and other than electricity the whole railway network plays on it. Thus these diesel engines are the back bone of our economy (Basic Statistics on Indian Petroleum & Natural Gas, 2019-20). Diesel engines have a very significant task by which it acting a significant task in Indian economy (Frank Lujaji et. al. 2011). The consumption of crude oil during 2019-2020 is 201.9 million metric tons (IEA 2020). Indian Government spent 102 billion USD to imports crude oils from other countries in the year of 2019-2020 (All India / Region wise Power Generation Overview, 2020, Amar Deep et. al. 2018).

The expanding costs of oil coming about items due to exhaust oil saves have likewise set up an overwhelming undertaking before scientists to search for elective powers that is a lot of cleaner and efficient than the current day petroleum derived fuels, for example, diesel and gasoline (Frank Lujaji et. al. 2011). Diesel engines have colossal uses in India in the field of cultivating, ventures, transportation and furthermore in vitality creation territories. By which the diesel engine acting a significant job in Indian economy. Hence the current days the elective powers for the diesel engines are significant.

To address these above problems we have to find alternative methods to produce fuels .And subsequently we have made a good progress in the field of bio-origin fuels .Alcohol , jatropha, waste animal fat , waste frying oil, seeds, food grains, stables etc are the major players in bio-origin fuel which can contribute on our above ongoing problems (Pali Harveer Singh et. al. 2015, Y. Alhassan et. al. 2014).

Petroleum product makes our life easer but it has a huge impact on our society and environment. Biodiesel is a superior alternative fuel and it gets attentions for erstwhile. Both

vegetable oils and animal fats whether edible and non-edible could be used to produce biodiesel but concerned food security restricts with the use of non-edible oil (Kumar N. et. al. 2015). In early years so many hard works has been done by many researchers to make biodiesel as a diesel engine fuel.

Biodiesel is clean consuming, sustainable substitution for diesel to be utilized in existing diesel engines deprived of adjustment; it is the country's locally created financially accessible progressed biofuel (Deep A. et. al. 2013). Biodiesel was mixed with diesel to bring much of the beneficial features to diesel equipment, with reduction in overall fuel cost (Vibhanshu V. et. al. 2014).

Biodiesel is a sheltered elective fuel to supplant conventional oil diesel. It has high lubricity, is a perfect consuming fuel and can be a fuel segment for use in existing, unmodified diesel engines. This implies no retrofits are vital when utilizing biodiesel fuel in any diesel controlled burning engine. It is the main elective fuel that offers such comfort (D.Y.C. Leung Y et. al. 2006, Zhang Y et. al. 2003).

Animal fats stay alluring feedstock for biodiesel on the grounds that their expense is considerably lower than vegetable oil. This is mostly in light of the fact that vegetable oil market is less constrained than animal fat market, since a great part of animal fat delivered in India isn't viewed as palatable by people.

Y. Zhang et al. 2003 analyzed alkali catalyzed process utilizing virgin oil and ensued that Waste oil can be utilized as the crude material. Anildo Cunha Jr et al. 2013 implemented RMS optimizations and produce high quality biodiesel under mild condition (30c). Dhiraj S et al. 2012 concluded use of animal fat biodiesel as properties improver or solvent. Metin Guru et al. 2010 considered Chicken fat biodiesel blend as an elective fuel in traditional CI engine with no significant Modification. Haq Nawaz Bhatti et al. 2008 bring into being sheep, chicken and lamb fat methyl ester using acid catalyst were more suitable in comparison to base catalyzed reactions. Michele Espinosa da Cunha et al. 2008 identified comparable characteristics of

sheep biodiesel blends in CI engine without loss of efficiency. M. Kirubakaran et al. 2018 concluded that high quality biodiesel to be replaced with waste animal fat. Peter Adewale et al. 2015 reported lesser NOx outflow for animal fat biodiesel. Tashtoush et al. 2008 study the assessment and enhancement of change of waste animal fat into biodiesel and concluded compromise between response time and temperatures response culmination is the most basic fuel quality parameter.

Animal fat feedstock's can be made into top notch biodiesel that meets the ASTM particulars for biodiesel. Animal fats are high immersed which implies that the fat sets at a generally high temperature. Accordingly biodiesel produced using animal fat has a high cloud point. The high cloud purpose of the animal fat biodiesel doesn't have a lot of impact on the cloud purpose of the mix. In India the waste animal fats are best crude materials to made biodiesel in light of the fact that the fats are effectively be gather. WAFME biodiesel allows substituting the significant part of oil diesel which is utilized in compression ignition (CI) engine to accomplish the huge decrease

METHODOLOGY

Waste animal fat consists of mono carboxylic acids with trihydric alcohol glyceride. During heating free fatty acid content is improved by hydrolysis of receptive segments because of water from food. As per ASTM standard the density of waste animal fat oil was 0.880 kg/m^3 at temperature 40°C. Similarly the kinematic viscosity (40°C) and the flash point of the waste animal fat oil were 4.8 cSt and 146°C respectively with 58 cetane number along with calorific value and plugging point were 39.60 MJ/kg and 0°C respectively.

To use the waste animal fat in a useful way it should be transesterified and converted into biodiesel (Amar Deep et. al. 2018).

Blending process is done by blending 5%, 10% and 20% of WAFME biodiesel with neat diesel respectively. All the tests samples were kept in shut jugs for two weeks and routinely checked for the homogeneity and stage partition.

Figure 1 shows test rig schematic diagram which is used to determine the performance and emissions characteristics in current investigation. In this figure there is a control panel which is used for RPM, temperature, voltage measurement. For the measurement of different emissions there is an emission analyzer and to measure the brake power an electrical dynamometer is used. To start this engine we used hand lever.

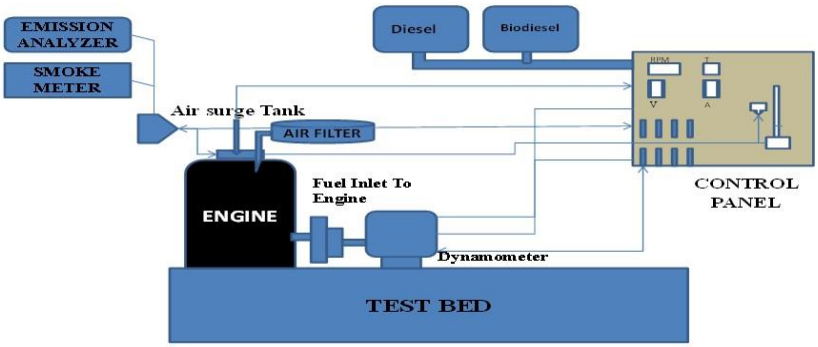

Figure 1 Test Rig Schematic Diagram.

For the evaluation of performance and emissions characteristics we used a diesel engine with some important specifications which was given in table 1.

Table 1 Diesel Engine Specification.

Number of Cylinder	1
Number of strokes	4
Fuel	H.S Diesel
Rated Power	3.6 KW ,1500RPM
Cylinder Diameter	87.5mm
Stroke length	110mm
Connecting Rod Length	234mm
Compression Ratio	16.51
Orifice Diameter	20mm
Dynamometer Arm Length	185mm

PHYSICO-CHEMICAL PROPERTIES

There is an overall after effect of physico-chemical properties of waste animal fat biodiesel and neat diesel mixes was made with neat diesel. In the table 2 the outcomes are summed up that is density, cetane number, calorific value and kinematic consistency. More noteworthy

is the measure of waste animal fat biodiesel in perfect diesel lesser is the thickness, cetane number, calorific worth and kinematic consistency.

Table 2 Physico-Chemical Properties.

FUEL	DENSITY(g/cm^3)	CETANE NO.	CALORIFIC VALUE (MJ/kg)	KINEMATIC VISCOSITY(cSt)
D100	0.831	48	43.3	3.5
WAFME	0.899	56	40.7	5.42
WAFME5	0.8563	51	43.1	3.574
WAFME10	0.8655	52	42.9	3.642
WAFME20	0.8749	53	42.2	3.880

RESULT

On a diesel engine the current investigation was done to assess the performance and emission qualities fueled with waste animal fat biodiesel blends which is the significant target of the examination.

BRAKE THERMAL EFFICIENCY

A comparison between the BTE of the diesel engine with the bmep for the diverse blends which seen in figure 2. As per investigation results we get than there are some increment in the BTE of diesel engine with the increase in the blending. This is due to raise in the viscosity with increasing blending percentage. Also decreasing heating value tends to decrement of the brake thermal efficiency at 20 percent blending. The results are in agreement with Deep A et al.2015.

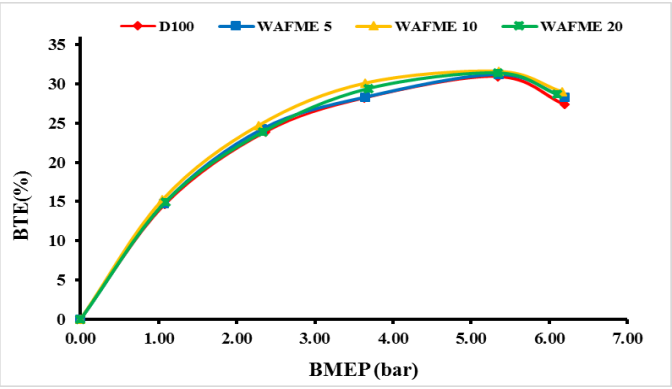

Figure 2 BTE vs. BMEP

For the blends the maximum thermal is observed in the engine WAFME5, WAFME10, WAFME20 and D100 are 29.4 %, 30.9%, 29.9% and 30.7% at 80% of load.

BRAKE SPECIFIC ENERGY CONSUMPTION

There was a superior boundary for the examination of various mixes of waste animal fat biodiesel and neat diesel that is brake specific energy consumption since density and calorific estimation of both are extraordinary. Figure 3 shows that the BSEC reduction with the increment in BMEP. WAFME10 blend of biodiesel has the highest BSEC due to high viscosity and low calorific values..

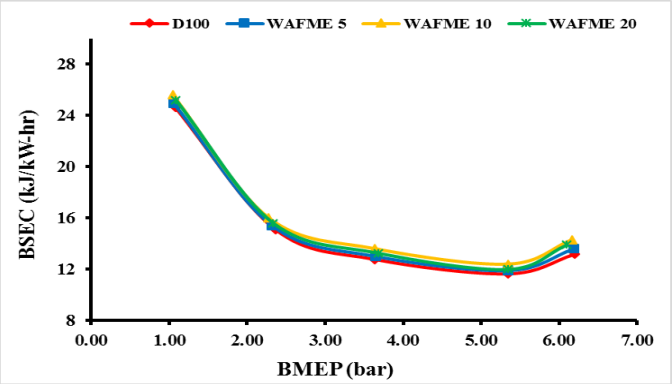

Figure 3 BSEC vs. BMEP

CABON MONOXIDE EMISSIONS

From figure 4 a decreased in CO emissions is observed due to the addition of the waste animal fat biodiesel in neat diesel. There is a decreased in CO for biodiesel fuel at higher loads. There is a decrement in the carbon monoxide due to decrement in viscosity and density of the fuel. And also there is a raise in volatility due to decreased in the density of the fuel.

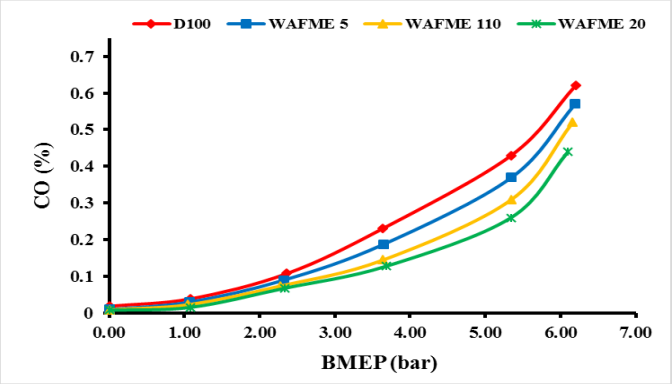

Figure 4 CO vs. BMEP

OXIDES OF NITROGEN EMISSIONS

Oxides of Nitrogen emissions gradually increases with BMEp. From figure 5 it is cleared that when the blending of biodiesel increase the NO_X emissions are also increases. The lower flash point and higher cetane number of biodiesel leads to proper combustion leading to formation of NOx. It is cleared that for NO_X emissions the combustion temperature and the load variations are the major factors.

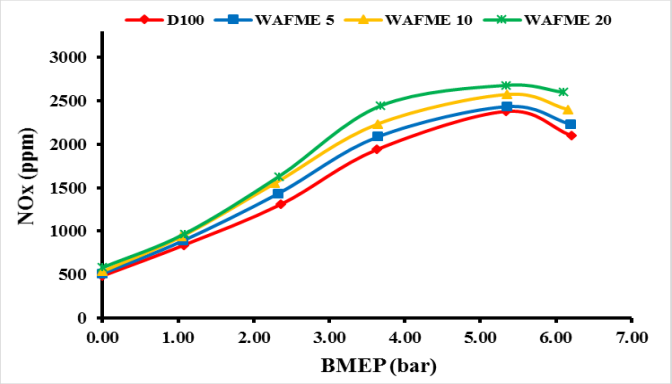

Figure 5 NO_X vs. BMEP

HYDRO CARBON EMISSIONS

In this figure, for the waste animal fat biodiesel there are some variations in the unburnt hydrocarbons. In this study it is cleared that when the blending percentage of waste animal biodiesel increases there is continuous decrease in HC emissions. The methyl ester addition contributed to stable combustion leads to decrease in HC at higher load as the engine runs at a slightly rich mixture the HC emission are found increasing with load.

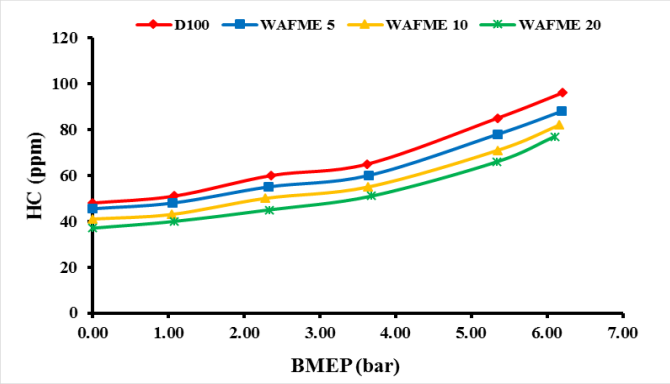

Figure 6 HC vs. BMEP

SMOKE OPACITY

From figure 7 it is found that the neat diesel under all load condition gives the maximum content in smoke level and the minimum smoke content is found in the WAFME20 blend. Availability of oxygen in biodiesel resulted in mixing of air and fuel leading to formation of diffusive flame. At higher load due to improper atomization of fuel resulting in higher sauter mean diameter of fuel droplet increasing ignition delay and cause high smoke formation.

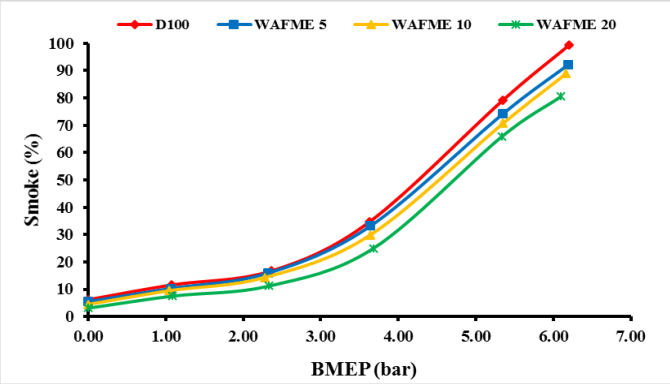

Figure 7 SMOKE OPACITY vs. BMEP

CONCLUSION

The outcomes of this examination demonstrated that the waste animal fat biodiesel is a manageable fuel for building nations like India.

- The maximum BTE was obtained with WAFME 10 blend. The brake thermal efficiency of WAFME 5 and WAFME 20 blend was higher in comparison to neat diesel fuel but

lower as compared to WAFME 10 blend. Thus it shows that the break thermal efficiency increased on blending.

- The brake specific energy consumption of WAFME 5 and WAFME 20 blend was maximum at low load but reduces at full load in comparison to WAFME 10.
- The minimum Carbon monoxide and hydrocarbon emissions were observed with the WAFME 20 blend.
- The NO_X emissions observed with WAFME 5 and WAFME 10 were higher as compared to neat diesel fuel.

After the current examination unmistakably waste animal fat biodiesel is expected as elective fuel for Diesel engines as per National Biodiesel Mission of India and abundance availability of animal fat feedstock.

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