PERFORMANCE AND EMISSION TEST OF CANOLA AND NEEM BIO-OIL BLEND WITH DIESEL

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Abstract – Biodiesel, which is derived from trans - esterification of vegetable oils (or) *animal fats, is composed of saturated and unsaturated long chain fatty acid alkyl esters. The acids present in vegetable oils are mainly responsible for the production of biodiesel. Biodiesel reportedly has number of technical advantages over petro-diesel especially on safety and environmental considerations. Coming to the diesel engines the best alternative fuel is biodiesel because it can used directly without changing the engine modification. The experiments has carried out to examine the properties of neem and canola biodiesel performance and emission of engines with different blends (B20 & B30) at different load conditions (0,3,6,9,12) and the results are compared with diesel. From the review it is found that the use of biodiesel leads to substantial reduction in HC, CO, PM, NOX and* CO_2 *emissions.*

Key Words: **Diesel, Engine, Biodiesel, Canola oil, Neem oil, Methanol, Trans-esterification etc.**

1. INTRODUCTION

In the present scenario the diesel engine plays a major role in transportation and industrial experiments. In the recent years the demand in energy has increased dramatically. The production of biodiesel, biodegradable and non-toxic fuel, extracted from vegetable oil is a substitute fuel for CI engine. Hence for smooth running the vegetable oil has to be converted into biodiesel by a process called trans-esterification. The biodiesel is having high flash and fire point temperatures than diesel fuels, so it is safest among all alternative fuels. This work involves the production of biodiesel from neem and mustard oils and testing this dual biodiesel blends in the diesel engine.

1.1 Diesel Engine

The diesel engine (also known as a compression-ignition or CI engine), named after Rudolf Diesel, is an internal combustion engine in which ignition of the fuel which is injected into the combustion chamber is caused by the elevated temperature of the air in the cylinder due to mechanical compression (adiabatic compression). Diesel engines work by compressing only the air. This increases the air temperature inside the cylinder to such a high degree that atomized diesel fuel that is injected into the combustion chamber ignites spontaneously. This contrasts with spark-ignition engines such as a petrol engine (gasoline engine) or gas engine (using a gaseous fuel as opposed to petrol), which use a spark plug to ignite an air-fuel mixture. In diesel engines, glow plugs (combustion chamber pre-warmers) may be used to aid starting in cold weather, or when the engine uses a lower compression-ratio, or both. The original diesel engine operates on the "constant pressure" cycle of gradual combustion and produces no audible knock.

1.2 Biodiesel

Biodiesel refers to a family of products made from vegetable oil or animal fats and alcohol, such as methanol or ethanol, called mono alkyl esters of fatty acids. Biodiesel can be used alone (or) blended with petro diesel in any proportions. Biodiesel blend can also be used as heating oil.

- 100% biodiesel is referred to as B100
- 20% biodiesel, 80% petro diesel is labelled B20
- 30% biodiesel, 70% petro diesel is labelled B30

Blends of 20% biodiesel and lower can be used in diesel engine without any modifications. Study shows that, on the mass basis, biodiesel has an energy content of about 12% less than petroleum based diesel fuel. It reduces unburned hydrocarbons (HC), carbon monoxide (CO), and increase oxides of nitrogen (NOx) than diesel-fuelled engine. It is a domestic, renewable fuel for diesel engine derived from natural oil like Neem and Canola (Mustard) oil. Using biodiesel as a vehicle fuel increases energy security, improves public health and the environment, and provides safety benefits.

2. METHODOLOGY

Straight vegetable oils used in engine lead to various problems like fuel filter clogging, poor atomization and incomplete combustion because of high viscosity, high density and poor non-volatility. Transformation of vegetable oils into biodiesel can be realized using trans - esterification process.

2.1 Trans-esterification of Neem Bio-oil

2.1.1 Acid esterification

100 ml of refined neem oil is poured into the flask and heated up to 60˚C. The 45% v/v methanol is added with the preheated neem oil and stirred for a few minutes. 0.5% of sulphuric acid is added with the mixture. Heating and stirring should continue about 45min at atmospheric pressure. After completion of this reaction, the mixture is poured into a separating funnel for separating the excess alcohol, impurities and sulphuric acid. The excess alcohol, sulphuric acid and impurities moves to the top layer and it's discarded. The lower layer is separated for further processing of transesterified into methyl ester. This process reduces the acid value of refined neem oil to less than 1% of FFA.

Fig-1: Separation of Neem Bio-oil

2.1.2 Alkaline trans-esterification

After acid pretreatment the esterified oil is taken in flask and heated up to 60˚C.1% of KOH is dissolved in 30% (6:1 M) methanol. The dissolved solution is poured into flask. The mixture is heated and stirred for 1hr.On completion of reaction; the mixture is poured into separating funnel over 12 hr. The glycerol and impurities are settled in lower layer and it's discarded. The impure biodiesel remain in upper layer. It contains some trace of catalyst, glycerol and methanol. The washing process can be done by the 3/4th of hot distilled water added with methyl ester and gently stirred. The upper layer is pure biodiesel and lower layer is drawn off.

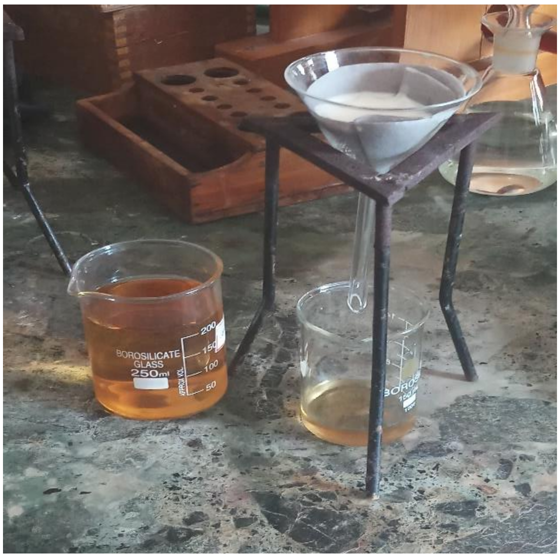

Fig-2: Filtration of final Neem Bio-oil

2.2 Trans-esterification of Canola Bio-oil

For the trans esterification of mustard oil, First 250 ml (90% pure) methanol was mixed with 150 ml (1 N) NaOH. This mixture was swirled in a glass container until NaOH is fully dissolved in methanol. As this is an exothermic reaction, so the mixture would get hot. This solution is known as methoxide, which is a powerful corrosive base and is harmful for human skin. So, safety precautions should be taken to avoid skin contamination during methoxide producing [10-15]. Next, methoxide was added with 1 liter of mustard oil, which was preheated about 55 degrees Celsius. Then the mixture was jerked for 5 minutes in a glass container. After that, the mixture was left for 24 hours (the longer is better) for the separation of glycerol and ester. This mixture then gradually settles down in two distinctive layers. The upper more transparent layer is 100% bio-diesel and the lower concentrated layer is glycerol. The heavier layer is then removed either by gravity separation or with a centrifuge. In some cases if the mustard oil contains impurities, then a thin white layer is formed in between the two layers. This thin layer composes soap and other impurities. Bio-diesel produced in the above process contains moisture (vaporization temperature 100 degree Celsius) and methanol (vaporization temperature 60 degree Celsius) and usually some soap. If the soap level is low enough (300 ppm - 500 ppm), the methanol can be removed by vaporization and the methanol will usually be dry enough to directly recycle back to the reaction. Methanol tends to act as a co-solvent for soap in biodiesel; so at higher soap levels the soap will precipitate as a viscous sludge when the methanol is removed. Anyway, heating the biodiesel at temperature above 100 degree Celsius would cause the removal of both the moisture and methanol as well.

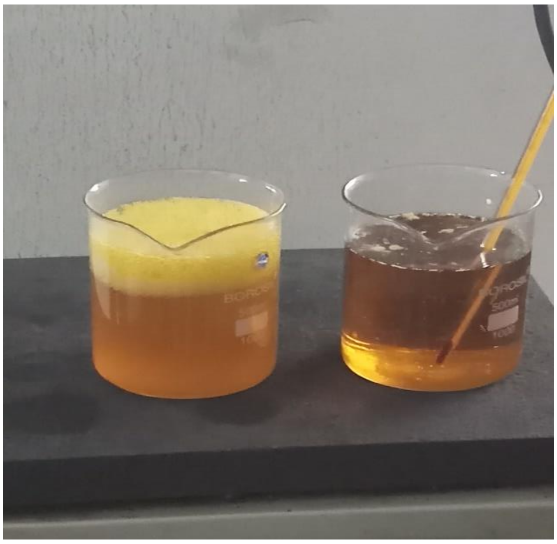

Fig-3: Heating of Canola Bio-oil

3. RESULTS AND DISCUSSION

The test were conducted to estimate the performance of 4 stroke diesel engine for different loads (0, 3, 6, 9 & 12) with biodiesel blends (B20 & B30) prepared by the trans-esterification process. Biodiesel blends are tested as per the biodiesel standard and used without making any changes in the engine. Performance parameters include specific fuel consumption and brake thermal efficiency. Emission contents like smoke density, HC, NO_x, CO and CO_2 are measured using smoke meter and five gas analyzer. These parameters are plotted against load and compared with pure diesel.

3.1 Performance characteristics

3.1.1 Brake Thermal Efficiency (BTE)

Brake thermal efficiency is defined as break power of a heat engine as a function of the thermal input from the fuel. It is used to evaluate how well an engine converts the heat from a fuel to mechanical energy.

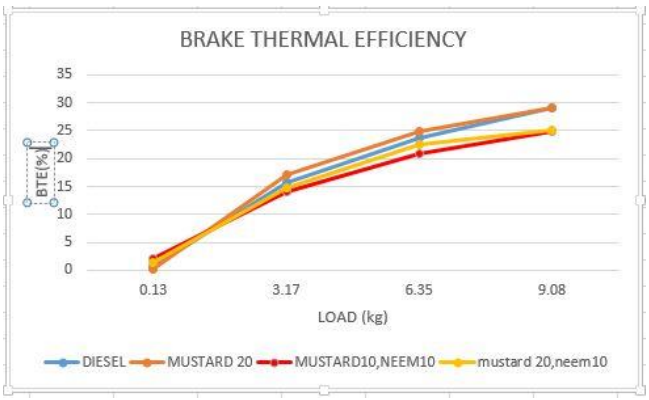

Fig-4: The variation of BTE with load

The figure-4 shows the brake thermal efficiency for different blends with minimum to maximum loads. It shows that the brake thermal efficiency gradually increased in mustard blend20 compared to diesel.

3.1.2 Mechanical Efficiency

Mechanical efficiency, is the parameter that gives the effectiveness of an engine in transforming its input energy to output energy. For an internal combustion engine, it is the ratio between the brake work and indicated work.

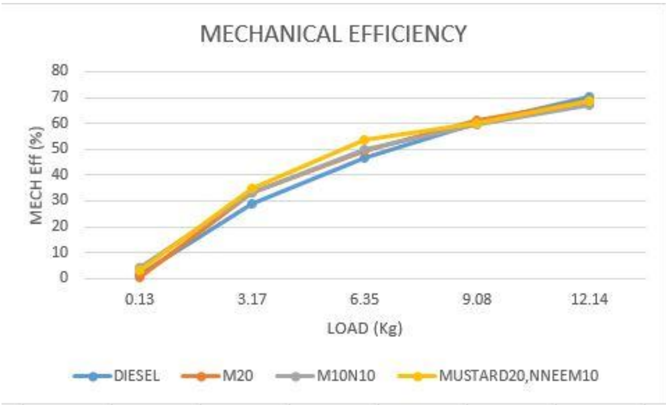

Fig-5: The variation of mech efficiency with load

The effect of mechanical efficiency is plotted in Figure-5 for varying loads with different blends. It was observed that mechanical efficiency constantly increased in all blends compared to diesel. From this graph analysis, B20 and B30 gives better mechanical efficiency instead of using diesel in IC engine.

3.1.3 Volumetric Efficiency

Volumetric efficiency in internal combustion is defined as the ratio of the mass density of the air-fuel mixture drawn into the cylinder at atmospheric pressure to the mass density of the same volume of air in the intake manifold.

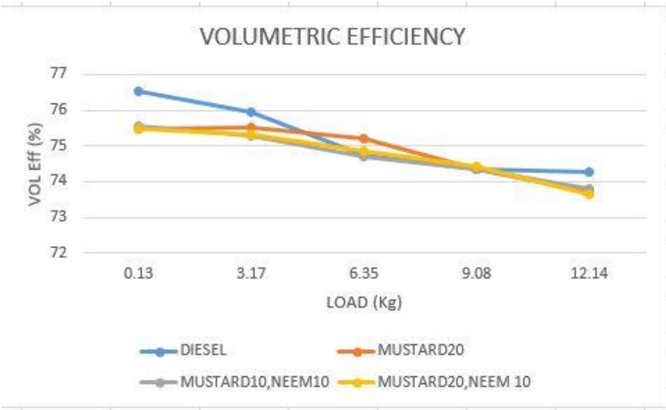

Fig-6: The variation of vol efficiency with load

The figure-6 shows that volumetric efficiency of all blends with various loads is somewhat similar to the diesel.

3.1.4 Specific Fuel Consumption

Specific Fuel Consumption (SFC) for an engine is defined as the amount of fuel that the engine needs to burn per hour to produce 1kw of brake power.

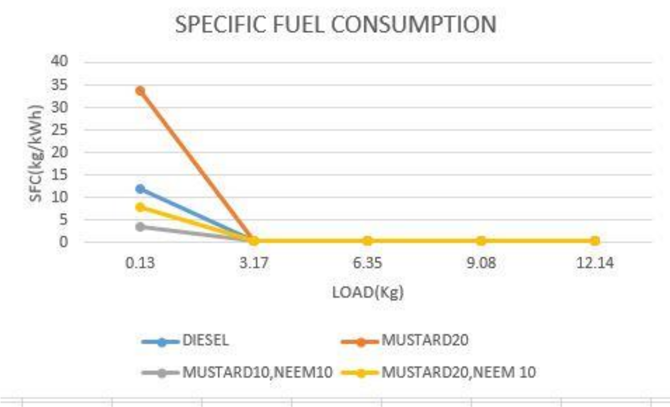

Fig-7: The variation of SFC with load

The variation of specific fuel consumption (SFC) is shown in figure -7. It shows that fuel consumption of biodiesel blends used in IC engine was decreased compared to diesel because of the injection of less quantity of biodiesel.

3.2 Emission Characteristics

3.2.1 Hydrocarbon Emission (HC Emission)

The variation of hydrocarbon emissions with load is shown in figure-8. The HC emissions depend upon mixture strength (i.e.) oxygen quantity and fuel viscosity in turn atomization. The HC emissions of biodiesel blends decreases gradually with varying the load compared to the diesel.

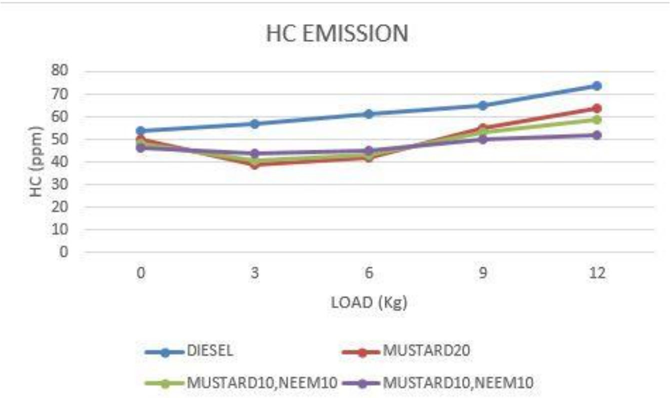

Fig-8: The variation of HC emission with load

3.2.2 Nitrogen Oxide Emissions

The variation of Nitrogen oxide emissions of the engine with diesel and biodiesels are illustrated in Figure-9. The NOx emission has been increased with increase in load on the engine for each diesel and biodiesel blends. These higher NOx emissions could be due to the higher exhaust gas temperature at higher loads as well as oxygen content of the biodiesel. The NOx emissions are slightly higher for both mustard and neem biodiesel blends as compared with pure diesel. But mustard biodiesel blends emit less amount of NOx compared to blend3 biodiesel.

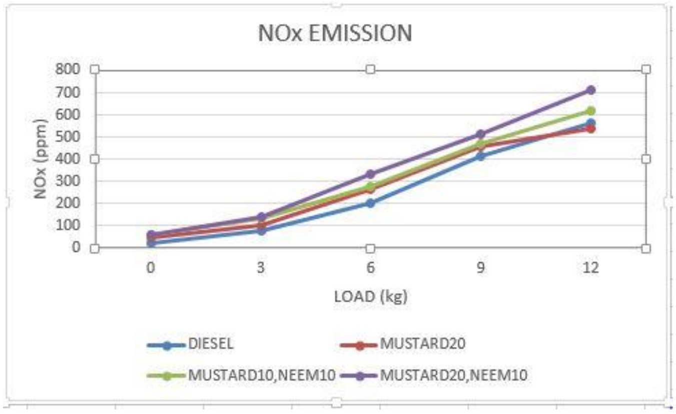

Fig-9: The variation of NOx emission with load

3.2.3 Carbon dioxide Emissions (CO_2 Emissions)

The variation of carbon dioxide emissions is illustrated in Figure-10. It has been observed that the CO2 emissions are inflated with increase in engine load for all fuel samples. The CO2 emission of the engine with diesel is higher than the Mustard and neem biodiesel. The lower CO2 emission of biodiesel compared to diesel is due to the presence of oxygen in biodiesel that helps in complete oxidization of fuel.

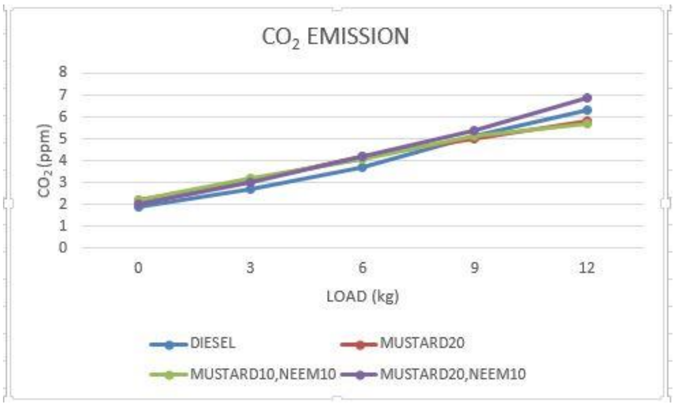

Fig-10: The variation of CO^2 emission with load

4. CONCLUSIONS

The analysis of performance and emissions characteristics of single cylinder diesel engine fueled with higher percentage of dual biodiesel blends have been examined and compared with pure diesel fuel. The followings are the conclusion made from the study:

- The brake thermal efficiency of the engine depends majorly on heating value and viscosity. The brake thermal efficiency of biodiesel blends is higher than the diesel. The mustard biodiesel blend having brake thermal efficiency higher than the blend2 (neem10 & mustard10) biodiesel.
- The mechanical efficiency is constantly increased in all blends compared to pure diesel.
- The CO2 and HC emissions of the engine with diesel fuel is lower than the biodiesel blends and the CO and HC emissions of blend2 (mustard10 & neem10) is lower than the mustard biodiesel blends.
- The NOx emission of the engine with diesel fuel is slightly higher than the biodiesel blends.

It is concluded that out of the three biodiesel blends, mustard20 biodiesel blends is best as compared with other blends and diesels interms of performance and emissions. So the mustard20 blend can be used as alternative fuel to diesel.

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