BIODIESEL AN ALTERNATIVE FUEL AND ITS EFFECTS ON ENGINE PERFORMANCES AND ENVIRONMENT

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INTRODUCTION:

The increase in international crude oil price and the concern on the effects of fossil fuel use on the environment made the world to focus on the use of biodiesel as a fuel. The resources of petroleum are decreasing day-by-day and the demands for fuels are increasing. Automotive industry relies mostly on petroleum to run their products. Diesel engines are widely used to power vehicles, engine-generator sets, aircraft ground support equipment and a number of other applications. Though diesel engines are highly efficient, the Particulate Matter (PM) and Hazardous Air Pollutant (HAP) produced by those engines are a major concern to the environment. So, there is a need to look for an alternative fuel which is non toxic and environment friendly. Biodiesel is one of the known alternative fuel. Biodiesel is biodegradable and renewable fuel. Currently knowledge about the impact of biodiesel on the performance of engines is limited.

BACKGROUND:

The performance of diesel engines can be improved by using biodiesel. The use of biodiesel is eco friendly and emission from it do not pollute the atmosphere. Biodiesel is a clean-burning fuel that can be used in compressed-ignition (CI) engines, and which is manufactured from the following renewable, non-petroleum based sources: virgin vegetable oils such as soy, mustard, canola, rapeseed and palm oils; Animal fats such as poultry offal, tallow, and fish oils; and used cooking oils and trap grease from restaurants can also be used. Biodiesel is a nontoxic, biodegradable, renewable fuel. Use of biodiesel produces less air pollutants and greenhouse gases. Biodiesel is produced in pure form (100% biodiesel or B100), but is usually blended with petro-diesel at low levels, between 2% (B2) to 20% (B20) in the U.S., but at higher levels in other parts of the world, particularly in Europe, where higher level blends up to B100 are used. Blends of biodiesel higher than B5 require special handling and fuel management as well as vehicle equipment modifications such as the use of heaters and changing seals/gaskets that come in contact with the fuel. The level of care needed depends on the engine and vehicle manufacturer. Biodiesel is a perfect fuel for buses and trucks.

Rudolf Diesel, the inventor of first compression-ignition (CI) engine, once said that “the use of vegetable oils for engine fuels may seem insignificant today but such oils may become, in the course of time, as important as petroleum and the coal-tar products of the present time.” He was indeed right because nowadays biodiesel is one of the greatest alternative sources of renewable fuel. The discovery of Transesterification of vegetable oil in 1853 by scientists E. Duffy and J. Patrick gave way to the invention of biodiesel fuel.

Rudolf Diesel’s prime model, a single 10ft iron cylinder with a flywheel at its base, ran on its own power for the first time in Augsburg, Germany on August 10, 1983. In remembrance of this event,

August 10 has been declared "International Biodiesel Day." This engine stood as an example of Diesel's vision because it was powered by peanut oil – a biofuel, though not biodiesel, since it was not transesterified. He believed that the utilization of biomass fuel was the real future of his engine.

In 1979, more than a century later after the discovery of the first transesterification of vegetable oil, South Africa initiated the use of transesterified sunflower oil, and refined it to diesel fuel standards. By 1983, the process for producing fuel quality, engine-tested biodiesel was completed and published internationally. An Austrian company, Gaskoks, adopted the technology from the South African Agricultural Engineers; the company erected the first biodiesel and the first industrial-scale plant in April 1989.

In September of 2005 Minnesota became the first U.S. state to mandate that all diesel fuel sold in the state contain part bio-diesel, requiring a content of at least 2% biodiesel.

Basic production process:

Most of the biodiesel produced today is done with base catalyzed reaction because of temperature and pressure process, it yields high conversion (98%) with minimal side reactions and reaction time it is a direct conversion to biodiesel with no intermediate compounds, and no exotic materials of construction are needed.

The most important aspects in the production of biodiesel for trouble free operation in diesel engines are: Complete reaction, removal of Glycerin, removal of Catalyst, removal of Alcohol, and absence of free Fatty Acids.

Vegetable oils cannot be used directly in CI engines in its pure form due to their low volatility and diffusibility but higher viscosity and density. When tests were performed on an engine, it was found that all of the vegetable oils had operational and durability problems when subject to long term usage. These problems can be eliminated by using an effective method known as tansesterification. The various characteristics of bio-oils from safflower oil were identified under different pyrolysis conditions. It was found that bio-oils from safflower were an environmentally friendly feedstock candidate for bio fuels and chemicals. This statement is based upon a case study found in the literature. In that case study biodiesel from safflower seed oil was used as fuel in the engine. Safflower seed oil is chemically processed by the transesterification reaction under methanol and NaOH environment to obtain biodiesel. The biodiesel was used in a single cylinder, four stroke diesel engine and performance and emission tests were performed experimentally. The test results were taken as a reference to explain the biodiesel effects on engine performances and emissions.

Experimental setup:

Experiments were carried out in engine test laboratory. Tests were performed on a single cylinder, four stroke, air cooled engine. Engine tests were conducted on a BT-140 model hydraulic dynamometer. An infrared measurement device was used to specify exhaust gas temperature. The fuel consumption was measured with burettes with 50 and 100 ml volumes and a stopwatch. Bsfc was calculated through the following equation.

$$Bsfc = V.\ \rho.3600/pe$$

Where "Bsfc" is the brake specific fuel consumption, "V" is the flow rate of the fuel as cm^3/sn, "ρ" is the density of the fuel as g/cm^3 and "pe" is the brake power as g/KWh.

Effect of biodiesel on engine power:

Properties of biodiesel, especially heating value, viscosity, lubricity have an important effect on engine power. The extensive study of literature shows that with biodiesel especially with pure biodiesel, engine power will drop due to the loss of heating value of biodiesel. The test results show that the maximum torque values were observed around 1600 rpm of engine for all test fuels including D2

fuel. The power and torque values for D2 fuel was found higher than the biodiesel blends.

Effect of biodiesel on engine economy:

In an engine fuelled with biodiesel, more fuel should be consumed to compensate the loss of heating value of biodiesel. Engine fuel consumption will increase with increasing content of biodiesel. Therefore, fuel consumption is higher for a biodiesel engine. The lower heating value, higher density and higher viscosity play primary role in engine fuel consumption for biodiesel

Effect of biodiesel on durability of engine:

The aspects that should be concentrated to check the durability of a biodiesel engine are carbon deposit, engine wear and problems in fuel system. Soot formations during combustion of fuel in the engine and fuel oxidation are related to the carbon deposits. Biodiesel has the lower soot formation and thus reduces the particulate matter (PM) emissions.

Effect of biodiesel on emissions:

When a fuel ignites and undergoes combustion, a number of combustible products are released to the atmosphere. They react with the oxygen in air. These combustible products are harmful to the environment. There is a need to look for a fuel which is eco-friendly and causes the reduction in the release of harmful combustible products.

Effect of biodiesel on Particulate Matter (PM) emissions:

Use of biodiesel instead of diesel causes the reduction in PM emissions. It is clear that the PM emissions decrease with the use of biodiesel. PM emissions decrease with the increase in the percentage of biodiesel in the blend. Oxygen content in biodiesel is the main reason for the reduction in PM emissions. The oxygen molecules content in biodiesel enable more complete combustion and promote oxidation of already formed soot. lower as the engine attains higher speed. With increase in engine speed, there will be an increase in turbulence

Effect of biodiesel on Nitrogen Oxides (NOx) emissions:

Majority of the studies in literature believe that the use of pure biodiesel causes the increase in NOx emissions. The effect of biodiesel derived from safflower oil and diesel fuel on NOx emissions is shown in the fig. 1.

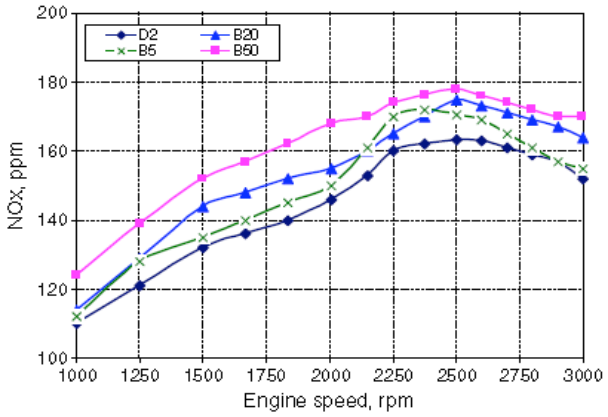

Fig. 1. Variation of NOx emissions for biodiesel blend and diesel fuels with engine speed.

Effect of biodiesel on Carbon monoxide (CO) emissions:

Based upon a thorough study of literature it is believed that carbon monoxide (CO) emissions are reduced by using biodiesel in place of diesel.

It is seen that the lowest CO emissions were found for B50 fuel. There are many factors that are responsible for the reduction in CO emissions by using biodiesel. CO emissions tends to reduce with the increase in the content of biodiesel in the blend. With the increase in the content of biodiesel, the oxygen content increase and thus leads to the reduction in the amount of CO emissions.

Effect of biodiesel on Hydrocarbon (HC) emissions:

Many studies reported in literature show that Hydrocarbon (HC) emissions reduce by using biodiesel instead of diesel. HC emission is an organic compound which forms due to incomplete combustion. HC emissions are formed due to

incomplete combustion or due to the lack of oxygen content in the fuel. The exhaust gases contain different hydrocarbon compounds. It is seen that B20 and B50 fuels had higher HC emissions.

Effect of biodiesel on CO2 emissions:

The presence of higher levels of CO2 in the atmosphere lead to green house effect. Use of conventional fuels releases more amount of CO2 to the atmosphere. So, there is a need to find an alternative fuel to reduce the CO2 emissions. Many authors show that the biodiesel resulted in fewer CO2 emissions when compared to diesel during complete combustion due to lower carbon to hydrogen ratio. Biodiesel is a low carbon fuel. Study of wide variety of literatures proves that, biodiesel will cause 50-80% reduction in CO2 emissions when compared to petroleum diesel.

Economic Feasibility:

Without any type of federal subsidy biodiesel is expensive than diesel. Though the cost of biodiesel is more than diesel fuel, increase in the demand for biodiesel production can gain significant profits in near future. As diesel fuel has to be imported from other countries and is becoming expensive day-by-day, biodiesel can become competitive for conventional diesel fuel. Biodiesel can be produced locally which means there will be reduction in the use of imported oil, which is supplied by potentially unstable Middle Eastern suppliers. Though soybean oil is expensive than petroleum, its use has significant economic benefits. Biodiesel production facilities provide employment opportunities. To overcome the raw material cost problem, production of biodiesel manufactured from yellow grease which is a food service waste product, is greatly expanded. At present yellow grease is available at low to no cost. Mostly, restaurants are required to pay for the disposal of their yellow grease. At present, government should provide some federal and state subsidy for biodiesel to become economically feasible.

CHALLENGES:

The major challenges that the use of biodiesel as a fuel presents are listed below are: an increase in the content of NOx emissions, biodiesel engines face operational problems, storage and handling of biodiesel is difficult, price of vegetable oil is dependent on the feed stock price, feed stock homogeneity, continuous availability of vegetable oils must be assured, and the conclusions are inconsistent for different blends.

CONCLUSIONS:

In conclusion it can be said that, with the use of biodiesel, there will be a reduction in the engine power, there will be an increase in fuel consumption of the engine, durability of engine can be improved by using biodiesel because, there will be lower soot formation, and high lubricity when compared to conventional diesel fuel, biodiesel can make the vehicle perform better, emissions such as Particulate Matter (PM), Hydrocarbon (HC), Carbon Monoxide(CO), Carbon dioxide (CO_2) can be reduced, biodiesel is environmental friendly, and Biodiesel is energy efficient, and biodiesel is produced locally and is more cost efficient.

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