

# Studying Effects of Alternative Biodiesel Fuel in Performance and Pollutants of Diesel Engines

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**Abstract**—Since injection engines have a considerable portion, in consumption of energy and environmental pollution, using an alternative source of energy with lower pollutant effects in this regard is necessary.

Biodiesel fuel is a suitable alternative for gasoline in diesel engines.

In this research the property of biodiesel, the function and the pollution effects of diesel engine, when using 100% biodiesel, using 100% gasoline and mixing ratio of both fuels for comparing them, have been investigated.

The researches have shown, using biodiesel fuel in prevalent diesel engine, will reduce the pollutants such as CO, half burned carbohydrate and suspended particles and a little increase in oxidation will achieve while power consumption, particularly fuel and thermal efficiency of diesel fuel has the same.

**Keywords**—Biodiesel, Diesel Engine, Environment, Gasoline

## I. INTRODUCTION

INCREASING daily usage of fossil fuels, increasing the price of oil products, shortage of available resources and environmental pollution, have been encourage the researchers for finding new sources of energy prefer encouraging non fossil fuels.

Since the transportation system have a considerable portion in energy consumption and environmental pollution, using the alternative source with low pollution it's necessarily in this section.

Most of the alternative fuels are renewable and can be reduce from natural resources; therefore it will decrease the dependence to petroleum.

The various forms of alternative fuels are: biodiesel, ethanol, methanol, propanol, natural gas, hydrogen, electricity and p serial fuels.

In Iran because of the increasing growth in liquid fuels consumption, that yearly may cost big expense to general budget, damage to environment, and with the concern to technical economy aspects and vast sources for some of the

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replacing fuels, researches in this regard and consumption of these source of fuels have become significantly important. Biodiesel is the following alkyl esters and can be obtained by exchange of animal facts and vegetable oils.

Radolf diesel (1900) invented the first diesel engine that worked with vegetable oil. In 1911 the proposed that diesel engine can be supplied with vegetable oil and significantly can help improving the agronomy of countries using it.

Today consumption of biodiesel in world has approved the prediction of Radolf diesel in 1911[2].

In this research we investigate the advantage and disadvantage of using vegetable oils, biodiesel and applied results of using biodiesel, gasoline and mixtures of gasoline with biodiesel in diesel engines.

## II- CONSUMPTION OF VEGETABLE OILS AND MIXING IT WITH GASOLINE IN DIESEL ENGINE

### A-Property of Vegetable Oils

Kinetic viscosity of vegetable oil will change between 30-40 cSt in 38°C. Molecular weight of vegetable oil is 20 times bigger than gasoline molecular weight in 600-900. Flash point of vegetable oils are very big over (>200 °C) and heat value of them are 39-40 MJ/kg compare with gasoline 45 MJ/kg. The presence of oxygen band in vegetable oils will reduce the heat value up to 10% and cetane number 32-40[2]. Mixture of vegetable oils with gasoline will repair various problems in diesel engines, which had been worked with pure vegetable oil before.

Problems using pure vegetable oil in diesel engines:

- Different spray and atomization and combustion characteristic from gasoline.
- Weak atomization during fuel spray because of high viscosity of oil.
- Incomplete combustion and high producing pollutants because of inadequate mixture of oil and air.
- Low volatility because of high temperature of flash point that may result in point.
- High temperature of pour point and cloud point that may
- Dilution of lubricant.
- Increasing sediment of carbon.
- Nozzle of injector.

If vegetable oils changes to biodiesel (that have the gasoline characteristic) by chemical reaction, these problems may solve [1].

### B- APPLIED PROPERTIES AND POLLUTION OF PURE VEGETABLE OILS IN DIESEL ENGINE

Researches shows that when diesel engines are working with pure vegetable oil they have equal potential with gasoline because handling the mass energy of vegetable oil will increase because of high density and high viscosity. Because of the low specific mass heat value in vegetable oils, therefore for stabilizing PM and pollutant particles of CO the input energy to engine require a high mass flow of fuel. The reports [12] show that the biggest disadvantage of vegetable oils is their natural high viscosity. High viscosity may results in weak fuel atomization, in complete combustion, injector obstruction, carbonization of rings and accumulation of fuel in oil lubricating. One method to solve these problems and improving the efficiency is to decrease the vegetable oil viscosity with mixing vegetable oil with gasoline; therefore less manipulation and changing diesel engine are required.

### C- THE FUNCTIONAL PROPERTY AND POLLUTION OF VEGETABLE OIL AND GASOLINE MIXTURES IN DIESEL ENGINES

Mixtures of 25% vegetable oil with 75% of gasoline, 50% of vegetable oil with 50% of gasoline, and 75% vegetable oil with 25% of gasoline, 100% pure vegetable oil as a fuel in diesel engine(model Lister-Petter TS2), 12 air cooling cylinder have been used.

The results have been shown in Fig. I, II, III, and IV. Species properties of gasoline and mixtures of gasoline and vegetable oils have been shown in Table I. Pure gasoline in compare with other mixtures of gasoline with vegetable oils has the highest heating value and the lowest viscosity. It has been observed that the highest percentage of vegetable oil in mixture will increase the viscosity and decrease heating value. Pure vegetable oil has the lowest heating value and the highest viscosity. pollutants CO ( Fig. I) for vegetable oil and mix it in full on less gasoline and low loads is a little higher than gasoline. Also, carbon dioxide (Fig. II) than vegetable oil and diesel fuel mixtures that this may be due to oxygen oil and diesel fuel than vegetable oil mixtures that this may be because vegetable oil is oxygenated. Unburned hydrocarbon (HC) (Fig.III) pollutants in time for minor types of vegetable oil mixtures are lower than gasoline, and loads more on this subject because of increased availability of relatively low-oxygen reaction, when fuel loads more engine cylinder engine is broken, is.  $\text{No}_x$  pollutants (Fig. IV) in vegetable oils and its mixture with gasoline is lower than pure gasoline fuel, because of there other heat value that it's most important characteristic of vegetable oil.

TABLE I  
PROPERTIES OF FUELS [7]

Fuel	High Heating Value(Mj/kg )	Poise	Relative Density
100% Gasoline	405.357	0.0445	0.850
25% Vegetable oil+ 75% Gasoline	43.288	0.087	0.877
50% Vegetable oil+ 50% Gasoline	42.158	0.162	0.890
75% Vegetable oil+ 25% Gasoline	40.841	0.367	0.907
100% Vegetable oil	39.358	0.669	0.927

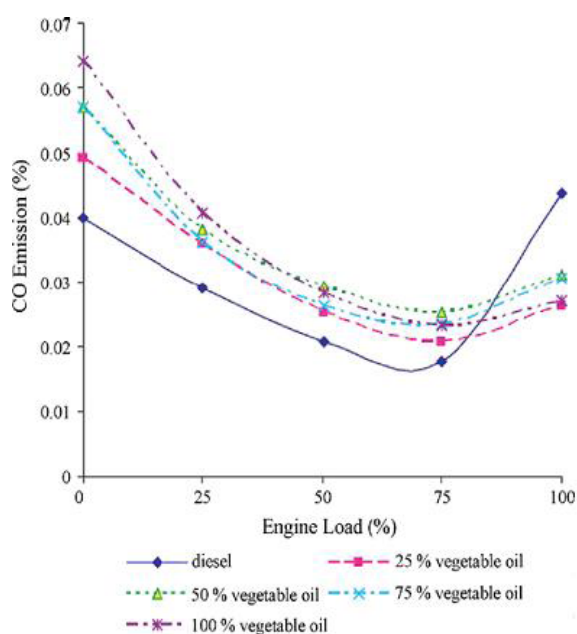


Fig. 1 Variation of CO pollutant with loading engine for different fuels [7]

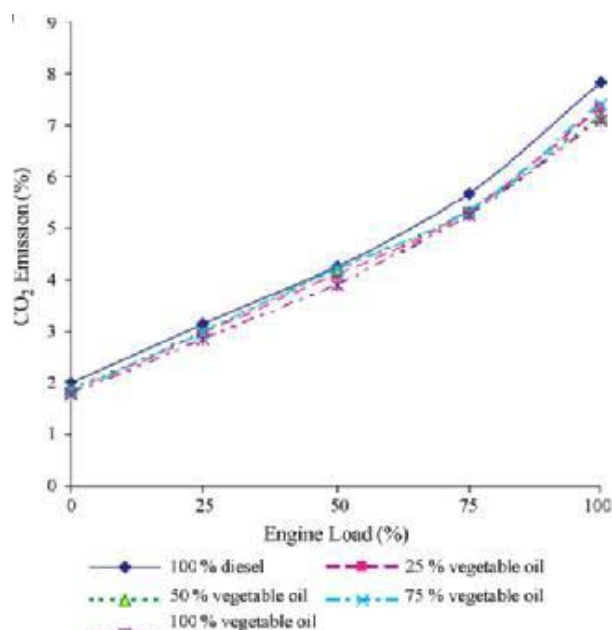


Fig. 2 Variation of CO<sub>2</sub> pollutant with loading engine for different fuels [7]

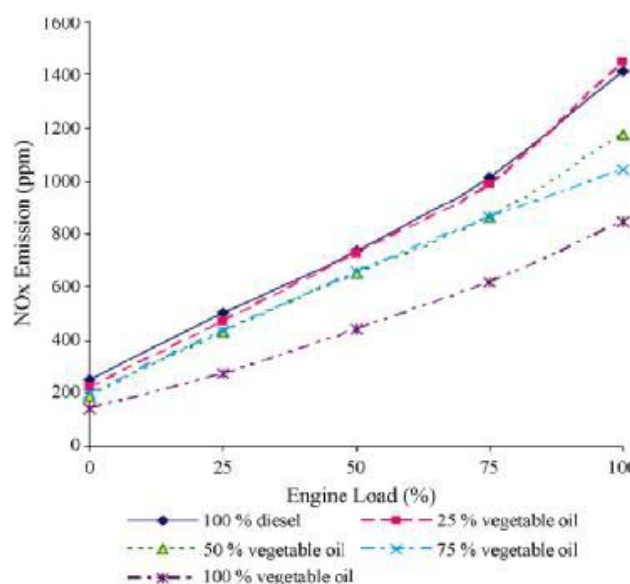


Fig. 4 Variation of NO<sub>x</sub> pollutant with loading engine for different fuels [7]

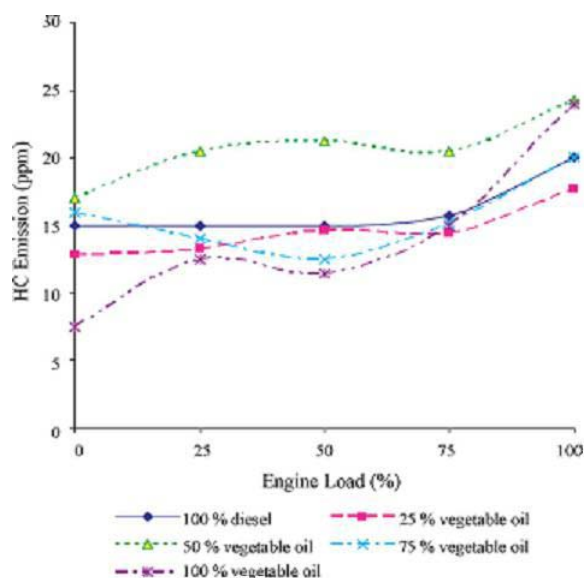


Fig. 3 Variation of HC pollutant with loading engine for different fuels [7]

### III- USING BIODIESEL AND ITS MIXTURES WITH GASOLINE IN DIESEL ENGINES

#### A-Biodiesel Producing

Generally the vegetable oil consists of 97% triglycerides 3% mono and diglycerides and free fatty acid. Segregation process of all glycerol and fatty acids of vegetable oil in the presence of catalyst is named esterification. Vegetable oils in the presence of catalysts like KOH and NaOH will react with methanol and will produce esterify vegetable oils [7].

#### B- Biodiesel Characteristic

Vegetable oils consist of fatty acids with different chain. Biodiesel characteristic is significantly depending on its fatty acid chain that is used for esterification. Because of its higher viscosity compare with gasoline, it has better lubricating property. Adding biodiesel to gasoline because of its lubricating property will reduce the abrasion engine and will increase the life time of fuel spray system [5]. Heating value of biodiesel is near 37.27Mj/lit, that it's, 9% lower than gasoline [4], it doesn't mix with water it has high boiling point and low stem pressure. Its flash point is higher than 130 °c while for gasoline the flash point is about 64°c [6], and its density is 0.88gr/cm<sup>3</sup>. Biodiesel is free from sulfur and have 10-12% weight percent of oxygen.

Advantage of biodiesel is:

- Non- toxin
- Mixture of biodiesel and gasoline will increase the engine efficiency.
- Because of its higher flash point it's more suitable and safety for storage.
- It's a renewable source of energy.
- The danger of cancer will be reducing up to 90%.
- It doesn't have any green house effects because the CO<sub>2</sub> pollutant that its produce is equal to CO<sub>2</sub> that is absorbate by the vegetable oil plant.
- It doesn't have any sulfur, so it's suitable with European pollutant standards. It doesn't have any sulphat oxide either, because it has oxygen, therefore the diffusion of PM is less too.
- Biodiesel doesn't have any kind of PAH (poly cyclic aromatic hydrocarbon), therefore pollutants such

as PAH and nitro PAH in compare with gasoline is very low.

- Gasoline consists of aromatic compounds that will diffuse PM and NO<sub>x</sub> [7].

Disadvantage of biodiesel:

- A little decrease in fuel economy (near 10% for pure biodiesel).
- The density of biodiesel in cold weather is higher than gasoline and in subfreezing condition we need to mix it with gasoline.
- It is expensive because low produce of vegetable oil [7].

#### C-THE APPLIED CHARACTERISTIC AND POLLUTION OF BIODIESEL AND ITS MIXTURES WITH GASOLINE IN DIESEL ENGINE

Mixture of biodiesel with gasoline is express with B-n that n represents [9] the percentage of biodiesel in the mixture. Reports show that producing moment B-20 and B-40 because of the complete of fuel is higher than gasoline.

In B-60 and B-100(pure biodiesel) near 4-23% of moment will reduce comparing with gasoline.

Brake specific fuel consumption for B-20 and B-40 is 0.8-7.4% lower than gasoline and in B-60 and B-100 is 48% higher because of the reduction in heat value in mix fuels.

The B-20 and B-40 brake heat efficiency is 26.79 and 29.19% respectively, that's higher than 24.64% for gasoline. The maximum brake efficiency in B-60 and B-80 and B-100 is 24.26, 23.69 and 27.72 respectively. This behavior is due to reduction in thermal energy and increase in fuel consumption, in compare with B-100 [10].

Reports [2, 9, 10, and 11] show that, UBHC, CO, CO<sub>2</sub> pollutants in biodiesel and its mixtures have been reduced, due to better combustion because of the presence of oxygen molecule in its structure. Reports [10] show that NO<sub>x</sub> pollutants in biodiesel and its mixtures will increase because of the higher temperature in combustion chamber.

For reducing NO<sub>x</sub>, the engine can work in 2 fuel level for example with high octane number as a main fuel and fuel with high cetane number as pilot fuel. Vegetable oils have high cetane number (40-45) and will be a standard spray system. The main fuel that has a high octane number goes into the engine with entering air. This method will reduce NO<sub>x</sub>, but CO and HC will increase. From exhaust gas recirculation (EGR) the NO<sub>x</sub> pollutants will reduce up to 50% [8].

- Adding a little biodiesel to gasoline, it's a suitable strategy for increasing the efficiency in consumption of replacing fuel at least in agricultural engine.
- B-20 is the best replacing fuel for diesel engine.

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#### IV- CONCLUSION

- Brick thermal efficiency in B-20 biodiesel will a little increase.
- BSFC in B-20 will a little decrease.
- In biodiesel and its mixtures PAH, HC, CO, CO<sub>2</sub> pollutants will decrease.
- NO<sub>x</sub> pollutant in biodiesel and its mixtures will increase and we can reduce it by EGR or double fuel system.