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Azadirachta Indica as an Alternative Fuel for CI Engines- A Review.

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***Abstract*— Fuel crisis and environmental concerns have led to look for alternative fuel of bio origin successes such as vegetable oils, which can be produced from forests, vegetable. The effect of neem bio-diesel and its blending with pre- mineral diesel on different types of diesel engine combustion, performance and emission compared with this papers .The result shows that blending of bio-diesel of 20x shows better break thermal efficiency lower specific fuel combustion and less exhaust gas temperature while found less carbon monoxide, nitrogen oxide and hydrocarbons emission. This research paper also compares the experimental results carried out by different researches to evaluate break power, specific fuel consumption and exhaust gas emissions. When running on different engines with fuel additive blended with bio-diesel it is found that B20x produces higher performance with less exhaust emissions and fuel consumption as compared to blended diesel and mineral diesel.**

***Index Terms*— Biodiesel, Emissions, Azadirachta indica, Performance.**

I. INTRODUCTION

The world has been confronted with energy crisis due to the decrease of fossil fuel resources and the increase of environmental restrictions. Therefore attention has been focused on developing the renewable or alternate fuels to replace the petroleum based fuels for transport vehicles. There are several alternative sources of fuel like vegetable oils, biogas, biomass, primary alcohols which are all renewable in nature. Among these fuels, vegetable oils appear to have an exceptional importance as they are renewable and widely available, biodegradable and non-toxic, and environmental friendly. In agriculture-based country, like India, the use of vegetable oils has to be identified and initiated in order to prevent environmental degradation and reduce dependence on imported fossil supplies by partially replacing them with renewable and domestic sources. A great deal of research has been conducted on their feasibility and the researchers have concluded that neat vegetable oils hold promise as alternative fuels for Diesel engines for short-term use [1-4]. However researchers have reported that the use of neat vegetable oil causes engine-related problems. High viscosity, low volatility, and poor cold flow conditions of these fuels cause severe engine deposits, injector coking, piston ring sticking, and difficulty in starting especially in cold weather.

Globally, there are many efforts to develop and improve vegetable oil properties in order to approximate the properties of diesel fuels. It has been remarked that high viscosity, low volatility and polyunsaturated characters are the mostly associated problems with crude vegetable oils. These problems can be overcome by four methods; pyrolysis, dilution with hydrocarbons blending, Microemulsion, and transesterification [5-8]:

A. *Pyrolysis (thermal cracking)*

Pyrolysis is the thermal decomposition of the organic matters in the absence of oxygen and in the presence of a catalyst. The paralyzed material can be vegetable oils, animal fats, natural fatty acids or methyl esters of fatty acids. Many investigators have studied the pyrolysis of triglycerides to obtain suitable fuels for diesel engine. Thermal decomposition of triglycerides produces alkanes, alkenes, alkadines, aromatics and carboxylic acids. It has been observed that pyrolysis process is effective, simple, wasteless and pollution free [9]. According to Sharma et al. [10], pyrolysis of the vegetable oil can produce a product that has high cetane number, low viscosity, acceptable amounts of sulfur, water and sediments contents, acceptable copper corrosion values. However, ash contents, carbon residues, and pour points were unacceptable.

B. *Dilution*

Mainly, vegetable oils are diluted with diesel to reduce the viscosity and improve the performance of the engine. This method does not require any chemical process. Singh and Singh [9] reported that substitution of 100% vegetable oil for diesel fuel is not practical. However a blend of 20% vegetable oil and 80% diesel fuel was successful. The use of blends of diesel fuel with sunflower oil, coconut oil, African pear seed, rice bran oil, PP (Pistachia Palestine), waste cooking oil, palm oil, soybean oil, cottonseed oil, rubber seed oil, rapeseed oil, J. curcas oil, P. pinnata oil. For instance, Ziejewski et al. [11] investigated the effects of the fuel blend of 25% sunflower oil with 75% diesel fuel (25/75 fuel) in a direct injection diesel engine. The authors found that this blend is not suitable for long-term use in direct injection engines. This is because the viscosity at 313 K was 4.88cSt (maximum specified ASTM value is 4.0cSt at 313 K).

Generally, direct use of vegetable oils and their blends have been considered to be difficult to use in both direct and indirect diesel engines.

C. *Micro-emulsion*

A micro-emulsion is defined as a colloidal equilibrium dispersion of optically isotropic fluid microstructure with dimensions generally into 1–150 nm range formed spontaneously from two normally immiscible liquids and one and more ionic or more ionic amphiphiles. Micro-emulsions using solvents such as methanol, ethanol, hexanol, butanol and 1-butanol have been investigated by many researchers. Micro-emulsion with these solvents has met the maximum viscosity requirement for diesel fuel. It has been demonstrated that short-term performances of both ionic and non-ionic micro-emulsions of aqueous ethanol in soybean oil are nearly as well as that of No. 2 diesel fuel [12].

The fuel properties of the liquid product fractions of the thermally decomposed vegetable oil are likely to approach diesel fuels. Soybean oil pyrolyzed distillate had a cetane number of 43, exceeding that of soybean oil (37.9) and the ASTM minimum value of 40. However, the viscosity of the distillate was 10.2 mm^2/s at 311 K, which is higher than the ASTM specification for No. 2 diesel fuel (1.9–4.1 mm^2/s) but considerably below that of soybean oil (32.6 mm2/s) [12].

D. *Transesterification (alcoholysis)*

As said, Transesterification is the conversion of one ester into another, i.e. a glycerine ester into an alkyl ester in the case of bio diesel where methanol replaces the glycerine. The bio diesel molecule is indeed smaller and less complex. Bio diesel has lower viscosity than raw vegetable oil because the Transesterification process shortens the carbon length of the fatty acid molecules in the oil Transesterification converts the triple chain triglyceride vegetable oil molecule to three single chain methyl ester molecules, but the chain lengths of the fatty acids themselves remain the same. The fatty acids composition of the bio diesel depends on the feed stock and is changed by Transesterification. Transesterification process converts triglycerides esters into alkyl esters (bio diesel) by means of a catalyst (KOH) and an alcohol reagent (usually methanol, which yields methyl esters bio diesel). In Transesterification the triglyceride molecule is broken into three separates methyl esters molecules plus glycerine as a by-product. Triglycerides are esters, esters are acids such as fatty acids combined with an alcohol, and glycerine is a heavy alcohol. The catalyst breaks the bond holding the fatty acid chains to the glycerine, fatty acid chain then bond with the methanol. [13]

Transesterification process happens in three stages. First, one fatty acid chain is broken off the triglyceride molecule and bonds with methanol to form a methyl ester molecule, leaving a diglyceride molecule (two chains of fatty acids bound by glycerine). Then a fatty acid chain is broken off the diglyceride molecule and bonded with methanol to form another methyl ester molecule, leaving a monoglyceride molecule. Finally the monoglycerides are converted to methyl esters. [14]

Azadirachta indica oil → Methanol Methyl ester + glycerin &soap
(Trans fatty acids) (Bio-Diesel)

It has been reported that dilution of vegetable oils with such materials as diesel fuels, a solvent or ethanol produced heavy carbon deposit on the inlet valves and showed a considerable top ring wear. Thermal cracking refers to a chemical change caused by the application of thermal energy in the presence of air or nitrogen sparge. The viscosity of pyrolysed vegetable oil is reduced, but still exceeds the specified value of 7.5 cSt. The pyrolysed vegetable oils contain acceptable amounts of sulphur, water and sediment, but unacceptable ash, carbon residue amounts and pour point. Engine testing on pyrolysed oil has been limited to short-term tests. It has been reported that the engine tests on microemulsion consisting of vegetable oil: methanol: 2-octanol: cetane improver indicate the accumulation of carbon around the orifices of the injector nozzles and heavy deposits on exhaust valves. It has been reported that dilution of vegetable oils with such materials as diesel fuels, a solvent or ethanol produced heavy carbon deposit on the inlet valves and showed a considerable top ring wear. Hence, out of these, transesterification is the most popular and best way to use neat vegetable oils [14].

II. PROPERTIES OF AZADIRACHTA INDICA OIL

Physical and chemical properties of Azadirachta indica oil, Azadirachta indica methylester and conventional diesel are presented in Table 1 .The fuel properties of Azadirachta indica biodiesel were within the limits and comparable with the conventional diesel. Except calorific value, all other fuel properties of Azadirachta indica biodiesel were found to be higher as compared to diesel [15].

Properties	Diesel	Azadirachta indica Oil	Azadirachta indica BioDiesel
Density(kgm^{-3})	830	912-965	820-940
Viscosity(cSt)	4.7	20.5-48.5	3.2-10.7
Flashpoint(C)	60	214	120
Cetane number	45	31-51	48-53
Calorific value($MJkg^{-1}$)	42	32-40	39.6-40.2
Sulphur (ppm)	0.042	1990	473.8
Iodine value	-	65.80	-
Titre(C)	-	35-36	-
Fire point(C)	65	222	128
Pour point(C)	-16	10	2
Cloud point(C)	-12	19	9
Total glycerine (%)	-	-	0.26
Free glycerine (%)	-	-	0.02
Carbon residue(%mass)	0.17	-	0.105
Water content (%)	0.02	0.098	0.036

Table: 1

Azadirachta indica oil can be used as fuel in diesel engines directly and by blending it with methanol. The economic evaluation has also shown that the biodiesel production with a high calorific value matches diesel. Its blends with diesel substituting nearly 35% of the later have been suggested for use without any major engine modification and without any worthwhile drop in engine efficiency. Engine tests with Azadirachta indica oil and Azadirachta indica biodiesel were done in India and Bangladesh, showing satisfactory engine performance. Yield of biodiesel from different non-edible oils (Jatropha curcas, Pongamia pinnata, Madhuca Indica and Azadirachta Indica) which are commonly available in India were examined and the results recommended the biodiesel production from Azadirachta Indica oil on the basis of high yield and quality from Azadirachta indica is very profitable.

III. LITERATURE REVIEW

Sahoo *et al.* [16] have experimented with jatropha, karanja and polanga biodiesel in a Diesel engine. They reported higher peak cylinder pressure and shorter ignition delay for all biodiesels when compared with diesel.

Banapurmath *et al.* [17] have experimented with methyl esters of honge (HOME), jatropha (JOME), and sesame (SOME) in a single cylinder, four stroke, direct injection compression ignition (CI) engine and reported a higher emission of CO, HC, and smoke and lower NOx as compared to that of diesel.

Edwin *et al.* [18] have studied the combustion process of rubber seed oil (RSO) and its methyl ester (RSOME) and also reported higher emissions of CO, HC, and smoke and lower NOx as compared to that of diesel.

Balusamy *et al.* [19] have experimented with methyl ester of Thevetia Peruviana seed oil (METPSO) and reported a lower emission of CO, HC, and a higher NOx as compared to that of diesel.

Qi *et al*. [20] have compared the combustion characteristics of diesel and biodiesel from soybean oil in a single cylinder, naturally aspirated Diesel engine and concluded that the peak cylinder pressure of biodiesel is close to that of diesel. They also reported that the peak rate of pressure rise and peak heat release rate during premixed combustion phase are lower for biodiesel.

Narun *et al*. [21] have conducted experiment with diesel fuel and diesel NOME blends in a four stroke naturally aspirated Diesel engine.

Atul Dhar *et al.* [22] reported that brake thermal efficiency was highest among all test fuels. All blends showed higher brake thermal efficiency than mineral diesel. Author found 20% efficiency with mineral diesel, 23% efficiency with pure biodiesel of 100% blend, which is 15% higher. They attributed this increase in brake thermal efficiency is due to presence of oxygen in the biodiesel molecules which improves the combustion efficiency using Azadirachta indica as biodiesel.

R.Senthilkumar *et al.* [23] observed that the brake thermal efficiency of blends 10% Azadirachta indica biodiesel and 90% diesel, 20% Azadirachta indica biodiesel and 80% diesel are almost very close to brake thermal efficiency of diesel. Brake thermal efficiency found 24.7% brake thermal efficiency by using pure diesel while 25.1% brake thermal efficiency by using30% Azadirachta indica biodiesel and 70% diesel, which is 1.63 % higher for blend 30% Azadirachta indica biodiesel and 70% diesel than pure diesel. They attributed this due to presence of increased amount of oxygen in respective fuels, which might have resulted in its improved combustion as compared to pure diesel.

Nishant Tyagi et al. [24] observed that break thermal efficiency of B10 is very close to break thermal efficiency of pure diesel. Author found 28% brake thermal efficiency by using pure diesel while 31% brake thermal efficiency by using20% Azadirachta indica biodiesel and 80% diesel. Break thermal efficiency of B20 is 14.2 % higher than break thermal efficiency of pure diesel due to the more oxygen content. Author attributed that an increase in break thermal efficiency may be attributed to the complete combustion of fuel because of oxygen present in blends perhaps also help in combustion of fuel using Azadirachta indica as biodiesel.

IV. CONCLUSION

Azadirachta indica can be used as an alternative fuel without much modifications of diesel engine and almost the same performance of a diesel engine with a petro diesel fuel. The Performance and Emission characteristics of Azadirachta indica varies from Engine to engine. The conventional methods used for the analysis of performance and emission characteristics of Azadirachta indica are expensive. So one can think over utilizing the CFD, which provides alternative to cost effectiveness speedy solution to engine design and optimization of engine for the Azadirachta indica Fuel. CFD results are the integral part of the design process and it have eliminated the need of Engine.

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