A Review on Production, Performance and Exhaust Emissions of Various Non-edible oil Biodiesel

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Abstract*- Global energy demand is increasing due the population growth and industrialization. In order to fulfill the energy demand with considering global concern, it is necessary to find out alternative fuel. Biodiesel is one the most promising alternatives for diesel needs. The methyl esters of vegetable oils, known as biodiesel. The advantage of Biodiesel is reduces greenhouse gas emissions. The present review paper focuses on the usage of different non-edible feed stock for biodiesel production, performance of engine and exhaust emission gases such as CO, HC, and NOX has been discussed.*

Keywords- Biodiesel, Exhaust emissions, Tran's esterification and Performance.

I. INTRODUCTION

The life on earth needs energy to sustain and in modern world energy drives the economic growth. The closeness in physicochemical properties of biofuel to petroleum based products has resulted in increasing interest in liquid biofuel [1]. High petroleum prices demand the study of biofuel production [2]. The reserves of fossil fuel are depleting because of uncontrolled usage, raising demands for petroleum based products from all over the world and uncertainty is supposed to be considered to motivate multiple initiatives in pursuit of an effective alternative energy source, which can replace fossil fuels supplement or search for alternative fuel [3]. Biodiesel is environmentally friendly liquid fuel similar to petro-diesel in combustion properties [4]. Biodiesel has become more attractive recently because of its environmental benefits and it is made from renewable resources [5]. Biodiesel is synthesized from edible, nonedible and waste cooking oil or animal oil can be regarded as an alternative diesel fuel. The various alternative fuel options tried in place hydrocarbons oils are mainly biogas, producer gas, ethanol, methanol and vegetable oils. Out of all these, biodiesel offers an advantage because of their comparable fuel properties with that of diesel fuel [6].This review paper focuses on production, performance and emission characteristics of various non-edible oil like Pongamia, Jatropha, Neem and Madhuca Indica.

The term, biodiesel, was introduced in the United States during 1992 by the National Soy Development Board (presently National Biodiesel Board), which has pioneered the commercialization of biodiesel in the USA. Biodiesel is essentially free and engines fueled with biodiesel emit significantly fewer particulates, hydrocarbon, and less carbon monoxide than those operating on conventional diesel fuel. The oil from seeds such as Jatropha and Pongamia can be converted to a fuel commonly referred as biodiesel [7]. Biodiesel is a mono alkyl esters of long chain fatty acids derived from edible and non-edible oils and animal fats. Biodiesel is defined as a fuel comprised of mono alkyl esters of long chain fatty acids from vegetable oils or animal fats [6]. There are different feed stocks for biodiesel production. The use of edible vegetable oils is considered as first generation feed stocks for biodiesel. Non-edible vegetable oils are second generation feed stock for biodiesel production. Some examples of non-edible oil seed crops are Jatropha curcas, Calophyllum inophyllum, Madhuca indica, Linseed, Pongamia pinnata (karanja), Nicotiana tabacum (tobacco), and Ricinus communis (castor), Azadirachta indica (neem). Moreover, Microalgae, which is regarded as third generation, feed stock for biodiesel production [8].

II. PRODUCTION OF BIODIESEL

Fahed Ahmed et al. [9] carried on production of biodiesel from Jatropha curcas seed oil using base catalyzed Tran's esterification. The methanol to oil molar ratio of 4 with KOH concentration of 2.5% w/w and 75 min reaction time gave the optimum yield of biodiesel. Mookan Rengasamy et al. [10] reviewed on biodiesel production from pongamia pinnata oil using synthesized iron Nano catalysts. The synthesized iron nanoparticles were used as Nano catalyst for the production of biodiesel using pongamia pinnata oil with methanol. The Trans esterification reaction for conversion of triglycerides into fatty acid methyl esters was carried out at a molar ratio of 3:1 methanol to oil, reaction time of 2 h, stirring speed of 400 rpm at 65°C.Vuppaladadiyam et al. [11] studied on Tran's esterification of Pongamia pinnata oil using base catalysts: A laboratory scale study. The crude oil extracted from pongamia pinnata seed was used to synthesize biodiesel by Tran's esterification with methanol in the presence of two different base catalysts viz. NaOH and KOH at pre-determined optimum temperature of 60°C, stirring speed of 300rpm for 45 minutes. The conversion was nearly 68% and 73%.Khayoon et al [12] reviewed on utilization of crude karanja (pongamia pinnata) oil as a feed stock for the synthesis of fatty acid methyl esters. Methyl esters were synthesized from crude karanja oil by single step esterification with methanol using sulfuric acid (H2SO4) and (H3PO4) as a catalysts in a homogeneous batch process. With H2SO4 as a catalyst the yield was high as 89.8% at 65°C.Xindeng et al. [13] reviewed on ultrasonic Tran's esterification of Jatropha curcas L. oil to biodiesel by a two-step process. Trans esterification of high free fatty acid content Jatropha oil with methanol to biodiesel catalyzed directly by NaOH and high concentrated H2SO4 or two step process were studied in an ultrasonic reactor at 60°C. NaOH was used as catalyst, biodiesel yield was 47.2%. With H2SO4 as catalyst the biodiesel yield was 92.8%. Shakinaz et al. [14] reviewed on production of biodiesel using the microwave technique. Using the conventional technique, the best yield % for the production of biodiesel from Jatropha oil was obtained using a methanol/oil molar ratio of 7.5:1, potassium hydroxide as catalyst (1.5%) and a reaction time of one hour with the reaction temperature maintained at 65°C.Siddhartha Jain and M.P. Sharma [15] reviewed on biodiesel production from Jatropha curcas oil. The kinetics study of two-step acid-base catalyzed trans esterification process carried out at pre-determined optimum temperature of 65 and 50°C for esterification and transesterfication process under the optimum condition of methanol to oil ratio of 3:7 (v/v), catalysts concentration 1% (w/w) for H2SO4 and NaOH and 400 rpm of stirring. The maximum yield of 21.2% of methyl ester (ME) during esterification and 90.1% from Tran's esterification of preheated JCO has been obtained. Nurun nabi et al. [16] reviewed on Karanja (Pongamia pinnata) biodiesel production in Bangladesh, characterization Karanja biodiesel and its effect on diesel engine emissions. The Karanja Methyl Ester was produced by well-known esterification followed by Tran's esterification method. A maximum of 97% FAME was produced from Karanja oil.

III. ENGINE PERFORMANCE AND EXHAUST EMISSIONS OF VARIOUS NON EDIBLE OIL

A. Karanja (Pongamia pinnata L.)

Mohite et al. [17] studied on investigation on performance and emission characteristics of mix oil biodiesel blends. The BTE of biodiesel blends were decreased by 6.05%. BSFC of biodiesel blends were increased by 11.49%. Lowest HC emission up to 70%and CO emission up to 66.66%. Reduction in smoke opacity up to 37.32%. Nantha gopal and thundil karupparaj [18] reviewed on effect of pongamia biodiesel on emission and combustion characteristics of DI compression ignition engine. SFC increases with increase in biodiesel increases with increase in biodiesel. Reduction in CO, UBHC and smoke emissions with marginal increase in NOX emission. Harshob Singh et al. [19] studied on performance and emission characteristics of a diesel engine fueled with biodiesel extracted from karanja oil. BTE and BSFC werehigher than that of diesel fuel lower CO2 and CO emission and higher NOX emission was observed. Shrithar et al. [20] studied on the experimental investigations on mixing of two biodiesel blended with diesel as an alternative fuel for diesel engine. The specific fuel consumption values of dual biodiesel blends were comparable with diesel fuel. The emissions of smoke, hydrocarbon and nitrogen oxides of dual biodiesel blends were higher than that of diesel. Shankarappa kalgudi and Suresh [21] studied on an experimental study of performance and emission characteristics of CI engine fuelled with hybrid blends of biodiesels. They found that break power, break thermal efficiency, and break specific fuel consumption and emission characteristics for hybrid blends are better than the diesel fuel or D100. Ganesh Singh chauhan et al. [22] reviewed on experimentation on feasibility of karanja seed oil to use as in diesel engine using 4-stroke stroke single cylinder DI diesel engine test rig. BTE and BSFC increase with increase in blends. CO, CO2, HC and NOX emissions higher than that of mineral diesel. Nagarhalli et al. [23] reviewed on emission and performance characteristics of karanja biodiesel and its blends in a C.I. engine and its economics. The results indicate that CO emissions were slightly higher. HC emissions decreased by 12.8% for B20 and 2.85% for B40. NOX emissions decreased up to 39% for B20 and 28% for B40. BSEC increased by 7% for B20 and 1.9% for B40. Prabhakar et al. [24] reviewed on the performance and emission studies of a diesel engine with pongamia methyl ester at different at different load conditions. The results showed that the break thermal efficiency decreased and BSFC increased slightly for Pongamia methyl ester blends as compared with diesel fuel. CO and Smoke emissions were reduced by 34% and 25% and Nitrogen oxide (NO) was increased by 8.5% for B20 at full load condition.

B. Jatropha curcas

The experimental study on performance and emission characteristics of jatropha biodiesel in a diesel engine test rig for varying injection pressures studied by Bharath et al. [25], Were BSFC is increases as the injection pressure increases. HC emission was ranges between 31-59 ppm. NOX emission was ranges between 50-1500 ppm. CO2 emission ranges between 2-9 percent by volume. Madiwale et al. [26] reviewed on properties investigation and performance analysis of diesel engine fuelled with Jatropha, Soybean, Palm and cotton seed biodiesel using ethanol as a an additive. The performance analysis of investigation shows that there is an improved BP (Break Power), increased BSFC (Break specific fuel consumption) and increased BTE (Break thermal efficiency) for various load on engine for Jatropha, Soybean, Palm and Cotton biodiesel diesel blend with ethanol as additive. Pankaj Dubey and Rajesh Gupta [27] reviewed on the study of the performance and emission characteristics of a dual fuel powered single cylinder diesel engine. The BSFC was increases and break thermal efficiency was decreased by 2.9%. The reduction of CO, NOX, and CO2 emissions were 41.6%, 3%, 4.43%. HC was increased by 29.31%. Gaurav Paul et al. [28] reviewed an experimental and numerical investigation of the performance, combustion and emission characteristics of a diesel engine fueled with jatropha biodiesel. The performance characteristics shows that break specific fuel consumption increases and break thermal efficiency decreases with the use of jatropha biodiesel. Whereas the emission of NOX and CO2 increase; smoke and PM emission decreases for the same. Mofijur et al. [29] reviewed on evaluation of biodiesel blending, performance and emissions characteristics of Jatropha curcas methyl ester: Malaysian prospective. The average reduction break power (BP) is 4.67% for B10 and 8.86% forB20. BSFC increases as biodiesel percentage increased. Hydrocarbon emission was 3.84% and 8.86% for B10 and B20. Carbon monoxide emission was 16% and 25% for B10 and B20. NOX was 3%and 6% for B10 and B20. Chauhan et al. [32] reviewed on a study on the performance and emission of a diesel engine fueled with jatropha biodiesel oil and its blends. Lower break thermal efficiency and higher BSFC was observed. The experimental results show that HC, CO and smoke was reduced with increase NOX emission. Sunil Kumar et al. [33] reviewed on experimental evaluation of CI engine performance using diesel blended with jatropha biodiesel. High BSFC and low BTE was observed with comparable emissions of CO, CO2, HC, O2, and NOX. S. Jindal [34] reviewed on injection timing on combustion and performance of a direct injection diesel engine running on jatropha methyl ester. BTE increased by 8% and reduction in BSFC by 9% when jatropha methyl ester is used as fuel.

C. Neem

Jayashri et al. [35] carried on the analysis of performance and emission on compression ignition engine fuelled with blends of neem biodiesel. The result showed that higher brake thermal efficiency. Low HC, CO and NOX.

D. Mahua (Madhuca indica)

Swarup Kumar Nayak and Bhabani pattanayak [36] reviewed on experimental investigation on performance and emission characteristics of diesel engine fuelled with mahua biodiesel using additive. BTE increases with increase in additive. BSFC and EGT decreases with increase in additive. CO, HC, NOX, and smoke emissions were decreases with increase in additive percentage.Saravanan et al. [37] investigated the performance and emission of a diesel engine fueled with Madhuca indica biodiesel. The results showed that power loss was around 13% with 20% increase in fuel consumption with mahua methyl ester. Emissions such as carbon monoxide, hydrocarbons were lesser for mahua ester compared to diesel fuel by 26% and 20% respectively.

IV. CONCLUSION

Biodiesel has concerned much because of its economic and environmental benefits as well as it is renewable origin. Biodiesel produced from non-edible oil resource can reduces the use of edible oil for biodiesel production. Biodiesel is an oxygenated fuel that leads to complete combustion. Biodiesel can be used in the diesel engine without engine modifications with reduced exhaust emissions. This review paper summarizes the production of biodiesel from Pongamia pinnata and Jatropha curcas. Biodiesel yield was very high for pongamia and Jatropha oil. Also performance and emission characteristics various non-edible oil like Pongamia, Jatropha, Neem and Mahua biodiesel has been discussed. Compared to all non-edible, the performance and emission characteristics of Pongamia and Jatropha biodiesel was very low. So biodiesel from Pongamia and Jatropha can be used in the diesel engine without engine modification with reduced emission gases like CO, HC, and NOX.

Table 1. Engine Performance And Emisions Of Various Biodiesel Feed Stocks

BIODIESEL FEED STOCK	ENGINE PERFORMANCE	EMISSION RESULTS	REFERENCES
Mixed biodiesel of karanja and linseed	BTE decreased by 6.05% BSFCincreased by 11.49%	HC emission 70%, CO emission 66.66%.Smoke opacity 37.32%	[17]
Pongamia biodiesel	SFC increases	Low CO, UBHC, Smoke emission and High NO_X emission	[18]
Karanja methyl ester	BTE and BSFC is Higher than	Lower CO, CO_2 and Higher NO_X	[19]

BIODIESEL FEED STOCK	ENGINE PERFORMANCE	EMISSION RESULTS	REFERENCES
	diesel		
Mixed biodiesel of Pongamia and Palm oil	Specific fuel consumption dual biodiesel blends comparable with diesel	Smoke, hydrocarbon and nitrogen oxides of dual biodiesel blends were higher than that of diesel.	[20]
Hybrid biodiesel	Break power, break thermal efficiency, and break specific fuel consumption better than diesel	Emission characteristics are better than diesel.	[21]
Karanja seed oil	BTE and BSFC increases	CO, HC, CO_2 and NO_X emission increases	[22]
Karanja biodiesel	BSFC increased by 7% and 1.9% for B20 and B40	High CO emission, HC emission decreased by 12.8% and 2.85% for B20 and B40, NO_X emission decreased by 39% and 28% for B20 and B40	[23]
Pongamia methyl ester	BTE decreases and BSFC Increases	CO, HC, CO_2 and NO_X emission increases	[24]
Jatropha biodiesel	BSFC increases	HC emission was 31-59 ppm, NO_X emission was 50-1500 ppm, CO_2 emission was 2-9%	[25]
Jatropha, Soybean, Palm and Cotton seed biodiesel	Increased BP, BTE and BSFC	-	[26]
Dual biodiesel	BSFC increases and BTE reduced by 2.9%	CO, NO_X, CO_2 were 41.6%,3%,4.43% and 29.31%	[27]
Jatropha biodiesel	BSFC decreases and BTE increases	NO_X and CO_2 increases, smoke and PM emission decreases	28]
Jatropha methyl ester	Break power was 4.67% and 8.86% for B10 and B20. BSFC increases	HC was 4.67% and 8.86% for B10 and B20, CO was 16% and 25% for B10 and B20. NO_X was 3% and 6% for B10 and B20.	[29]
Jatropha biodiesel	Low BTE and high BSFC	HC, CO and smoke reduces and NO_X increases	[32]
Jatropha biodiesel	High BSFC and low BTE	Comparable emissions of CO, CO_2, HC, O_2, and NO_X.	[33]
Jatropha methyl ester	BTE increased by 8%	-	[34]
Neem biodiesel	High BTE	Low HC, CO and NO_X	[35]
Mahua biodiesel Mahua	BTE increases, BSFC and EGT decreases Power loss by 13% Increase in BSFC by 20%	HC, CO and NO_X emission reduces CO and HC were reduced by 26% and 20%	[36] [37]

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