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POTENTIAL OF JATROPHA BIODIESEL - A REVIEW

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Abstract: Energy is basic requirement for economic development of a country. Every sector of Indian economy—agriculture, industry transport, commercial and domestic needs input of energy. The economic development plans implemented since independence have necessarily required increasing amount of energy. As a result consumption of energy in all forms has been steadily rising all over the country. This growing consumption of energy has also resulted in the country becoming increasingly dependent on fossil fuels such as coal, oil and gas. Rising prices of oil and gas and potential shortage in future lead to concern about the security of energy supply needed to sustain our economic growth. Increased use of fossil fuels also causes environmental problems both locally and globally [1].

The major part of all energy consumed in most parts of the world comes from fossil fuel sources such as petroleum, coal and natural gas. However, these non-renewable sources will be exhausted in near future. Thus, the search for alternative sources of renewable and sustainable energy has gained importance with the potential to solve many current social issue such as the rising price of global warming caused by combustion of fossil fuel. This paper reviews the production and performance of biodiesel obtained from Jatropha oil.
Keywords:Jatropha oil, biodiesel, alternative fuel, transesterification.

IIntroduction

Diesel engines dominates the field of transportation and agriculture machinery on account of its superior fuel efficiency, the consumption of fuel in India is several times higher than that of petrol consumption[2]. Roughly estimate of petrol and diesel consumption is 30 and 70%, respectively.The diesel engine is a major contributor to air pollution especially within cities and along urban traffic routes. In addition to air pollution that causes ground level ozone and smog in the atmosphere, diesel exhaust also contains particulate and hydrocarbon toxic air contaminants (TAC)[3].

Now society has become more aware of harmful effects of the various exhaust emission coming out of the engines and there is tremendous pressure on researchers to reduce exhaust emissions. Various harmful effect of exhaust emission are already established and known to today's society. So research is being done all around the world to reduce the emissions of automobiles[2].

IIBiodiesels:-

Biodiesels are the fuels produced from vegetable oil, oilseed and animal fats. They are renewable and clean-burning replacement of diesel fuel. Biodiesel fuel is renewable, biodegradable, non–toxic, and free from sulphur. Biodiesels are generally mono alkyl esters of long chain fatty acids derived from vegetable oil or animal fat. This makes them environment friendly. They can be used in any diesel engine directly without any changes. Rudolph Diesel the inventor of diesel engine demonstrated his engine with peanut oil. Petroleum diesel was discovered later.[3]

Biodiesel can be blended with petroleum diesel as it has similar characteristics with lower hazards exhaust emissions. Biodiesel is processed from renewable biological sources such as vegetable oils and animal fats. The oil from vegetable crops and animal fats are extracted or processed to obtain the crude oil. It usually contains free fatty acids, phospholipids,steros, water, odorants and other impurities[4]. The free fatty acids and water contents have significant negative effects during the transesterification reaction of glycerides with alcohols using alkali or acid catalyst since they caused soap formation, consume catalysts and reduce its effectiveness and results in a lower conversion. Many researches have been undertaken on vegetables oils as a sources for diesel fuel which includes palm oil, soybean oil, sunflower oil, coconut oil, rapeseed oil and so on. However, animal fats with high saturated fatty acids which normally exists in a solid form at room temperature may causes problems in the production process, causing its processing coast to be significantly higher than for vegetables oils. Thus, vegetable oils are more favorable and draw a higher attention than animal fats for the fact that they are renewable and potentially an in exhaust source of energy [5].We have reviewed the production of biodiesel using vegetable oils mainly non edible Jatropha curcas as potential feedstock, the technologies implemented, the process variables, economic aspects and environmental consideration of biodiesel production.

There are two types of biodiesels:-

a. Edible oil based
b. Inedible oil based

Biodiesel in India

As India is deficient in edible oils, non-edible oils become the main choice for biodiesel. Generally, a blend of 5–20% is used in India (B5–B20). Indian oil corporation (IOC) has taken up Research and Development work to establish the parameters for the production and use of biodiesel in its R & D centre at Faridabad. Research is also carried out in Kumaraguru College of Technology to marginally alter the engine parameters to suit the Indian Jatropha seeds and to minimize the cost of transesterification.As mentioned earlier about 60 Mha of waste land including the sides of roads and railway tracks, can be used for cultivation of Jatropha plants as well as other crops.However, the land being cultivated for Jatropha in various states is given in, which shows that the maximum Jatropha cultivation is being done in the state of Maharashtra followed by Gujarat, Tamil Nadu and Rajasthan [6,7].

Jatropha Oil

Jatropha curcas is a drought-resistant tree belongs to the Euphorbiaceae family, which is cultivated in Central and South America, South-east Asia, India and Africa. It is easy to establish, grows almost everywhere even on gravelly, sandy and saline soils. It produces seeds for 50 years with a high oil content of about 37% or more. The oil from the seeds has valuable properties such as a low acidity, good stability as compared to soybean oil, low viscosity as compared to castor oil and better cold properties as compared to palm oil. Besides, Jatropha oil has higher a 2 ataly number compared to diesel which makes it a good alternative fuel with no modifications required in the engine. However, most non-edible oils contain a high level of free fatty acids (FFA) which is undesirable as it lowers the yield of biodiesel. This is because a high FFA (>1%w/w) will promote more soap formation and the separation of products will be difficult during alkali-catalysed transesterification. Eq. (1) shows the undesired saponification reaction which form soap and water when sodium hydroxide is used as the catalyst]. Jatropha oil contains about 14% of FFA which is far beyond the acceptable limit of a 1% FFA level. Thus, pretreatment step to reduce the FFAs of feedstock is required for a better biodiesel yield[8].

$$R1\text{-}COOH + NaOH \rightarrow R1COONa + H2O$$

(FFA) (sodium hydroxide) (soap) (water)

Performance of diesel engine fueled with Jatropha Oil biodiesel

The performance of neat 3atalyze oil in the application to the single cylinder water-cooled direct injection diesel engine developing a power output of 3.7 kW at the rated speed of 1500 rpm at various output have been investigated as the basis for comparison with the blending, biodiesel and dual fuel operation techniques by Kumar et al. They found that 3 atalyze oil resulted in a slightly reduced thermal efficiency as compared to diesel. HC emission was higher with 3 atalyze oil as compared to diesel. The maximum smoke level with 3atalyze oil was highest among that of its ester and diesel. Ignition delay was higher with neat 3atalyze oil. In addition, lower heat release rate are found with 3atalyze oil.

The test results on a single-cylinder direct-injection engine operating on neat 3atalyze oil as well as blends of diesel and 3atalyze oil were presented by Forson et al. Their tests showed that 3atalyze oil could be conveniently used as a diesel substitute in a diesel engine[9].

For agricultural applications where small amounts of fuel are consumed in every engine, use of neat vegetable oil is likely to be more attractive than the biodiesel. Even though the neat3atalyze oil is proper to apply for short-term use such as the agricultural machinery, pump operation, etc. it is hardly find the test results on those engines.

A performance evaluation of JO biodiesel had been carried out by Prasad etal.on a low heat rejection diesel engine and compared with the pure diesel operation of a conventional diesel engine. They found that JO biodiesel was found to be an effective substitute for use in CI engine, except for higher smoke levels[10].

To reduce Nox emission from CI engines running on JO biodiesel, EGR system was introduced by Suryawanshi and Deshpandeand Pradeep and Sharma. They found that Nox emissions were decreased with the application of EGR with minor effect on fuel consumption rate, brake thermal efficiency and cylinder pressure etc. In the experimental work by Pradeep and Sharma, EGR level was optimized as 15% based on adequate reduction in NO emissions, minimum possible smoke, CO, HC emissions and reasonable brake thermal efficiency[11].

Mandepe et al.[12] introduced common rail direct injection diesel engine to determine the effects of JO biodiesel on performance and emission characteristics. They found that HC and Nox emissions are compatible to that of fossil diesel fuel. However, CO emissions tend to increase and PM emissions were significantly lower than those of diesel fuel.

The performance and emission characteristics of single cylinder direct injection CI engine operated with neat methyl esters of 3atalyze oil, karanja oil, and sesame oil, respectively were reported by Banapurmath et al. They found that all the methyl esters tested in this study result in a slightly reduced thermal efficiency and increased smoke, HC and CO level. It was also observed that NO emissions were lower for biodiesel operation compared to diesel. This tendency is not coincident with the general emission characteristics of biodiesel in CI engines [13].

Jindal et al.investigated experimentally the effect of compression ratio and injection pressure on performance and emission characteristics in DI CI engine running on JO biodiesel. Increase in compression ratio associated with increase in injection pressure improves the performance of the engine. Increase in compression ratio leads to increase in emission of HC and exhaust temperature whereas smoke and CO emission reduces. NO emissions are found to remain unaffected at higher injection pressure. Therefore, they concluded that for fuelling the engine with JO biodiesel, one should go for higher compression ratio associated with higher injection pressure [14].

Methods of biodiesel production-

A number of methods are currently available that have been well established for the production of biodiesel fuel.

Crude oils are worthwhile to be modified in order to reduce their viscosities so that the product obtained has suitable properties to be used as engine fuels. There are many procedures available for this modification to produce a better quality of biodiesel. This can be accomplished in four primary ways; blending of crude oils, microemulsions, thermal cracking and transesterification[**5**].

Blending or dilution-Crude vegetable oils can be mixed directly or diluted with diesel fuel to improve the viscosity so as to solve the problems associated with the use of pure vegetable oils with high viscosities in compression ignition engines.[5]

Micro-emulsification-Another approach to reduce the viscosity of vegetable oils is by micro emulsion. Micro emulsions are clear, stable isotropic fluids with three components: an oil phase, an aqueous phase and a surfactant. The aqueous phase may contain salts or other ingredients, and the oil may consist of a complex mixture of different hydrocarbons and olefins. This ternary phase can improve spray characteristics by explosive vaporization of the low boiling constituents in the micelles. All micro-emulsions with butanol, hexanol and octanol can meet the maximum viscosity limitation for diesel engines[5].

Pyrolysis-Pyrolysis is the process of conversion of one substance into another by means of heat or with the aid of catalyst in the absence of air or oxygen. The material used for pyrolysis can be vegetable oils, animal fats, natural fatty acids and methyl ester of fatty acids[5].

Transesterification-Transesterification (alcoholysis) is the chemical reaction that involves triglycerides and alcohol in the presence of a catalyst to form esters and glycerol. This transesterification involving three consecutive reversible reactions, they are the conversion of triglycerides to diglycerides, followed by the conversion of diglycerides to monoglycerides. A catalyst is usually used to improve and enhance the reaction rate so that the reaction can be completed in a shorter reaction time. The transesterification reaction can be 4atalyzed by alkalis, acids or enzymes[5]. Basic catalysts are usually favoured over acid catalysts because of the higher reactivity and the milder process conditions such as the lower temperature required[5]. Methanol is the most preferred because of its low cost and its physical and chemical advantages as polar and short chain alcohol. Methanol can also react with triglycerides quickly and easily dissolve the alkali catalyst.The overall transesterification reaction is given by three consecutive and reversible equations as shown below.

Triglyceride (TG)+ROH↔Diglyceride (DG)+ RCOOR1 (2)

Diglyceride (DG)+ROH↔Monoglyceride (MG) + RCOOR2 (3)

Monoglyceride (MG) + ROH↔Glycerol+ RCOOR3 (4)

The fuel obtained after transesterification possess following properties.

Table 1: Fuel Properties of Jatropha Biodiesel

Property	Jatropha Oil (Raw)	Jatropha Oi (Bio-Diesel)	ASTM Standard	Conventional Diesel
Viscosity	24.5	3.0 – 5.65	6.0	2.7
Density	940	862 - 886	900	–
Calorific Value	42.15	37.2 – 43.(	–	–
Flash Point	180	180 – 280	>130	45 min
Cloud Point	10	4 – 10	–	–
Pour Point	5	2 – 6	10	5
Cetane Number	51	43 – 59	47 min	45 min

[15]

Conclusion

Boidiesel fuels are recognized as one of the effective solutions for this problem. We have studied the properties of biodiesel prepared from jatropha oil. These fuels are compatible with diesel engine. From this review, the following conclusions are drawn:

1. Jatropha oil has high viscosity and low volatility. This makes it unsuitable for direct use in diesel engine.
2. By transesterification process the fuel properties are brought closer to fossil diesel fuel.
3. JME is produced from non-edible oils, were used in a diesel engine. Their commercialization will produce green jobs and economic stability for India.

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