Production of biodiesel from *jatropha curcas* oil by using pilot biodiesel plant

D.RAMESH*, A.SAMAPATHRAJAN, P.VENKATACHALAM
Agrl. Engg. College & Research Institute
Tamil Nadu Agricultural University
Coimbatore, Tamil Nadu, India

Introduction

The consumption and demand for the petroleum products are increasing every year due to increase in population, standard of living and urbanization. Diesel consumption pattern in India has not varied much and is around $36x10^6$ tonnes as reported by the Ministry of Petroleum and Natural Gas (Table 1). The increase in crude oil import affects the country's economy and its development. The diesel vehicles were banned in New Delhi for serious problem of air pollution due to higher emissions of polluted gases. The acid rain, global warming and health hazards are the results of ill effects of increased polluted gases like SOx, CO and particulate matter in atmosphere.

Today's diesel engines require a clean burning, stable fuel that performs well under the variety of operating conditions. Biodiesel is the only alternative fuel that can be used directly in any existing unmodified diesel engine. Because it has similar properties to diesel fuel, biodiesel can be blended at any ratio with diesel fuel. In most of the developed countries, biodiesel is produced from soybean, rapeseed, sunflower, peanut, etc., which are essentially edible in Indian context. Among the various vegetable oil sources, non-edible oils are suitable for biodiesel production. Because edible oils are already in demand and too expensive than diesel fuel. Among the non-edible oil sources, *Jatropha curcas* is identified as potential biodiesel source and comparing with other sources, which has added advantages as rapid growth, higher seed productivity, suitable for tropical and subtropical regions of the world.

Table 1. Production and import of crude oil in India (MT)

Year	Production	Import	Total	Import %
1971	6.8	11.7	18.5	63
1981	10.5	16.2	26.7	61
1991	33	20.7	53.7	39
2001	32	57.9	89.9	64
2002	32	73.5	105	70

Biodiesel

Biodiesel is a variety of ester-based oxygenated fuels derived from natural, renewable biological sources such as vegetable oils. It's name indicates, use of this fuel in diesel engine alternate to diesel fuel. Biodiesel operates in compression ignition engines like petroleum diesel

thereby requiring no essential engine modifications. Moreover it can maintain the payload capacity and range of conventional diesel. Biodiesel fuel can be made from new or used vegetable oils and animal fats. Unlike fossil diesel, pure biodiesel is biodegradable, nontoxic and essentially free of sulphur and aromatics. The estimated biodiesel requirement of India is presented in the table 2.

Table 2. Estimated biodiesel requirement in India

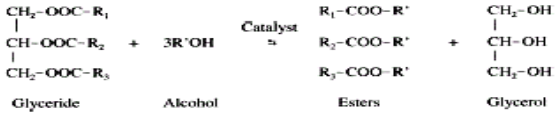
Year	Diesel requirement, MMT	Biodiesel requirement blending, MMT		
		5%	10%	20%
2004-05	46.97	2.35	4.70	9.40
2006-07	52.33	2.62	5.23	9.92
2011-12	66.90	3.35	6.69	13.38

Advantages of biodiesel

1. Produced from sustainable / renewable biological sources
2. Ecofriendly and oxygenated fuel
3. Sulphur free, less CO, HC, particulate matter and aromatic compounds emissions
4. Income to rural community
5. Fuel properties similar to the conventional fuel
6. Used in existing unmodified diesel engines
7. Reduce expenditure on oil imports
8. Non toxic, biodegradable and safety to handle

Chemistry of biodiesel production

Biodiesel is produced by transesterification of large, branched triglycerides in to smaller, straight chain molecules of methyl esters, using an alkali or acid or enzyme as catalyst. There are three stepwise reactions with intermediate formation of diglycerides and monoglycerides resulting in the production of three moles of methyl esters and one mole of glycerol from triglycerides. The overall reaction is:



Alcohols such as methanol, ethanol, propanol, butanol and amyl alcohol are used in the transesterification process. Methanol and ethanol are used most frequently, especially methanol because of its low cost, and physical and chemical advantages. They can quickly react with triglycerides and sodium hydroxide is easily dissolved in these alcohols. Stoichiometric molar ratio of alcohol to triglycerides required for transesterification reaction is 3:1. In practice, the ratio needs to be higher to drive the equilibrium to a maximum ester yield.

The *Jatropha curcas* plant and oil

The oil yielding plant *Jatropha curcas* L. is a multipurpose and drought resistant large shrub, which is widely cultivated in the tropics as a live fence. The Jatropha plant can reach a height up to 5 m and its seed yield ranges from 7.5 to 12 tonnes per hectare per year, after five years of growth. The oil content of whole Jatropha seed is 30-35 % by weight basis.

Table 3. Problems in use of jatropha oil as fuel in diesel engine

Problems	Causes
Coking of injectors on piston and head of engine	High viscosity of raw oil, incomplete combustion of fuel. Poor combustion at part load with raw oil
Carbon deposits on piston and head of engine	High viscosity of oil, incomplete combustion of fuel.
Excessive engine wear	High viscosity of raw oil, incomplete combustion of fuel. Dilution of engine lubricating oil due to blow-by of raw oil

The above problems can be solved by converting raw jatropha oil in to biodiesel through transesterification process.

Biodiesel pilot plant

The biodiesel pilot plant consists of a transesterification reactor with heater, a stirrer, chemical mixing tank, three glycerol settling tanks and washing tank. The capacity of pilot biodiesel plant is 250 litres/day. The cost of the pilot plant is Rs. 2.5 lakhs. The process flowchart for biodiesel production and pilot biodiesel plant are shown in figure 1 and 2.

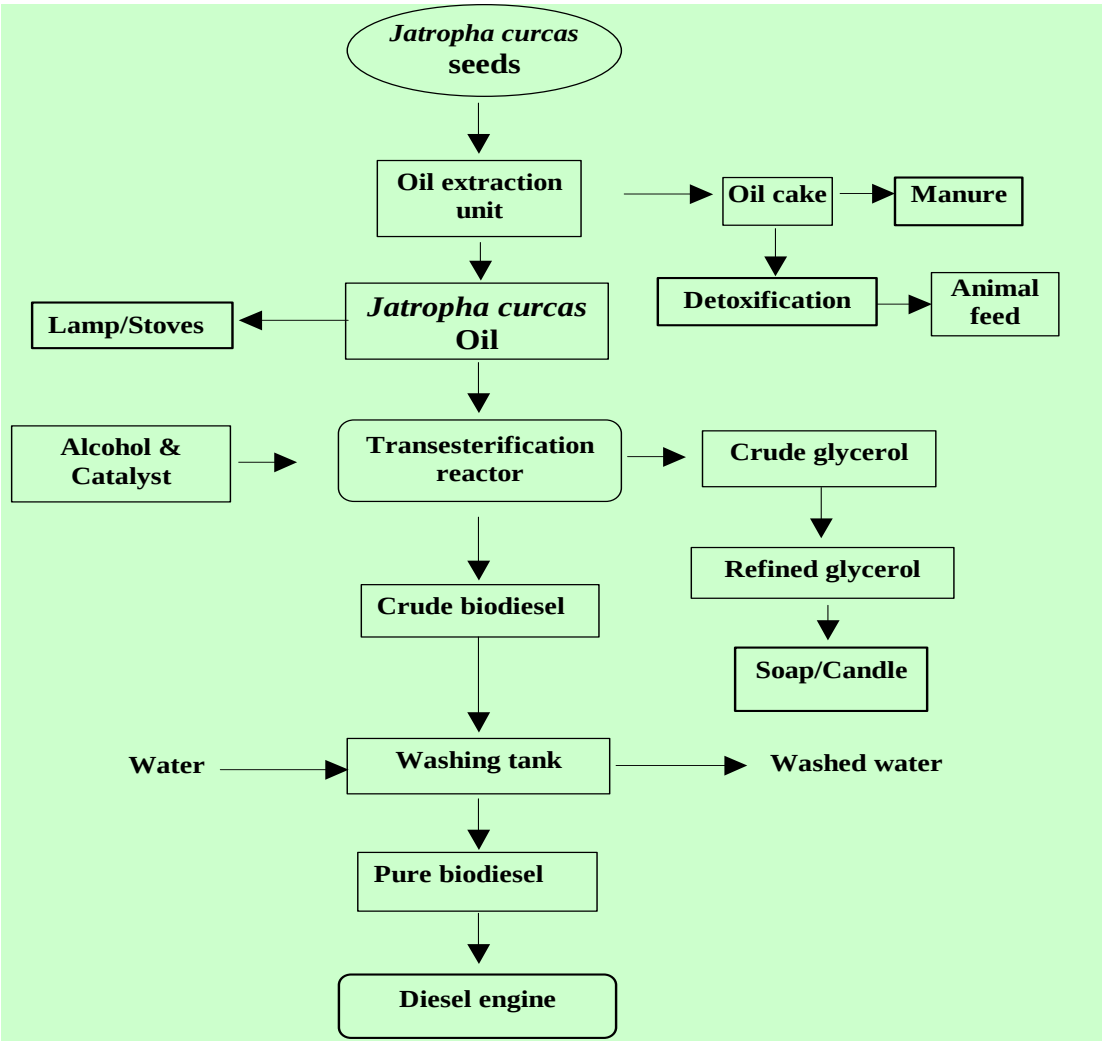


Fig. 1. Process flowchart for biodiesel production from jatropha seeds and by products

Fig. 2. Pilot biodiesel plant

Pilot biodiesel plant operation

In the pilot biodiesel plant, jatropha oil is blended with alcohol and catalyst mixture in transesterification reactor. The reactor is kept at reaction temperature for specific duration with vigorous agitation. After reaction, the biodiesel and glycerol mixture is sent to the glycerol settling tank. The crude biodiesel is collected and washed to get pure biodiesel. Depending upon the need, the size of the unit can be scaled up to get higher production capacity. The fuel properties of jatropha biodiesel produced in the pilot plant are given in the table 4.

$$\text{Jatropha oil + Alcohol} \xrightarrow{\text{Catalyst}} \text{Jatropha biodiesel + Glycerol}$$

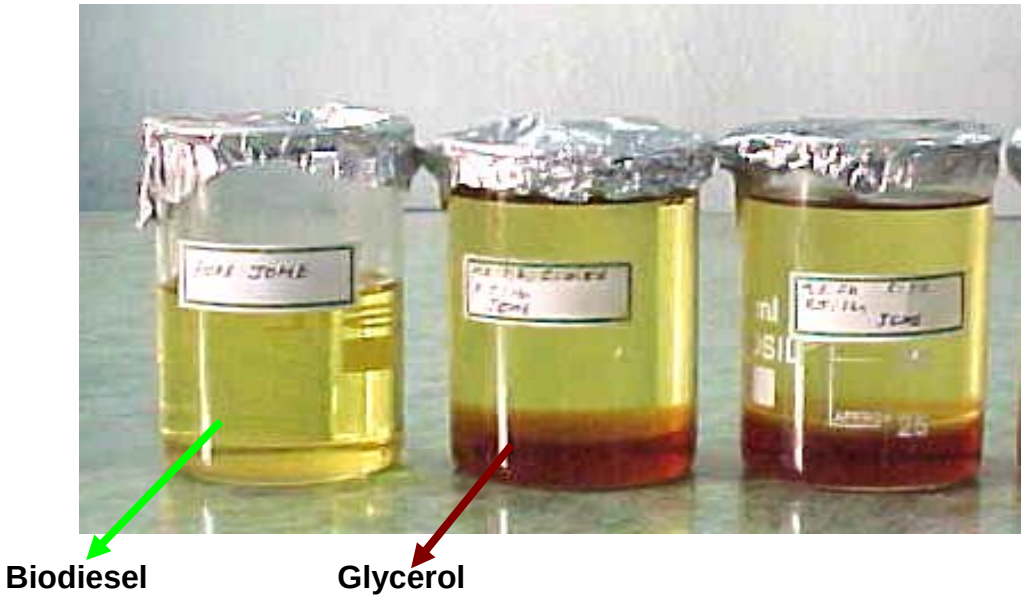


Fig. 3 Jatropha biodiesel with glycerol samples

Table 4. Fuel properties of jatropha oil and its biodiesel

Properties	Jatropha Oil	Jatropha biodiesel	Diesel
Density, g/ml	0.920	0.865	0.841
Viscosity @ 40^{o}C, Cst	3.5	5.2	4.5
Calorific value, MJ/kg	39.7	39.2	42.0
Flash point, ^{o}C	240	175	50
Cloud point, ^{o}C	16	13	9

Salient features of the pilot biodiesel plant:

- Simple in operation
- Low cost technology
- Shorter reaction time

Economics of biodiesel production

Cost of raw jatropha oil	=	Rs. 22/litre
Biodiesel processing cost	=	Rs. 9/litre
Cost of production	=	Rs. 31/litre
Less return from crude glycerol	=	Rs. 3/litre
Net cost of production	=	Rs. 28/litre
Dealers margin	=	Rs. 1/litre
Profit	=	Rs. 3/litre
Sale price of biodiesel	=	Rs. 32/litre

Conclusion

Jatropha biodiesel is ideal solution to meet out higher diesel demand and oil imports. By mixing of 20 per cent biodiesel with diesel will help India to save $7.3x10^{6}$ tonnes of diesel per year. In India about 33 million hectares of wasteland is available and can effectively be used for cultivation of jatropha plants. By installing the developed pilot biodiesel plant at each district, dependence on diesel fuel for farm operations can be reduced. It offers business possibility to agricultural enterprises and rural employment.

Corresponding author :
Dr. D.RAMESH
Assistant Professor
Department of Farm machinery
Agricultural Engineering College and Research Institute
Tamil Nadu Agricultural University
Coimbatore, Tamil Nadu – 641 003
India
[1]E-mail: ram_tnau@yahoo.co.uk

Dr. A. SAMPATHRAJAN
Dean,
Agricultural Engineering College and Research Institute
Tamil Nadu Agricultural University
Coimbatore, Tamil Nadu – 641 003
India

Dr. P. VENKATACHALAM
Professor and Head,
Department of Bioenergy
Agricultural Engineering College and Research Institute
Tamil Nadu Agricultural University
Coimbatore, Tamil Nadu – 641 003
India


Jatropha plants

Jatropha seeds

Jatropha oil

Pilot Biodiesel plant

Jatropha Biodiesel and glycerol

Jatropha Biodiesel fuelled engine