Research Paper Engineering

Economic Analysis of Biodiesel Produced from Waste Cooking Oil

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ABSTRACT

Present work is focused on comparing the economic feasibility of biodiesel with conventional petroleum diesel. It includes estimates of various resources used in the production of biodiesel from waste cooking oil starting from waste cooking oil to various reactants, energy and labor cost. Estimates are prepared using some existing data and other suitable assumptions. It is found that the biodiesel conversion cost comes about 11 rupees per kg. With waste cooking oil net biodiesel cost comes at 35 rupees per kg. Hence waste cooking oil proves to be a greener as well as economically viable feedstock for biodiesel production.

Keywords : Economic feasibility, Biodiesel production, waste cooking oil.

INTRODUCTION
The world is presently confronted with the twin crises of fossil fuel depletion and environment degradation. Indiscrimination extraction and lavish consumption of fossil fuels have led to reduction in underground based carbon resources. According to an estimate, the reserves will last 218 yrs for coal, 41 yrs for oil and 63 yrs for natural gas. Depleting reserves of crude petroleum, uncertainty in availability, environmental degradation and rapid hike in petroleum prices have led to search of alternate fuels (Lin et al., 2011). Many researchers around the world have explored several alternative energy resources, like biogas, biomass, alcohol, hydrogen, vegetable oil, which have the potential to quench the ever-increasing energy thirst of today's population (Denis et al., 2009).

Biodiesel, a clean renewable fuel, has recently been considered as the best substitute for a diesel fuel because it can be used in any compression ignition (CI) engine without the need for modification. The feed stocks used for biodiesel production currently are mainly high quality food grade vegetable oils, such as soya bean oil in U.S.A, rapeseed oil in Europe, palm oil in Malaysia (Azam et al., 2005). Lower cost feed stocks, such as waste cooking oil, grease, soap stocks are preferred because of their economic viability, since feedstock costs are about more than 85% of the total cost of biodiesel production (Hass et al., 2006; Zhang et al., 2003).Some of the properties, such as the high cetane value or good lubricity and lower sulphur content, are obvious advantages of bio-diesel while others, including the lower heating value, high freezing point (and inferior flow properties at low temperature), or corrosion properties are its drawbacks.

MATERIAL
Many vegetable oils like Soybean, Groundnut, Rapeseed, Palm, Olive etc. are wildly used for frying a number of food items. But after heating above a critical temperature for deep frying, they become unfit for further cooking, as their further use may lead to cholesterol formation in human beings. Presently, the WCOs are still lower cost feedstock making biodiesel production more competitive to the production of petroleum based diesel fuel. Waste cooking oil can be used as a biodiesel feedstock, as it is available in vast quantities and in its present form if it is used in engines, it will be big threat to the environment (Buasri et al., 2008; Cigizoglu et al., 1997; Kerschbaum and rinke, 2004). Some researchers (Pugazhvadivu and Jeyachandran, 2005) suggested to pre-heating the WCO before using it in diesel engines which reduces the viscosity of the WCO and lowers the exhaust emissions as compared to the diesel.

WCO BIODIESEL PREPARATION
In this work the WCO was first properly filtered to separate any kind of suspended impurities present. Then WCO is heated up to 120^{0}C for about 10 minutes in order to remove water content in the oil to avoid soap formation. This oil is then allowed to cool up to 65^{0}C temperature before mixing with KOH and methanol to prevent methanol evaporation. Simultaneously methyl alcohol (CH_3OH) is taken in molar ratio of 1:6 and Catalyst (KOH) is taken as 1% by weight of oil. The mixture of methyl alcohol and KOH is stirred until whole KOH dissolves in methyl alcohol. This mixture is poured in WCO. Since methanol is immiscible with the oil, the mixture is stirred continuously for about 30 minutes. During the reaction the temperature of mixture is kept about 55-60^{0}C. The mixture is left for 2-3 hours for gravity separation of methyl esters and glycerol. The heavier glycerin settled at the bottom was removed and then remaining sample was washed in warm water (about 80^{0}C) by stirring with about 30% warm water for one minute and then again this water is allowed to settle in a separating chamber for 2-3 hours to remove the catalyst and other impurities which are dissolved in water. Finally, the remaining sample is heated up to 110^{0}C ~120^{0}C for 8-10 minutes for removing any water content.

ECONOMICS OF BIO-DIESEL
The term "Life Cycle Assessment" is used to assess the total environmental performance of a product all along its lifetime, often referred as from 'cradle to grave'. Other terms, such as life cycle analysis and eco-balance, are also used. When talking about fuels, the proper term in use is "Well-to-Wheel (WTW) Analysis". Similarly in case of minerals, "Mine-to-Mill Analysis" is carried out. In order to be able to examine the

complete cycle of a transport fuel, the analysis is often divided into following five stages:

- Feedstock production.
- Feedstock transportation.
- Fuel production.
- Fuel distribution.
- Vehicle use.

These stages can be divided even further into a Well-to-Tank (WTT) and Tank-to-Wheel (TTW) portions of the WTW analysis. The WTT analysis considers the fuel from resource recovery to the delivery to the vehicle tank, i.e., the feedstock production, transportation, fuel production and fuel distribution. The TTW analysis considers the fuel economy, i.e., the vehicular use of the fuel. This way, the WTW analysis integrates WTT and TTW into a complete fuel history.

COST ESTIMATION OF BIODIESEL PRODUCTION
COST OF RAW MATERIALS
Cost of Waste Cooking Oil

Assuming the market Price of WCO = Approx. 20 / Kg

Requirement of WCO per day = 800 Kg

Requirement of WCO for a month = 800 * 25 = 20000 Kg

Cost of WCO for a month = Rs. 20 * 25 * 800 = 400,000 Rs

Cost of Methanol

Price of 1Kg of Methanol is Rs. 40

Daily requirement of Methanol = 176 Kg

Cost of Methanol for a month = 176 * 25 * 40 = 176,000 Rs

Cost of KOH

Price of 1Kg of KOH = Rs. 300 / Kg

Daily requirement of KOH = 8 Kg

Cost of KOH for a month = 8 * 25 * 300 = 60,000 Rs

Cost of Water

Monthly requirement of water for water washing = 0.3 * 20000 = 6000 Kg

Cost of water for a month = 6000 * 0.25 = 1500 Rs

Total raw material cost for a month = 637,500 Rs

ELECTRICITY COST
Assumptions:

- 1KWh of electricity = Rs. 7/-(for industrial uses)
- Specific heat of WCO is 1.97 KJ/Kg K
- Specific heat of water is 4.2 KJ/Kg K
- Heat loss due to radiation, convection = 10%
- Power of heater is 40 KW.
- 25 Working day in a month.

1) Electricity cost for heating oil from 20 ^{o}C to about 120 ^{o}C.

$Q = m*C_p*\Delta T$ / efficiency

= 100 kg * 1.97 * (120-20) / 0.9

= 21888.89 KJ

Heating duration = 21888.89 / 40 = 547.22 sec or 10 min (approx.) is required to reach 120 ^{o}C.

Electricity cost = 1/6 h* 40 KW * 7

= 46.67 Rs / batch of 100 Kg oil

= 46.67 * 8 * 25 per month

= 9334 Rs / month

2) Electricity cost for stirring alcohol and catalyst Assumptions

- Power of motor is 7.2 KW
- We stir the solution for 10 minutes in 7 batches of 25 Kg each

Electricity cost per batch = 7.2 KW * 1/6 hr * 7 = 8.4 Rs
Electricity cost per month = 8.4 * 7 * 25 = 1470 Rs

3) Electricity cost for stirring alcohol and catalyst mixture with WCO for 30 minutes Assumption

- Power of motor is 10 KW
- We stir the solution for 30 minutes

Electricity cost per batch of (100+22+1=123) Kg of mixture

= 10 KW * ½ hr * 7 = 35Rs

Electricity cost per month = 35 * 8 * 25= 7000 Rs

4) Maintenance of temperature during mechanical stirring

Tank in which mechanical stirring is taking place is insulated but still radiation losses takes place and even convection losses cannot be neglected. Cost of maintaining temperature of about 60 ^{0}C is assumed to be 900 Rs per month.

5) Electricity cost for heating water 200C to 800C for water washing

Q (for 30 Kg batch) = $m*C_p*\Delta T$ / efficiency

= 30 * 4.2 * 60 / 0.9 = 8400 KJ

Power of heater is 10 KW

Heating duration = 8400 / 10 = 840 sec or 0.233 hr

Electricity Cost per batch = Rs. 0.233 * 10 * 7 = Rs. 16.33

Electricity Cost per month = 16.33 * 8 *25

= 3267 Rs

6) Electricity cost for final heating of sample to 1200C for removing water if present

Assume this cost to be 9000 Rs.

Total electricity cost involved is

= Rs. (9334 + 1470 + 7000 + 900 + 3267 + 9000) = Rs. 30,971

APPARATUS COST
Total cost of apparatus and equipments is about 200000 Rs

Assuming these equipments works for 10 yrs and taking 6% interest rate

Equipment cost for a month Rs. 2670 (approx.)

MISCELLANEOUS COST

Miscellaneous cost is as shown in Table 1.

Purpose	Cost per month (Rs.)
Transportation Cost	8,000
Labour Cost	20,000
Rent Cost	2,000
Maintenance Cost	1,000
Manufacturing Unit Establishment Cost	2,500

Table 1

Net Miscellaneous Cost = Rs. 33,500 for a month.

CONCLUSION

On the basis of present work it can be concluded that the biodiesel conversion cost comes about 11 rupees per kg, hence with waste cooking oil net biodiesel cost comes at 35 rupees per kg where as diesel cost without subsidies. Hence waste cooking oil biodiesel found to be a better alternative to petro diesel and in future help to acquire the energy security for coming generations and provide a safe passage for waste cooking oil disposal.

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