Methodology to Create a Thumba-Argemone dual Fuel blends for Engine Testing

Sumit Kanchan
School of Mechanical Engineering, Lovely Professional University

Abstract

Conventional fossil fuels are reducing with the respect of time and it has been estimated that these fuels will vanish in next few years. Apart from this, as emission level is increasing day by day due to these conventional fuels, it has become a dire need to develop some new alternative fuels to these non-renewable fossil fuels. From the economic and environmental point of view, biofuels are being considered as better alternative fuels to replace all non-renewable conventional fuels. For all alternative biofuels to be effective, it is important that they should be easy to renew and their availability should be higher and also should be environmentally friendly.

Introduction

Biodiesel is being considered as the popular and most preferred economic and environmentally friendly alternative fuel because it belongs to renewable sources like vegetable oils and also consists higher oxygen content results in complete combustion and reduction in emissions. Since the demand for edible oils in India is very high due to which it is very difficult to replace their use for production of biodiesels. Hence working on biodiesel extraction from various non-edible oils like Argemone Mexicana and Thumba oil could be feasible and can reduce the food crisis as well. Following are the main considerations which clearly concludes that the research work on biodiesel from Argemone Mexicana and Thumba could give impressive results,

- The net heat release rate for dual biodiesel blends was found lower than pure diesel. Therefore, further investigation can be carried out to increase the net heat release rate.
- Soot Loading characteristics of Dual fuel blend in Lubricating oil for its pumping ability can be worked on.
- Effect of Compression ratio on combustion and Emission characteristics.
- It was found that by-products like fatty acids or glycerol are produced after the transesterification process. Hence a lot of research work can be done to use these by-products for various industrial purposes which can result in economical biodiesel extraction.
- As many researchers concluded that 1-6% of NO_X emission increased by using dual biodiesel blends, hence more research study can be done to reduce their NO_X level by changing various engine hardware components. [1-3]
- It was concluded that the transesterification process of vegetable oils increases the water hazards level. Hence a lot of scope for research is available where a number of techniques can be developed which can signify the importance of waste materials from transesterification process of raw oils.
- The results of various researchers conclude that use of dual biodiesels can become a good source of environmentally friendly alternative fuels. [4,5]
- Stability of dual biodiesels for long-term purposes can be studied.

In the chapter efforts have been made to highlight, the experimental setup used and method of carrying experimental investigation which is being considered as important factors for the successful research study.

Selection of material

For this study, two non-edible vegetable oils are selected like Thumba and Argemone Mexicana.

Thumba vegetable oil

Thumba Biodiesel (Citrullus Colocynthis) generally referred as Colocynth, belongs to a family of Cucurbitaceous. This Biodiesel is a non-edible vegetable oil, generally named as Indrayan in Hindi and Bitter Apple in English. This plant is being considered as a drought resistant type of species having a long deep root system, mostly found in many areas of Africa and Asia. In India, this type of plant is mainly grown in Rajasthan

and Gujarat deserts. This plant also belongs to a Creeper plant species family and largely found in sandy soil. It does not require any type of special care and its full growing cycle is 180 days approximately. Nowadays, the oil of this plant is mainly used in soap industries. The qualities of this plant related to diesel oil other than 'Jatropha' makes it more dominant. [6] Hence due to its small crop cycle, makes it an important part of the rural economy. Thumba fruit is almost similar to watermelon and the colour of seeds are grey in colour. This is being considered as best energy future energy source of fuel for India due to various properties. Its use is not bound only to oil sources or biofuels but for medicinal values, it also plays a very important role. One of the best advantages of Thumba oil is that it can be cultivated even on poor soils like sandy soils and also requires less amount of moisture and care. The yield of oil from Thumba seeds varies between 35% to 43% and can play a vital role in improving rural employment in India. The seeds were bought from Ludhiana market in Punjab. Qualities of Thumba oil are enlisted in below table-1

Table-1: Qualities of Thumba plant

Characteristics	Thumba Plant
Plant Type	Creeper
Crop Cycle	6 Months
Soil Type	Sandy Soil
Manure	No Special Requirement

Figure 1.1: Thumba plant with fruit

Figure- 1.2: Thumba seeds

Argemone Mexicana vegetable oil

In this research study, the main aim is to investigate the analysis of using dual biodiesel blends. From the literature review, a number of researchers have been carried out using various non-edible dual biodiesel blends like Jatropha, Karanja, Mahua, Pongamia pinnata etc. But they need special care and attention in their cultivation. Hence, after selecting Thumba vegetable seed oil, Argemone Mexicana seed oil was selected as a second non-edible vegetable oil to prepare this dual biodiesel blend. Argemone Mexicana classified among poppy family species which was initially found in Mexico. This is the reason that as a suffix, Mexicana is used. After many studies have been conducted on this vegetable oil as biodiesel, many other countries have started recognizing this as among best source of biodiesel because of its higher oil yield (34%-40%) like India. It is not used only for biodiesel fuels but also for medicinal values as well. In India, commonly it is referred as Satya nashi. [7] Another advantage for its cultivation is that poor soil and wasteland can be used. Flowers produced from these plants are yellowish in colour and the height of the plant is generally found to be 0.12m. As these plants are drought resistant hence, less attention is required. Argemone seeds are almost similar to mustard seeds with black in colour. Argemone Mexicana plants can also be grown in such areas where rainfall is recorded in lower quantity. Mostly these types of plants are found along roadsides with thorny fruits. Single step transesterification is required to extract biodiesel from these seeds due to the low content of fatty acids. Therefore, biodiesel production process can be completed at a low cost related to other non-edible oils.

Figure- 1.3: Argemone Mexicana seeds

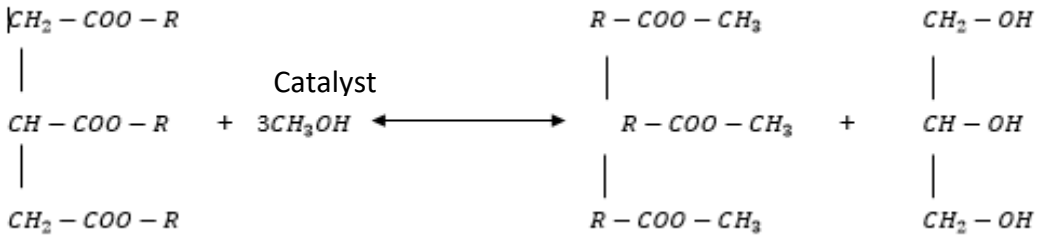
Figure- 1.4: Argemone plant

Production of Biodiesel

In this study, the two plants named as Argemone Mexicana and Thumba are selected in which biodiesel production will be carried out by means of transesterification process as discussed below:

Transesterification

Transesterification also referred as Alcoholysis, defined as the removal of fatty acid esters or biodiesel and glycerol in the form of byproducts from a chemical reaction including the use of alcohol (methanol or ethanol) and oil or fat (triglyceride). This process is generally used to decrease the viscosity parameter of triglycerides. Below is general equation representing Methanolysis means methanol is used for the reaction of removing FFAEs from triglycerides:



Triglyceride 3-Methanol 3-Biodiesel Glycerol

Figure-1.5: General Transesterification equation

From the equation, the free fatty acids removed are referred as biodiesels. Hence in order to remove the viscosity for both the selected vegetable oils like Thumba and Argemone Mexicana, the above-discussed transesterification reaction for effective results carried out for this investigation at a temperature of about 60^0C for initially mixed 1.5 liters of Argemone oil and at the 400ml of methanol and 10 gram of catalyst, potassium hydroxide after dissolving for 10-15 minutes poured into the oil. Similarly, the same process will be done for Thumba biodiesel production but instead of 400ml of methanol, the only 390ml of KOH is poured. After the completion of the reaction, a mixture prepared is allowed to settle. After some time, two separate layers gets created in which the bottom layer or glycerol is drawn off while the topmost layer is removed and washed so that any remaining glycerol, catalyst or alcohol is eliminated. The top layer is generally referred as FAMEs or Biodiesel. During transesterification process, there are various parameters which should be considered very keenly to make the process of Alcoholysis effective as discussed below:

- Oil temperature plays a very important role in the conversion of vegetable oil to biodiesel. Many researchers concluded that heating the vegetable oil before mixing the same heated oil with catalyst increases biodiesel recovery.
- The reaction temperature is another important parameter which influences the rate of reaction strongly. Generally, it has been studied that maintaining the temperature at 55^0C to 70^0C in a mixture of vegetable oil and catalyst increases the biodiesel production efficiency. One more important variable i.e. molar ratio (alcohol to oil) which also affects the conversion efficiency. Many researchers concluded that molar ratio of 6:1 subject in an increase of removing of glycerol from vegetable oil leaves biodiesel with zero fatty acids.

- In order to increase the conversion reaction, catalysts are also being used in which alkaline catalysts are more commonly used. It has been found that 94%-99% yield of biodiesel or esters can be extracted from vegetable oils by adding only 0.5%-1% of the catalyst by weight.

Blend Preparation

After completing the final separation process, following are the four blends which will be prepared for further testing and analyzing process:

- B10 (Argemone 5% + Thumba 5% + Diesel 90%)
- B20 (Argemone 10% + Thumba 10% + Diesel 80%)
- B30 (Argemone 15% + Thumba 15% + Diesel 70%)
- B40 (Argemone 20% + Thumba 20% + Diesel 60%)

Process for the production of Biodiesel

Below is a flowchart which clearly indicates that what are the processes used in transesterification in yielding of biodiesel from raw vegetable oils

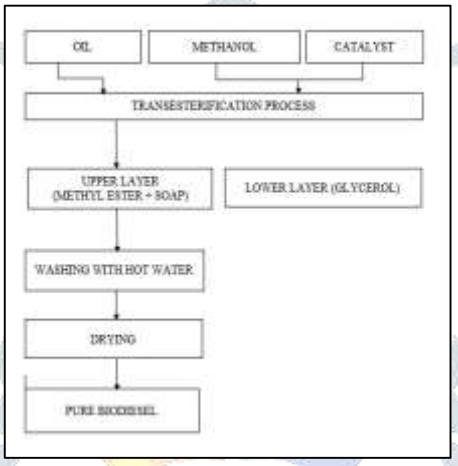


Figure-1.6: Biodiesel production flow chart

Before starting the process of transesterification to yield biodiesel, both the two selected vegetable oils like Thumba and Argemone Mexicana were purchased from Ludhiana market in Punjab. Both were easily available in the market. The most important parameter which plays a very important role in selecting these two oils is that both these two oils are non-edible oils which means less effect on food security. As the velocity of these two raw vegetable oils was higher, hence in order to make them usable for engine testing, transesterification process was used to their viscosity nearer to an affordable range. The transesterification process was conducted at Swarn Singh National Institute of Bioenergy (SSS NIBE), Kapurthala, Punjab. The figure-7 and figure-8 below shows bottles filled with raw Thumba and Argemone oil respectively.

4

Figure-1.7: Thumba oil

Figure- 1.8: Argemone oil

Before starting transesterification process for Thumba oil, the Fatty acid value measured was 4.4 MgKOH/gram of sample, which concludes one-step transesterification can be used. After that, 1500ml of oil was poured into the reactor and heated @ 65^0C by means of hot water circulation. As the oil attained some temperature, dissolved solution of 390ml of methanol and 10gram of KOH was poured into the oil for removing glycerol, soap etc from raw Thumba oil. The reactor was continuously stirred for about 2 hours and then the whole mixture is poured with water 5-10 times to eliminate impurities like soap, glycerol etc as shown in below figure-9. After proper washing, the mixture was allowed to settle in a separating funnel as shown in figure-10 below for two days so that any heavy matter will settle at the bottom to be removed.

Figure- 1.9: Washing with water

Figure 1.10: Separation process

Finally, after heating at 100-105^0C in a hot air oven the pure Thumba biodiesel is shown in figure-11 below:

Figure 1.11: Thumba biodiesel (B100)

For Argemone, the measured fatty acid value was 12.27MgKOH/gram of sample. This results in two-step transesterification process because of higher acid value. The remaining procedure for Argemone biodiesel production was same as in case of Thumba biodiesel production but the methanol concentration was 400 ml for 1500ml of oil. The figure-12 below shows the final B100 Argemone biodiesel.

Conclusion

After preparation of separate biodiesel blends of Thumba and Argemone Mexicana by means of Transesterification, following are the four-dual biodiesel blends with varying proportion of Diesel, Thumba biodiesel and Argemone Mexicana biodiesel were prepared:

- **B10:** The figure 7.7 below displays the sample which contains a mixture of 90% Diesel, 5% Thumba biodiesel and 5% Argemone biodiesel results in the formation of a dual blend referred as B10.

- **B20:** The figure 7.8 below displays the sample which contains a mixture of 80% Diesel, 10% Thumba biodiesel and 10% Argemone biodiesel results in the formation of a dual blend referred as B20.

References

[1] Narayan Lal Jain, S.L. Soni, M.P. Poonia, Dilip Sharma, Amnesh K. Srivastava, Hardik Jain, Performance and emission characteristics of preheated and blended thumba vegetable oil in a compression ignition engine, *Applied Thermal Engineering* 113 (2017), pp. 970-979.

[2] A. Pal, S.S. Kachhwaha, S. Maji, MKG Babu, 'Thumba seed oil: a sustainable source of renewable energy for biodiesel production' *Journal of Scientific and Industrial Research*, Vol-69 (2010), pp. 384-389.

[3] Sunilkumar R. kumbhar, H.M. Dange, Performance analysis of single cylinder diesel engine, using diesel blended with thumba oil, *International journal of soft computing and engineering (IJSCE)*, Vol-4, Issue-1, 2231-2307.

[4] Ratnam Ramesh Gujar, Rajesh Kale, S.B. Chavan, Study of Citrullus biodiesel blends on emission and performance characterization of IC engine, *International journal of innovative research in science, engineering and technology (IJIRSET)*; Vol-4, Issue-9, 2015, 2347-6710.

[5] B. Mishra, Dr A. Pal, R.B. Sharma, M. Jain, 'Performance study of a diesel engine by using thumba oil (Citrullus colocyntis) biodiesel and its blends with diesel fuel and results' *International Journal of Research in Advent technology*, Vol-3, No-7, 2015, 2321-9637.

[6] A. Karnwal, N. Kumar, M. Hasan, Production of biodiesel from thumba oil: Optimisation of process parameters, *Iranica J. Energy Environ.* 1 (2010) 352-358.

[7] Pawar Komal D., Gawande Sagar M., Godase Dhiraj v., "Optimization of thumba biodiesel to develop zero effluent discharge", *International Journal of Emerging technologies in Engineering Research (IJETER)*, Volume-4, Issue 6, June (2016), 2454-6410.