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Development of Small Scale Pilot Biodiesel Plant and Production of Biodiesel with Jatropha Oil

Ashish Mogra [*], Satish Verma[2]
[*]Department of Mechanical Engineering, SVKM, NMIMS, Shirpur
2 Mechanical Engineering Department, SRICT Ankleswar, Gujarat, Dist. Bharuch, India
* ashish.svnit5@gmail.com

Abstract
A biodiesel pilot plant is developed with a capacity of 35 litre biodiesel. A reaction chamber is designed in which the mixture is stirred by means of a mechanical stirrer operates by electrical motor through a reduction system to a maximum speed of 800 rpm. The function of these stirrer in inside the chamber is to reduce foaming. The processor container is heated internally by coil heater and the temperature is controlled thermostatically to a maximum of 600oC. The produced biodiesel from jatropha oil was tested and the results obtained are found similar properties to those for conventional diesel fuel. It is thus confirming that the plant can produce biodiesel within specification. The purpose behind this work is to fabricate a small scale biodiesel plant for the production of biodiesel fuel used in commercial vehicle.
Keywords: Biodiesel plant; reaction chamber; jatropha; mechanical stirrer.

I. Introduction

It is observed in the past years the consumptions of petroleum fuel is increased due to human population and growth of industries, which has caused decrease of fossil fuel resources and increasing petroleum price. Biodiesel is the name of a clean burning alternative fuel produced from domestic, biodegradable and renewable raw material including fresh or waste vegetable oils, animal fats, non- edible and oilseed plants. That can be produced by the trans esterification of vegetable oils in the presence of ethanol or methanol with potassium hydroxide or sodium hydroxide as catalyst with glycerol as a by-product. The biodiesel process itself is more than just a chemical reaction. Some biodiesel standards are ASTM D6751 (American Society for Testing and Materials) and EN 14214 (European norm) [1]. Coalescing method for separation of glycerine from biodiesel in which the high voltage / low current is required is invented for production of biodiesel. A biodiesel plant is designed and fabricated to reduce the separation time of glycerine, increase in efficiency and purity of recovered methanol. The fabricated plant has a capacity of 70 litres. [2]. A pilot plant of capacity of 90 litres of biodiesel is designed and fabricated, soy oil and ethanol as a raw material for the production of biodiesel. Ethanol potassium hydroxide is used as a catalyst. To reduce the separation time of glycerine from biodiesel, increase in efficiency and to get purity of recovered methanol, a novel biodiesel processor system is designed. Batch type stirred tank reactor (STR) has been provided which used mechanical and hydraulic system for efficient mixing [3]. A biodiesel plant with a capacity of 20 litre has been fabricated. The mechanical stirrer which is driven by electrical motor consist of 7 blades and 4 baffles to reduce foaming and promote localized induced turbulence to enhance stirring. The biodiesel is produced by food grade palm oil and used cooking oil [4]. Neem Methyl Ester is used for the production of biodiesel. An experimental setup is developed for production of biodiesel and it is tested with direct injection diesel conditions. It is found that produced biodiesel from NME has near properties with classical esters of vegetable oil [5]. Ofori Boateng Cynthia et al. [6] and S. Mangaraj et al. [7], have make a review on feasibility and post production of jatropha oil. They had found a positive outcome form the jatropha seeds for production of biodiesel fuel.

II. Raw material for production of Biodiesel

Biodiesel can be produced by edible and non-edible oil. In present work non-edible oil is used for production of biodiesel. Jatropha is a type of non-edible oil. These seeds are expected to use lands that are largely unproductive and those that are located in poverty struck are a sand in degraded forests. Furthermore, non-edible oil plants like jatropha are well adapted to dull, semi-arid conditions and require low fertility and moisture demand to grow. In continuation with that jatropha oil have presence of toxic components which is not suitable for human food. These all reasons makes use of jatropha oil as a raw material for production of biodiesel.

Fig.1: Jatropha Seeds [1]

III. Jatropha oil extraction

Jatropha (Jatropha curcas, Ratanjyot, wild castor) as the most likely potential alternative source of renewable energy for wide spread cultivation due to its multiple advantages. Solvent (hexane) extraction, mechanical screw press and manual ram press are the most used methods for oil extraction. For extraction of oil from jatropha mechanical screw press is selected. The by-product after extraction of oil from jatropha can be used as a biological waste in agriculture. The access quantity of oil after extraction from these method is 75%. The mechanical screw is fabricated by local methods. Fig.2 shows a mechanical screw press for extracting oil from jatropha seed.

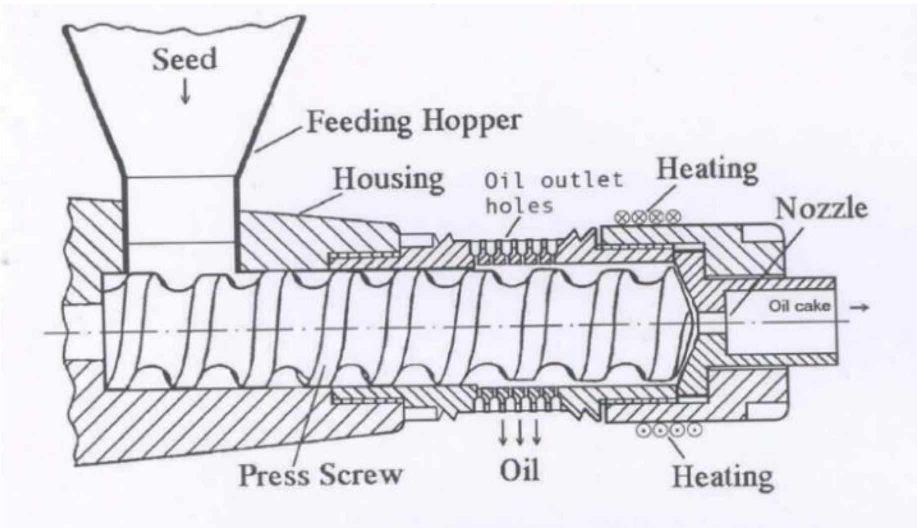

Fig.2: mechanically operated oil press for jatropha (5)

IV. Fabrication procedure of biodiesel plant

The present work consist of design and development of a biodiesel pilot plant. The present work include evaluation of the plant with production of biodiesel from Jatropha oil by a process of transesterification of oil and methanol with potassium hydroxide as a catalyst. The components of the plant were fabricated locally through welding, machining, and assembled by bolting. The experimental setup of biodiesel plant include Reaction Chamber (processor and sedimentation container), thermostat , digital temperature sensor, inlet and delivery valve, water pump, nozzle, electrical motor and control panel shown in figure. The reaction chamber consists of two concentric cylinders i.e. processor and sedimentation container of diameters 300 and 450 mm respectively and a capacity of 35 and 60 litres respectively. The sedimentation cylinder is made from stainless steel and tapered at the bottom to take a discharge pipe and a lever valve to allow the mixture to be gravity drained. Heating is done by a 200kW stainless steel heater at the bottom of the processor container and controlled to give a maximum temperature of 300^{o}C. Temperature control is by means of a thermostat located at the bottom of the container. The whole design assembly stands on four legs and is floor mounted to absorb the vibration of processor container. The Sodium Hydroxide equipment is provide at the height to create pressure difference for formation of in processor container. Stirred tank reactors (STR) technology is selected, the stirrer shaft is driven by a 2 kW 3000 Hz explosion proof sparkles dc motor mounted on the lid and driven via a reduction system. The maximum speed about 600 rpm is to be able to meet with high density vegetable oil jatropha which is digitally controlled. For reaction chamber bolting and fastening is used. Top of reaction chamber is covered by the plate and fastened by rivets. In reaction chamber high pressure is generated for feeding feedstock a funnel is attached. This small plant is take three hours to complete one batch of biodiesel. It is drained to wash tank after completion of process. The constructed fabricated biodiesel plant is shown in Fig.3. Switch board is used for regulating temperature and speed panel. This biodiesel plant is fabricated in like a way that its accessories and parts can be assemble and dissemble when required. This make plant easy to handle and cleaning can be done frequently to avoid corrosion problem.

The processor container and stirrer are connected by means of mild steel rod. This rod carry the load of electrical motor, so it is bolted with processor container to avoid vibration problem. Processor container is made leakage prove by providing oil seal over the container. Lever valve is provided at the bottom of processor container to allow the high temporized biodiesel in sedimentation container. The sedimentation tank is also fabricated with precisely by providing funnel shape. At the top of the sedimentation tank a nozzle is provided to cool hot biodiesel at desirable temperature.

Fig. 3. The Fabricated Processor

V. Process of producing the Biodiesel

Biodiesel is made by a chemical process called transesterification, in which reactions takes place. This process is organically derived from oils (vegetable oils, animal fats and recycled restaurant greases) are combined with alcohol (usually methanol) and chemically altered to form fatty esters such as methyl ester. The process results in two products first is methyl esters (the chemical name for biodiesel) and second is crude glycerol (a valuable by-product usually sold for use in the production of soap).The non-edible oil i.e. jatropha is first pre-treated before being transesterified. Pre-processing consists in oil filtration to eliminate any suspended material and heating to 100 ° to evaporate the water contained. After establishment of pre-treatment, a volume of alcohol was added to a mass of non-edible jatropha oil. The reaction for the production of biodiesel was carried out with a 5:1 fixed ratio of alcohol: jatropha oil, with 1% catalyst (NaOH), under constant mixing and controlled temperature. The reaction is presented in following equation form.

$$\begin{array}{lclcl} \mathbf{CH_2COOR1} & & & \mathbf{CH_2OH} & \mathbf{R_1COOR} \\ \mathbf{CH_2COOR1} & + \ \mathbf{3ROH} & \underset{\longleftarrow}{\xrightarrow{\textbf{Catalyst}}} & \mathbf{CHOH} \ + & \mathbf{R_2COOR} \\ \mathbf{CH_2COOR1} & & & \mathbf{CH_2OH} & \mathbf{R_3COOR} \\ \textbf{(Triglyceride)} & \textbf{(Alcohol)} & & \textbf{(Glycerol)} & \textbf{(Biodiesel)} \end{array}$$

Fig. 4: Schematic of the Transesterification processes [4]

Separation will take place in two different layers for setting down the mixture over the night. Drainage valve is provided at the bottom for the container for collecting the biodiesel. Distilled water is used for washing biodiesel. Due to low density biodiesel will float on top layer of heavier glycerol. If it is found to have a good separation between the layers of biodiesel on top and glycerol on the bottom then drained the glycerine from the bottom. Take the biodiesel off into another container. While being extract out biodiesel care must be taken that it should not bring any glycerol or visible soap along with it. The produced biodiesel can be used after blending to diesel engine. The blending ratio is vary depending upon the raw material used to produce biodiesel. Most commonly B20 or B40 ratio is used in diesel engine. The crude glycerol can be used to make soap. It can be also be used as burning fuel due to its high calorific value in the range of 15-25 MJ/kg depending upon purity. The block diagram shows how the process occurs from raw material to final biodiesel. The pilot plant has provided one recovery of methanol arrangement. Methanol recovery is obtained when the process takes place in processor container. In which temperature of mixture will be increasing repeatedly. By that vapour will formed. Hence, this vapour is recover by the help of pipe at the top of dome shape of processor container and sent it in to the methanol recovery tank. The aim of this recovery arrangement is to reuse of methanol.

Fig. 6 Curd glycerol by product of biodiesel

Fig. 7 Biodiesel produced by jatropha oil

VI. Conclusions

The fabricated biodiesel plant is having capacity of producing biodiesel with given particulars. Produced Biodiesel from jatropha oil is having advantage over the agriculture prospectus. This seed can be produced on any land and also on large scale. One more advantage for selecting criteria, jatropha seeds as a raw material is it's economically feasibility. The produced biodiesel is tested in Lab and it is found similar properties given as per the ASTM standard for biodiesel. By blending with diesel it can be used in diesel engine. It is found that for better efficiency of diesel engine biodiesel produced from jatropha oil is generally preferred over the other biodiesel produced from different resources.

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