International Journal of Latest Engineering Research and Applications (IJLERA) ISSN: 2455-7137

Volume –04, Issue – 06, June 2019, PP –01-05

Design and Fabrication of Biodiesel Processsor

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Abstract: According to WHO(World Health Organization) the edible oil should not be heated more than twice. Oil heated more than twice may result in increase of carbon in the oils, which in long term may cause health problems. Many restaurants happen to discard the waste oil by throwing it into drainage which is a waste of resource, keepingthis in mind the aim of the project is to recycle waste edible oils by converting it into Biodiesel through esterification process. The waste edible oils are collected and processed in the Biodiesel processor.

Keywords: Biodiesel, Esterification, Edible oil, Trans-Esterification, Waste oil.

I. INTRODUCTION

Biofuels are a wide range of fuels which are derived from biomass. The term covers solid biomass, liquid fuels and various biogases. Biofuels are gaining increased in public and scientific attention, driven by factors such as oil price hikes and the need for increased in energy security. Bio-ethanol is an alcohol made by fermenting the sugar components of a plant materials and it is made mostly from sugar and starch crops. With advanced technology being developed, cellulosic biomass, such as trees and grasses, are also used as feedstock for ethanol production. Biodiesel is a renewable fuel that can be produced from vegetable oils, animal fats, and used cooking oil including triglycerides.

Biodiesel, an alternative biodegradable diesel fuel, is derived from triglycerides by transesterification with methanol and ethanol. Concerns about the depletion of diesel fuel reserves and the pollution caused by continuously increasing energy demands make biodiesel an attractive alternative motorfuel for compression ignition engines. There are four different ways of modifying vegetable oils and fats to use them as diesel fuel, such as pyrolysis (thermal cracking), dilution with hydrocarbons (blending), emulsification and transesterification. The most commonly used process is transesterification of vegetable oils and animal fats. The transesterification reaction is affected by molar ratio of glycerides to alcohol, catalysts, reaction temperature, reaction time and free fatty acids and water content of oils or fats. In the transesterification, free fatty acids and water always produce negative effects, since the presence of free fatty acids and water causes soap formation, consumes catalyst and reduces catalyst effectiveness, all of which result in a low conversion.

Cooking oils make some of the best biodiesel. These are unsaturated oils with a single or double bond per fatty acid. Canola is probably the best oil for making biodiesel, since it ages slowly, remains liquid to low temperatures, and has high energy content. Olive oil is good oil for making biodiesel. It has a slightly higher gel point, is slightly less stable, and has about the same energy content as Canola oil due to its slightly increased polyunsaturated and saturated content.

Hydrogenated oils are oils that have been chemically altered to remove the double bonding. The purpose behind hydrogenation is to lengthen the shelf life of cooking oil, but they are unhealthy oils for our bodies. Also, it is difficult to make biodiesel from hydrogenated oils. That is not by accident; the best cooking oils make the best biodiesel there is a persistent myth on the internet that Chinese restaurants have the best oils for biodiesel that is true if they use unsaturated, non-hydrogenated oils. Look for restaurants that sell healthy foods; their WVO makes the best biodiesel. Not only do they use the better oils, but they are more likely to be lower in FFA than other restaurants due to their cooking practices.

II. HEADINGS

1. Literature Survey

Zhang et al. [1], conducted a study on production of biodiesel from waste cooking oil. Four different continuous process flow sheets for biodiesel production from virgin vegetable oil or waste cooking oil under alkaline or acidic conditions on a commercial scale were developed. A technological assessment of these four processes was carried out to evaluate their technical benefits and limitations. Analysis showed that the alkali-catalyzed process using virgin vegetable oil as the raw material required the fewest and smallest process equipment units but at a higher raw material cost than the other processes. The use of waste cooking oil to produce biodiesel reduced the raw material cost. The acid-catalyzed process using waste cooking oil proved to be technically feasible with less complexity than the alkali-catalyzed process using waste cooking oil, thereby making it a competitive alternative to commercial biodiesel production by the alkali-Catalyzed process. Boyce and Hossain [2], in their work compared optimum conditions of alkaline catalyzed transesterification process for biodiesel production from pure sunflower cooking oil (PSCO) and waste sunflower cooking oil (WSCO) through transesterification process. The highest approximately 99.5% biodiesel yield acquired under optimum conditions of 1:6 volumetric oil-to-methanol ratio, 1% KOH catalyst at 40ºC reaction temperature and 320 rpm stirring speed. Result of the test showed that the biodiesel production from PSCO and WSCO exhibited no considerable differences. Prafulla et al. [3], carried out comparative study on biodiesel production from waste cooking oil using sulfuric acid (Two-step) and microwave-assisted transesterification (One-step). The two-step transesterification process was used to produce bio-diesel (alkyl ester) from high free fatty acid (FFA) waste cooking oil. While Microwave assisted transesterification was done by using catalytic BaO and KOH in biodiesel production from waste cooking oil. The study shown that that the microwave-heating method consumes less than 10% of the energy to achieve the same yield as the conventional heating method. Further, fuel properties of biodiesel produced were compared with ASTM Standards for biodiesel and regular diesel. Deshpande et al. [4], studied transesterification reaction on castor oil in a batch reactor using potassium hydroxide as a catalyst. The variables chosen for the study were reaction time, Oil to methanol ratio, catalyst concentration; and reaction temperature. The effects of these variables on the viscosity of biodiesel were studied, since this is one ofthe important specifications in ASTM standard. Apart from viscosity other properties like specific gravity, acid value, and sap value were also determined for the biodiesel product. From the study it was concluded that the optimum operating condition are oil to methanol mole ratio 1:9, temperature 30oC, catalyst concentration 1 wt % and run time45 min.

2. Methodology

This processor different processes can be divided into three parts in first par the waste oil is filtered and mixture of methanol and catalyst namely NaOH is prepared according to the required proportions. In the second part it consists of a reactor tank which has a temperature controller with it with the help of pipe and valve mechanism and sensors the oil and meth oxide are pumped in the reactor tank and reaction takes place. In the third part the generated Biodiesel is pumped in the wash tank where it is washed with water to remove any impurities present in the mixture

The meth oxide tank ensures the storage of a mixture of pure methanol and a catalyst (NAOH). A catalyst is used to ensure the reaction takes place quickly. The processing stage consists of a reactor tank connected to its own pump for recalculating and mixing of the reactants. Mixing all of the reactants in one container ensures homogeneity of the oil in the container and also the meth oxide ratio's. The solution is heated up to 60°C by means of heating element which is followed by constant circulation of solution by means of pump. The constant circulation ensures proper mixing of solution as well as even distribution of heat. The solution is allowed to settle down for2-3 hours the layer of biodiesel gets separated along with a deposit of glycerin on the bottom of the tank. This glycerin is extracted out by means of drain off valve and discarded. The glycerin formed is totally harmless to the environment. There are many methods of washing available when processing biodiesel. An ideal washing method maximizes interaction between the fresh biodiesel and washing water, while minimizing the risk of emulsifying.

3. Design of the Model

The project design is proposed keeping in mind the main objectives of the project i.e. production of a biodiesel processor which is cheap and simple in construction. The main focus of project is to fabricate a Biodiesel Processor which would help recycle the waste vegetable oils used in the restaurants, hotels by converting it into Biodiesel. The Processor consists of four tanks namely Oil tank, Meth-oxide tank, Reactor tank, and Wash tank. The processing stage consists of a reactor tank connected to its own pump for recirculating and mixing of the reactants. Mixing all of the reactants in one container ensures homogeneity of the oil in the container and also the meth oxide ratio. PTC Creo, formerly known as Pro/ENGINEER and Wildfire, isa 3D CAD, CAM, CAE, and associative solid modeling app. It is one of a suite of 10 collaborative applications that provide solid modeling, assembly modeling, 2-D orthographic views, finite element analysis, direct and parametric modeling, sub-divisional and NURBS surface modeling, &amp NC and tooling functionality for mechanical designers. This project uses Creo as the design software that is used to create 3d as well as 2d model.

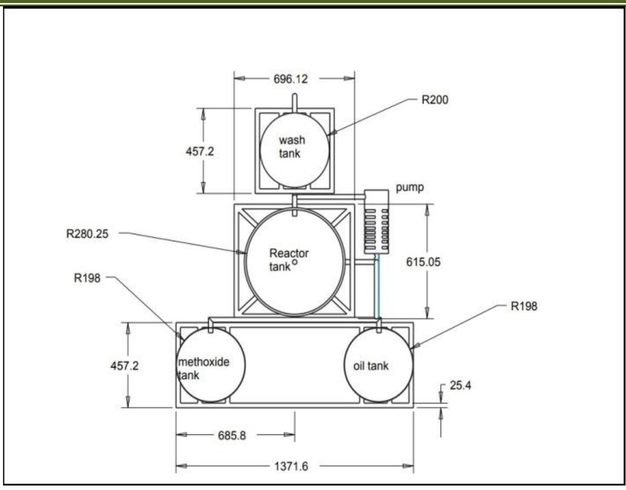

Fig. Top View of the Model

The Processor consists of four tanks namely Oil tank, Meth-oxide tank, Reactor tank, and Wash tank. The processing stage consists of a reactor tank connected to its own pump for recirculating and mixing of the reactants. Mixing all of the reactants in one container ensures homogeneity of the oil in the container and also the methoxide ratio's.

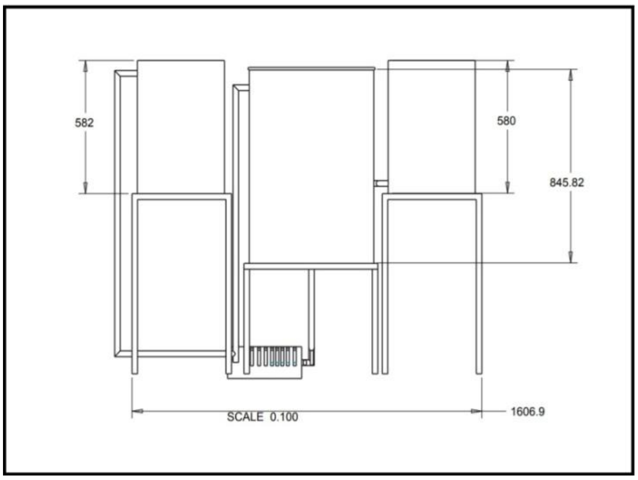

Fig. Side View of the Model

For the preliminary design of Biodiesel Processor Creo 3.0 software was used.Even though, the manufacturing of processor is little varying with the original design, the main structure was retained from the main concept.

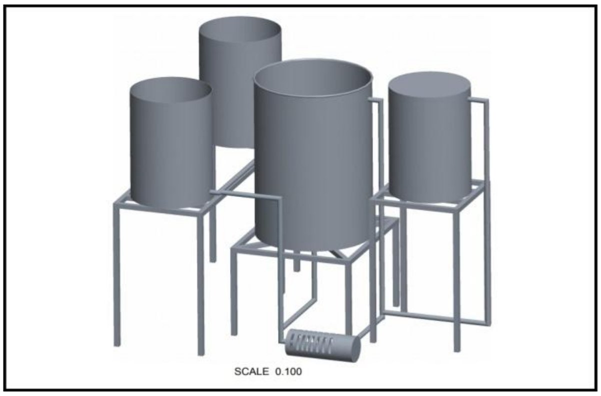

Fig.3D Model of the Processor

III. PROPORTION OF METHANOL AND CATALYST

1. METHANOL

For the transesterification reaction to take place the proportion of methanol plays a vital role. The proportion of methanol varies from oil to oil, each oil has different glycerides so before calculation of methanol proportion the nature of oil must be known.Oils from various feedstock's are basically triglycerides molecules composed three ester mostly attached to a glycerin one. which means from each molecule of oil we can produce maximum 3 molecules of biodiesel.

1 mol Oil + 3 mol of methanol= 3 mol biodiesel + 1 mol of glycerol

Trans-esterification being a bi-directional chemical reaction and a rather slow one, more reactant is to be added to shift the equilibrium towards product side in order to ensure complete conversion of oil to biodiesel. Molar mass of methanol is 32.04g.

Molar mass of oils can be determined from the methyl ester composition. Different oil have different composition and hence different molecular weight. If we assume,

average chain length of the ester = 18,

We get the molecular weight of oil as 812g

i.e. 812 g of oil needs 32.04*3= 96.12gms of methanol

To be on safer side we use 100-120g of Methanol.

The ratio is 1:6-1:10.

2. CATALYST

Biodiesel production is widely conducted through transesterification reaction, catalyzed by homogeneous catalysts or heterogeneous catalysts. The most notable catalyst used in producing biodiesel is the homogeneous alkaline catalyst such as NaOH, KOH, CH_3ONa and CH_3OK. The choice of these catalysts is due to their higher kinetic reaction rates. However because of high cost of refined feedstock's and difficulties associated with use of homogeneous alkaline catalysts to transesterify low quality feedstock's for biodiesel production, development of various heterogeneous catalysts are now on the increase. Development of heterogeneous catalyst such as solid and enzymes catalysts could overcome most of the problems associated with homogeneous catalysts. Therefore this study critically analyzes the effects of different catalysts used for producing biodiesel using findings available in the open literature. Also, this critical review could allow identification of research areas to explore and improve the catalysts performance commonly employed in producing biodiesel fuel.

The weight catalyst in biodiesel production is calculated based on your oil weight.

5wt. % of catalyst for 100 g of oil

I.e. catalyst is (5/100) x 100 g = 5 g of catalyst.

IV. ADVANTAGES AND DISADVANTAGES

1. Advantages

- Low toxicity, in comparison with diesel fuel.
- Renewable fuel, obtained from vegetable oils or animal fats.
- Degrades more rapidly than diesel fuel, minimizing the environmental consequences of Biodiesel spills.
- Lower emissions of contaminants: carbon monoxide, particulate matter, polycyclic aromatic hydrocarbons, aldehydes.
- Lower health risk, due to reduced emissions of carcinogenic substances.
- No sulfur dioxide (SO2) emissions.
- It has higher flash point (100°C minimum).
- May be blended with diesel fuel at any proportion; both fuels may be mixed during the fuel supply to vehicles.
- It is the only alternative fuel that can be used in a conventional diesel engine, without modifications.
- Used cooking oils and fat residues from meat processing may be used as raw materials.

2. Disadvantages

- Slightly higher nitrous oxide (NOx) emissions than diesel fuel.
- Higher freezing point than diesel fuel. This may be inconvenient in cold climates.
- It is less stable than diesel fuel, and therefore long-term storage (more than six months) of biodiesel is not recommended.

- May degrade plastic and natural rubber gaskets and hoses when used in pure form.
- It dissolves the deposits of sediments and other contaminants from diesel fuel in storage tanks and fuel lines, which then are flushed away by the Biodiesel into the engine, where they can cause problems in the valves and injection systems.
- Slightly higher fuel consumption due to the lower calorific value of biodiesel.

V. CONCLUSION AND FUTURE SCOPE

1. Conclusions

The catalytic modification of vegetable oils is a promising method to obtain a substitute fuel for diesel engines. Among various types of modification, the transesterification process is more economical, easier and faster, producing a stable product which can be used directly in current engines.

This project aims to design and implementation the Biodiesel processor in recycling waste edible oils to produce biodiesel which can be used to power diesel engines. There is a requirement of increase in research work in the field of renewable energy sources to meet the future energy requirements.

These models vary in complexity and accuracy and therefore the model chosen must match the application for which it is needed. It will be very helpful in recycling oils at a smaller scale. In this day where the world is challenged to be more responsible in its sourcing of energy, the method of recycling oils could be a solution that also helps mitigate the energy requirement. If additional design and study of this concept proves it to be more effective in Biodiesel production it could be used as an alternate source of energy.

2. Future Scope

- The size of the processor was limited to 30 liters if the processor size was increased it could produce Biodiesel in bulk amount. Various other oil can be processed into biodiesel such as motor oils, chicken waste, grease.
- This processor can be implemented in municipalities, institutions where in a waste oils can be collected and processed into biodiesel instead of disposing waste oil in drainage.

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