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A LOW COST REACTOR FOR MANUFACTURING BIODIESEL FROM WASTE VEGETABLE OIL

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ABSTRACT

A very simple and cost effective reactor for manufacturing biodiesel is designed and fabricated from fully recycled materials. This reactor can be effectively used in a home or a small hotel to manufacture biodiesel from recycled vegetable oil. The biodiesel thus manufactured has the calorific value of 10932.57 Cal/gm. The biodiesel obtained from waste vegetable oil is much cheaper than the available petroleum based diesel. This will also reduce the reuse of vegetable oil in the hotel industry, thus making the industry and the food healthier. The inputs given to the reactor are waste vegetable oil, methanol and potassium Hydroxide and the output is biodiesel and glycerin.

KEYWORDS: Biodiesel, Waste Vegetable Oil, Reactor, Transesterification

INTRODUCTION

The costs of petroleum based fuels are going very high. This in turn affects the price of each and every commodity used in our day to day life. An auxiliary, cheap fuel; that could be readily used in the existing engines without many changes is the biodiesel. It becomes more cost effective when manufactured from waste vegetable oil.

Various research works are being carried out in the manufacturing of biodiesel and its commercial feasibility. Zhang et al. [1] in his paper on biodiesel production from waste cooking oil emphasizes the economic feasibility and raw material availability on depending on waste vegetable oil for biodiesel production. Biodiesel processing and production by Gerpen et al. [2], had made a study about the process of manufacturing biodiesel. He says that it is an alternative fuel that is produced from vegetable oils and animal fats. It consists of monoalkyl esters formed by a catalyzed reaction by the triglycerides in the oil or fat with a simple monohydric alcohol. The reaction conditions generally involve tradeoff between reaction time and temperature as reaction completeness is the most critical fuel quality parameter. Much of the process complexity originates from contaminants in the feed stock, such as water and free fatty acids, or impurities in the final product, such as methanol, free glycerol and soap. Processes have been developed to produce biodiesel from high free fatty acid feed stocks, such as recycled restaurant grease, animal fat and soap stock.

A study on new markets for conventional and genetically modified agricultural fats and oils by U.S biodiesel development board [4] says that with environmental and energy source concerns on the rise, using agricultural fats and oils as fuel in diesel engines has captured increasing attention. Substituting petroleum diesel with biodiesel may reduce air emissions, increase the domestic supply of fuel, and create new markets for farmers. U.S. agricultural fats and oils could support a large amount of biodiesel, but high production costs and competing uses for biodiesel feed stocks will likely prevent mass adoption of biodiesel fuel. Higher-priced niche markets could develop for biodiesels as a result of environmental regulations. Biodiesel has many environmental advantages relative to petroleum diesel, such as lower CO, CO_2, SO_2, and particulate matter emissions.

Enhancing fuel properties by genetically modifying oil crops could improve NOx emissions, cold flow, and oxidative stability, which have been identified as potential problems for biodiesel. Research activities need to be directed toward cost reduction, improving fuel properties, and analyzing the economic effects of biodiesel development on U.S. agriculture. In an overview on the status of biodiesel as an alternative fuel for diesel engine by Jaichandar and Annamalai [3], growing concern regarding energy resources and the environment has increased interest in the study of alternative sources of energy. To meet the energy requirements, there has been growing interests in alternative fuels like biodiesel to provide a suitable diesel oil substitute for internal combustion engines. Biodiesels offer a very promising alternative to diesel oil since they are renewable and have similar properties.

Biodiesel is defined as a transesterified renewable fuel derived from vegetable oils or animal fats with properties similar or better than diesel fuels. Extensive research and demonstration projects have shown it can be used pure or in blends with conventional diesel fuels in unmodified diesel engines. This paper reveals the history of biodiesel development and production practices. Fuel related properties are reviewed and compared with those of conventional diesel fuels. The effect of use of biodiesel fuel on engine power, fuel consumption and thermal efficiency are collected and analyzed with that of conventional diesel fuel. In the subsequent section, the engine emissions from biodiesel and diesel fuels are compared, paying special attention to the most significant emissions such as Nitric oxides and particulate matter. In a journal of the Brazilian chemical society authored by Angelo et al. [5], the importance of biodiesel production was analyzed based on scientific articles and patents.

A critical analysis was presented on the most used oil sources, the catalyst and the methods to verify the transesterification yields. Also analyze were the comparative studies on emissions from pure fossil diesels and mixtures with biodiesel in variable proportions. Finally, some challenges and considerations focused on technological and infrastructural aspects of biodiesel production were indicated.

The studies in the field of biodiesel make it a promising renewable form of fuel that can be readily used in diesel engines. So an attempt is made to fabricate a reactor that readily transforms waste vegetable oil into biodiesel.

MATERIALS AND EXPERIMENTS

Designing of the Reactor

The process of transesterification was well studied and experimented. The reactor was so designed to mechanize the processes that were done manually in a laboratory. Care was taken to minimize the cost of raw material in building the reactor.

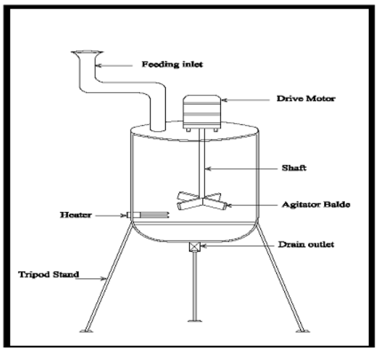

Figure 1: Diagram of the Biodiesel Reactor

Raw Materials for Reactor

A 0.5 HP, A.C, induction motor was used to drive the agitator. Agitator plates were made using mild steel. A steel shaft connected the motor to the agitator blade. A stainless steel vessel acted as a tank. A 1000 watts submersible heater supplied heat to the mixture.

Building the Reactor

The heater unit was fixed on the side of the tank just above the base of the tank. A lid was made out of mild steel to cover the top of the tank. The agitator motor was loaded on to this top cover of the tank with foundation bolts. Adequate rubber bushing was provided between the top cover and the motor to sustain the vibrations from the motor. A blade was welded and fabricated out of mild steel to perform the agitation. This was joined to the motor spindle by a steel shaft. Care was taken to provide ample space for the heater unit. A tripod stand was fabricated to support the reactor unit at a feasible height for the ease of operation. An inlet feeding port and a drain valve was fixed to the reactor. The biodiesel reactor was fully fabricated as per the design shown in figure 1.

Manufacturing Biodiesel

The waste oil was filtered in an adequate sieve to remove any sediments of food. It was fed in to the reactor through the inlet port. The heater unit was switched on and temperature of the oil was raised to 100^{o}C. This removed any water content present in the waste vegetable oil. Now the heater was switched off and the agitator turned on. The oil was well agitated. As the temperature falls to 80^{o}C, methanol, mixed with catalyst is fed into the reactor. The agitation was continued for another half an hour keeping temperature constant at 80^{o}C. Now all the units were switched off and the mixture was allowed to sediment for 24 hours. The glycerol was the sediment at the bottom of the reactor. The glycerol and the biodiesel were drained out through the valve provided at the bottom of the reactor. pH of the biodiesel was high. So it was mixed with water in a separating funnel and the water was sediment and drained away. This process was done thrice to wash away the soap content in the biodiesel due to the usage of potassium hydroxide as the catalyst. A mild heating was done to get pure biodiesel.

Tests Conducted

Calorific Value

Calorific value may be defined as the amount of heat released by a unit volume of a substance during complete combustion. A sample of biodiesel was drawn from the reactor and tested for its calorific value. The test method was IS: 1448(P-7) 2004. This method employs a bomb calorimeter to test the calorific value of the specimen.

Dynamic Viscosity

Dynamic viscosity is a quantitative expression of a fluids resistance to flow. The dynamic viscosity test was conducted with internationally accepted equipment- Brookfield LVDV2T digital viscometer.

Flash and Fire Point

The flash point of a flammable liquid is the lowest temperature at which it can form an ignitable mixture in air. At this temperature, the vapor may cease to burn when the source of ignition is removed. The fire point is defined as the temperature at which the vapor continues to burn after being ignited. The flash point and fire point was tested in open cup cleave land flash and fire point apparatus.

RESULTS AND DISCUSSIONS

The calorific value of the biodiesel from waste vegetable oil was found to be 10932.57 Cal/gm. This is slightly lower than the calorific value of petroleum based diesel fuels. But this can be compensated on commercial point of view as the cost per liter is very less for biodiesel. The dynamic viscosity at 40^{o} was 14.07 cP and at 100^{o}C was 4.66 cP respectively. A graph is plotted with temperature on X axis and corresponding viscosity on Y axis. The flash point of biodiesel from waste vegetable oil was 180^{o}C while the fire point reached 190^{o}C. This made the fuel safer for storage and transportation.

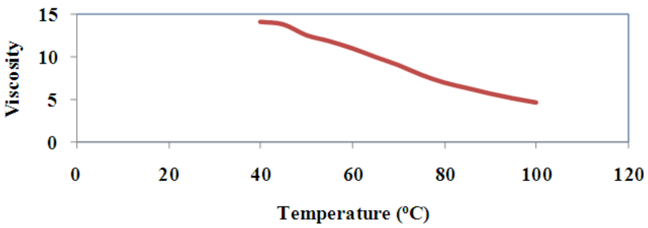

Figure 2

CONCLUSIONS

A low cost reactor for manufacturing biodiesel from waste vegetable oil was fabricated. Waste vegetable oil was converted to biodiesel using this reactor. The biodiesel was tested for its properties and the following conclusions were arrived at.

- The calorific value of biodiesel from waste vegetable is slightly lower compared to petroleum based diesel. But this is of least concern as the biodiesel is much lower priced.
- The biodiesel from waste vegetable oil will perform well in turbo charging applications as this posse a higher dynamic viscosity than petroleum diesel.
- The biodiesel proves to be a safer fuel when it comes to storage and transportation. Their higher flash and fire points prove them more resistant to accidental ignitions.

REFERENCES

1. Biodiesel production from waste cooking oil: 1. Process design and technological assessment Y. Zhang, M. A. Dub, D. D. McLean, M. Kates

2. Biodiesel processing and production by Jon Van Gerpen; University of Idaho, Moscow, ID 83844, USA.(2005)
3. The status of biodiesel as an alternative fuel for diesel engine – An overview by S. Jaichandar and K. Annamalai; Sreesastha Institute of Engineering and Technology, Chennai- 123, Tamilnadu. (2011)
4. U.S Biodiesel development: New markets for conventional and genetically modified agricultural fats and oils. – James Duffield, Hosein Shapouri, Michael Graboski, Robert McCormick and Richard Wilson.(1996)
5. Biodiesel: an overview by Journal of the Brazilian chemical society – Angelo C. Pinto, Lilian L. N. Guarieiro, Michelle J. C. Rezende.(2005)
6. Main technologies in biodiesel production: State of the art and future challenges – E. Santacesaria, G. Martinez Vicente, M. Di Serio, R. Tesser. (2012)
7. Contractual arrangements for small holders in biofuel chains: A case study of Jatropha in Mozambique. – Jos Bijman, Maja.S lingerland and Sander Van Baren.(2009)