DESIGN, FABRICATION AND PERFORMANCE EVALUATION OF TRANSESTERIFICATION REACTOR FOR BIODIESEL PRODUCTION USING WASTE VEGETABLE OIL

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ACCEPTANCE SHEET

This undergraduate thesis entitled, **DESIGN, FABRICATION, AND PERFORMANCE EVALUATION OF TRANSESTERIFICATION REACTOR FOR BIODIESEL PRODUCTION USING WASTE VEGETABLE OIL**, prepared and submitted by **HYLEEN JOY S. AGUSTIN** as partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN AGRICULTURAL BIOSYSTEMS ENGINEERING (AGRICULTURAL POWER, ENERGY AND MACHINERY ENGINEERING)**, is hereby approved:

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BIOGRAPHICAL SKETCH

The author, Hyleen Joy S. Agustin, born on December 01, 1997 at Cabanatuan, Nueva Ecija. She the oldest among the two children of Mr. Elmer G. Agustin and Mrs. Jennet S. Agustin.

She finished her elementary education at Victoria East Central School located at Sta. Barbara, Victoria, Tarlac on March 2010 and secondary education at Makabulos Memorial High School located at Victoria, Tarlac on March 2014. The following school year, she enrolled at Central Luzon State University and took Bachelor of Science in Agricultural and Biosystems Engineering.

During her college life, she became a member of Student Cultural Society (SCS) for 2 years and at the same time a University Athlete of Futsal team for 4 years. She also became a member of Society of Agricultural Engineering Students – Philippine Society of Agricultural Engineers (SAGES-PSAE).

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ABSTRACT

AGUSTIN, HYLEEN JOY SUAREZ, Department of Agriculture and Biosystems Engineering, College of Engineering, Central Luzon State University, Science City of Muñoz, Nueva Ecija, **June 2019. DESIGN, FABRICATION AND PERFORMANCE EVALUATION OF TRANSESTERIFICATION REACTOR FOR BIODIESEL PRODUCTION USING WASTE VEGETABLE OIL**

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Depletion of petroleum derived fuel and environmental concern has promoted to look over the biofuel as an alternative fuel sources. At present, used cooking oil is often disposed of in an environmentally hazardous manner, causing pollution and choking sewage systems. Although vegetable oil could be used directly as fuel in diesel engines, the most important limitation lies in the fact that high viscosity of vegetable oils results in poor atomization in the engines combustion chamber which eventually leads to other operational problems. Generally, biodiesel is less viscous than petroleum diesel that was good lubricant for diesel engines. This study deals with the design, fabrication and performance evaluation of transesterification reactor for biodiesel production using waste vegetable oil. The general objective of the study was to design, fabricate and evaluate the performance of transesterification reactor for biodiesel production using waste vegetable oil.

The principle of transesterification works on different parameters such as alcohol/oil ratio, catalyst concentration, reaction temperature, reaction time, and mixing speed. The treatment used were the different reaction time (90, 120 and 150 minutes) of used vegetable oil with methanol. Data were analyzed using single factor experiment at Complete Randomized Design (CRD) and comparison among means was done using Least

Significant Difference (LSD). The performance of transesterification reactor in terms of density, viscosity and yield of biodiesel were determined.

Result showed that the lowest density (0.86 g/cm^3) of biodiesel produced from the transesterification reactor was attained when the reaction time was at 120 minutes.

At the same reaction time, the lowest viscosity of biodiesel produced with a mean of 3.35 cst was attained when the reaction time was at 120 minutes.

While, the maximum yield of 81.82% biodiesel production was attained after 90 minutes of reaction time. Meanwhile, the lowest yield of 75.57% was attained when the reaction time was at 150 minutes.

The total investment cost of the concentrator was Php 14,700.00. Cost analysis showed that operating the transesterification reactor had a projected annual cost of 502,871.232 Php/year. The operating cost was 261.91 Php/hour and it can produce 8.18 liters of biodiesel in one hour. One-liter mixture of waste vegetable oil and methanol can convert to 818 ml of biodiesel and the cost per liter of produced biodiesel was 32.02 Php/L.

Keywords: biodiesel; transesterification; viscosity; density

LITERATURE CITED

BATARA, G. (2015). Design, Fabrication, and Performance Evaluation of a Small-Scale Barrel Type Potato Washer. Department of Agricultural Engineering, College of Engineering, Central Luzon State University, Science City of Munoz, Nueva Ecija, Philippnes

BEDONIA, J. B. (2017). Design, Fabrication and Performance Evaluation of Biomass Feedstock Concentrator for Bioethanol Production. Department of Agricultural Engineering, College of Engineering, Central Luzon State University, Science City of Munoz, Nueva Ecija, Philippnes

BILGIN, A., M. GULUM, I. KOYUNCUOGLU, E. NAC and A. CAKMAK. (2015). Determination of transesterification reaction parameters giving the lowest viscosity waste cooking oil biodiesel. Karadeniz Technical University, Faculty of Engineering, Department of Mechanical Engineering, Trabzon 61080, Turkey.

CLIFFORD, C. (2018). The Reaction of Biodiesel: Transesterification. John A. Dutton e-Education Institute College of Earth and Mineral Sciences at The Pennsylvania State University. Retrieved on December 3, 2018 at https://www.e-education.psu.edu/.

COKER, K. (2001). Modeling of chemical kinetics and reactor design. AKC technology, Boston Oxford Johannesburg Melbourne New Delhi Singapore. 2nd edition.

CORPUZ, P. (2017). Philippines Biofuels Annual Philippine Biofuels Situation and Outlook. USDA Foreign Agricultural Service.

DUDA, B. J. (2008). The Duda Diesel Guide on How to Make Biodiesel. Biodiesel & Alternative Energy Supplies. Retrieved on December3, 2018 at http://www.dudadiesel.com/biodiesel.php.

ELKADY, M. F., A. ZAATOUT and O. BALBAA. (2015). Production of Biodiesel from Waste Vegetable Oil via KM Micromixer. Journal of Chemistry Vol. 2015, Article ID: 630168, pp.9.

ELOMINA, J. (2018). Biofuels in the Philippines. Retrieved on December 3, 2018 at https://wiki.uef.fi/display/BIOMAP/Jerbelle+Elomina%2C+Philippine+Biofuel+Status.

ERYILMAZ, T., F. AKSOY, L. AKSOY, H. BAYRAKCEKEN, F. AYSAL, S. SAHIN and M. YESILYURT. (2018). Process Optimization for Biodiesel Production from Neutralized Waste Cooking Oil and the Effect of this Biodiesel on Engine Performance. Department of Biosystems Engineering- Bozok University,66200, Yozgat, Turkey. Vol 8, N0. 1, pp. 121 – 127.

HASAN A. M., M. A. MASHKOUR, and A. A. MOHAMMED. (2016). Impact of mixing speed and reaction time on the Biodiesel production from sunflower oil. Journal of the Association of Arab Universities for Basic and Applied Sciences.

HASSAN, M. H. and A. KALAM. (2013). An overview of biofuel as a renewable energy source: development and challenges. Department of Mechanical Engineering, University of Malaya, Kuala Lumpur, Malaysia. Procedia Engineering 56, pp. 39 – 53.

HUNT, D. (1977). Farm Power and Machinery Management. Laboratory Manual and Workbook. Seventh Edition. IOWA State University Press, AMES, IOWA pp. 3-4, 63-77.

INNOCENT, D., O. SYLVESTER, M. YAHAYA, I. NWADIKE, and L. OKORO. (2013). Comparative Analysis of Biodiesel and Petroleum Diesel. Department of Petroleum Chemistry and Engineering, American University of Nigeria, Lamido Zubairu Way, P.M.B 2250 Yola Bypass, Adamawa State, Nigeria. International Journal of Education and Research. Vol. 1, No. 8.

KEN RESEARCH. (2018). Philippines Cooking Oil Market Outlook to 2021. Ankur Gupta, Head Marketing & Communications. Unit 14, Tower b3, Spaze I Tech Business Park, Sohna Road, Sector 49 Gurgaon, Haryana - 122001, India.

KORBITZ, W. (2002). New trends in developing biodiesel worldwide, in Asia Biofuels: Evaluating & Exploiting the Commercial Uses of Ethanol, Fuel Alcohol & Biodiesel, Singapore.

KUMAR, A., N. KUMAR, P. BAREDAR, and A. SHUKLA. (2015). A review on biomass energy resources, potential, conversion and policy in India. Renewable and Sustainable Energy Reviews, Vol. 45, pp. 530-539.

MOLLAHOSSEINI, A., M. TABATABAEI, and G. NAJAFPOUR. (2015). Biochemical Engineering and Biotechnology, Edition: 2nd Edition, Chapter: Biofuel Production. Iran.

MONTEFRIO, M. J. F., and J. OBBARD. (2010). The Economics of Biodiesel Derived from Waste Cooking Oil in the Philippines. Energy Sources Part B Economics Planning and Policy.

MOSS, P. (2010). Biodiesel Plant Safety. BBI International. Retrieved on December 3, 2018 at http://www.biodieselmagazine.com/articles/4055/biodiesel-plant-safety/.

NICHIT, V., V. SHINDE, and S. B. CHAVAN. (2014). Design of Biodiesel Plant using Transesterification process for Non-edible oil seeds. International Engineering Research Journal. Pp. 1855-1861.

PETERS M. S. and K. D. TIMMERHAUS. (2003). Plant Design and Economics for Chemical Engineers. 5th ed. New York: McGraw Hill.

QUITOL, E. (2017). Inventor turns cooking oil into Biofuel. Philippine Information Agency. Republic of the Philippines.

RAMADAS, A. S., S. JAYARAJ, and C. MURALEEDHARAN. (2004) Biodiesel production from high FFA rubber seed oil. Journal of Fuel (2005), 84, pp. 335-340.

RAQEEB M. A. and R. BHARGAVI. (2015). Biodiesel production from waste cooking oil. Department of Chemical Engineering, SRM University, Chennai, India. Journal of Chemical and Pharmaceutical Research. Vol. 7(12), pp. 670-681. ISSN: 0975-7384.

REFAAT, A. (2010). Different techniques for the production of biodiesel from waste vegetable oil. Department of Chemical Engineering, Faculty of Engineering, Cairo University, Egypt. Int. J. Environ. Sci. Tech., Vol. 7 (1), pp. 183-213, ISSN: 1735-1472.

RICK DA TECH. (2018). Water Washing Biodiesel. Water Washing - Make Biodiesel. Retrieved on January 26, 2019 at http://www.make-biodiesel.org/Water-Washing/water-washing-bio.html.

ROMANO, S. and P. SORICHETTI. (2011). Chapter 2 Introduction to Biodiesel Production, DOI: 10.1007/978-1-84996-519-4_2, Springer-Verlag London Limited.

SCHUCHARDT, U., R. SERCHELI, and R. VARGAS. (1997). Transesterification of Vegetable Oils: A Review. J. Braz. Chem. Soc., Vol. 9, No. 1, pp. 199-210.

SHALABY, E. (2013). Biofuel: Sources, Extraction and Determination. Biochemistry Department of Agriculture, University of Ruyku, Cairo University, Egypt.

STATISTICA, (2019). Palm oil consumption in Philippines from 2000 to 2018. 55 Broad Street; 30th floor, New York, NY 10004, United States. RSC Advances.

TEOH, Y. H. (2015). Comparative Assessment of Performance, Emissions and Combustion Characteristics of gasoline/diesel and gasoline/biodiesel in a dual-fuel engine. Universiti Sains Malaysia.

THE PHILIPPINE STAR. (2015). Philippines seen among top biofuel consuming countries in Asia. Manila, Philippines. Retrieved on December 3, 2018 at https://www.philstar.com/business/2015/09/01/1494820/philippines-seen-among-top-biofuel-consuming-countries-asia#dg9IOL2lPj8jYovF.99.

TOWLER G. and R. SINNOTT. (2013). Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design. 2nd ed. Boston: Elsevier.

TURTON R., R. C. BAILIE, W. B. WHITING, J. A. SHAEWITZ and D. BHATTACHARYYA. (2012). Analysis, Synthesis and Design of Chemical Processes. 4th ed. Upper Saddle River: Prentice-Hall.

WASTE MANAGEMENT AND RESEARCH CENTER, (2006). Feasibility Report: Small Scale Biodiesel Production. Champaign, IL: Illinois Waste Management and Research Center. University of Illinois.