UNIVERSITI TEKNIKAL MALAYSIA MELAKA

OPTIMIZATION OF BIODIESEL PRODUCTION FROM WASTE COOKING OIL USING TAGUCHI METHOD

ANIS BINTI MOHAMAD TAIB

B091810190

BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY
(Technology Maintenances) WITH HONOURS

2022

Faculty of Mechanical and Manufacturing Engineering Technology

OPTIMIZATION OF BIODIESEL PRODUCTION FROM WASTE COOKING OIL USING TAGUCHI METHOD

Anis Binti Mohamad Taib

Bachelor of Mechanical Engineering Technology (Technology Maintenance) with Honours

2022

OPTIMIZATION OF BIODIESEL PRODUCTION FROM WASTE COOKING OIL USING TAGUCHI METHOD

ANIS BINTI MOHAMAD TAIB

A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering Technology (Technology Maintenaces) with Honours

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

DECLARATION

I declare that this Choose an item. entitled " Optimization Of Biodiesel From Waste Cooking Oil Using Taguchi Method" is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

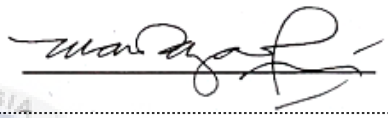
Signature : 

Name : Anis Binti Mohamad Taib

Date : 28/01/2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Technology Maintenances) with Honours.

Signature : 

Supervisor Name : Mahanum binti Mohd Zamberi

Date : 28/01/2022

DEDICATION

From the bottom of my heart this dedication specially for may parents Mohamad Taib bin Abdul Rahman and Aziah Binti Alang Ahmad, my sibling, my friend and also my teammates who being the most supportive people for me to go through this stage. With their word of encouragement and strong support to my system i can go this far in my life. To all UTeM Lecturer and staff who help me during the completion of research, special thanks for your dedication and never endless guidance for me. For me to go until this far seem very unbelieveble without guidance from my supervisor who always remind and guide my research to keep going on track. Despite all the memory of bittersweet completing studies and research, memory we endure together will remain forever in our mind.

ABSTRACT

The rising expense of petroleum products, as well the contribution of carbon emissions from petroluem diesel, which are damaging to the environment and human health, has prompted researchers looking for another means to substitute non-renewable energy. As an alternative, biodiesel shown a promising future to a global as a substitute to the fossil fuel. The main purpose of this research is to promote optimizing production of biodiesel from waste cooking oil using conventional batch tranesterification method. By utilizing the alkaline catalyst potassium hydroxide (KOH) all important variable impacting the overall biodiesel conversion such as methanol to oil molar ratio, catalyst loading, reaction time, reaction temperature has been examined. In order to achieve optimum yield production, all variables impacting the conversion of waste cooking oil were investigated by implementing Taguchi Method L9 (3^4) orthogonal array. All the produces biodiesel will be analyzed accordance to ASTM D6751 and EN14214 standard.

ABSTRAK

Peningkatan harga petroleum serta kesan pelepasan gas berbahaya yang membahayakan kesihatan manusia dan alam sekitar telah mendorong para pengkaji mencari alternatif lain untuk menggantikan sumber yang tidak boleh diperbaharui ini. Biodiesel merupakan salah satu alternatif terbaik dan mempunyai masa depan cerah untuk menggantikan bahan api fosil. Tujuan utama kajian ini adalah untuk meningkatkan dan mengoptimumkan penghasilan biodiesel dari minyak masak terpakai menggunakan kaedah transesterifikasi kumpulan konvensional. Penggunaan kalium hidroksida(KOH) sebagai pemangkin alkali serta pemboleh ubah yang memberi impak besar kepada pertukaran minyak masak terpakai kepada biodiesel, Contoh pemboleh ubah adalah methanol kepada nisbah minyak, reaksi pemangkin, reaksi masa, suhu tindak balas. Tuntasnya, jika ingin mendapatkan data tindak pemboleh ubah yang optimum, kesemua pemboleh ubah yang dimanipulasi hendaklah dianalisa menggunakan kaedah taguchi L9 (3^2) tatacara ortagonal. Setiap penghasilan biodiesel akan dianalisa mengikut piawai ASTM D6751 dan EN14214.

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

First and foremost, I would like to thank and praise Allah the Almighty, my Creator, my Sustainer, for everything I received since the beginning of my life. I would like to extend my appreciation to Universiti Teknikal Malaysia Melaka (UTeM) for providing the research platform. Thank you also to the Malaysian Ministry of Higher Education (MOHE) for the financial assistance.

My utmost appreciation goes to my main supervisor, Puan Mahanum Binti Mohd Zamberi, from Faculty Mechanical and Manufacturing, UTeM for all her support, advice and inspiration. Her constant patience for guiding and providing priceless insights will forever be remembered. Also, to my Academic Supervisor Encik Mohd Harris Fadhilah Bin Zainudin, Universiti Teknikal Malaysia Melaka (UTeM) who constantly supported my journey

Last but not least, from the bottom of my heart a gratitude to my beloved parents Mohamad Taib Bin Abdul Rahman and Aziah Binti Alang Ahmad, for encouragements and who have been the pillar of strength in all my endeavors. My special thanks for my teammates, Tuan Ismail Bin Tuan Zakaria, and Muhammad Ariff Bin Noor Salleh for their patience, idea and understanding. Finally, thank you to all the individuals who had provided me the assistance, support and inspiration to embark on my study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATION

D,d	-	Diameter
ASTM	-	American Society for Testing and Materials
EN	-	Europian Committe of stadardizations
WCO	-	Waste Cooking Oil
FFA	-	Free Fatty Acid
DoE	-	Design Of Experiment
OA	-	Orthogonal Array
ANOVA	-	Analysis Of Variance
S/N	-	Signal to Noise Ratio
RSM	-	Response Surface Method
AV	-	Acid Value
B100	-	100% Biodiesel
FAME	-	Fatty Acid Methyl Ester
GCMS	-	Gas Chromatography Mass Spectrometry
KOH	-	Potassium Hydroxide
MeOH	-	Methanol
MS	-	Mean Square
PCR	-	Percentage Contribution Ratio
SV	-	Saponification Value
TAN	-	Total Acid Number
NOx	-	Nitrogen Oxide
EGR	-	Exhaust Gas Recirculation

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Sustainability and energy problem have become more challenging starting from revolution industry time. Researcher Taghizade in (2016) stated that from all around the world are actively working on finding energy options that are reliable, secure, clean, economical, and sustainable to use. Futhermore, taken statement from Rezania in (2020) recently developing country actively working on finding new sources to replace non-renewable energy. Population arise around the world was one of the main reason for society to find another replacement for non-renewable energy that been said reduce year pass by with the population arise together with the demand for consuming non-renewable energy. Similarly with what Tavares (2017) said the increase demand of energy usage will adverse to economy global that lend so much on energy. Right now fossil fuel still being the major production of diesel around the world.

Nonetheless, sources of non-renewable energy supply was limited. This energy supply contribute to so many health and environmental problem. In the same way in study by Alias (2018) looking on another context, fossil fuel energy cannot be found everywhere. Moreover, only certain country, have the resources to import crude oil around the world . In this situation, so many step and level of process, the price of diesel in certain country with no resources was so expensive. Moving more to the future, so many contribution from

researcher in order to reduce the dependance on non-renewable energy. As a result, biodiesel might be viewed as a viable option for reducing the significant reliance on diesel fuels.

Biodiesel known as one of well known renewable energy to reduce greenhouse gas emmisions effect, and this production was in effort to replace the usage of non-renewable energy (Hanaki and Portugal-Pereira, 2018). The transportation sector's need for biodiesel is gradually increasing. Many countries for example Europian and the United State, have established energy laws requiring the use of greater biodiesel in their transportation sectors. Statistic from Idris on (2017) conclude that from 0.84 billion liters in 2000 to 20.2 billion liters in 2010 and 32 billion liters in 2014, worldwide biodiesel output has increased dramatically. Natural and promising economical in biodiesel industry was a brilliant choice source of sustainable energy. Liquid biofuel is an essential in daily life to fuel vehicle and engines. Futhermore, study together by Singh and Verma in (2019) admittedly that to produce biodiesel, process of transesterification take a big part in converting oil and glycerol into fatty acid alkyl ester and glycerol in the existence of an alcohol (methanol and ethanol) with suitable catalyst.

Romano and Sorichetti (2011) together also agree that common raw feestock include waste cooking oil, vegetable oil, grease, or fat from animal can be used to reduced wear and tear on engine. It should be brought to mind that, if the biodiesel can be a totally renewable fuel, it must be made from animal fats and vegetable oil, along with a biomass-derived alcohol, such as bioethanol, rather than a petrochemical product. Several nations, including Spain and Brazil, are conducting research in this area.

Consequently, the main purpose of this study is to get optimum yield biodiesel from waste cooking oil using conventional batch transesterification in the presence of potassium

hydroxide (KOH) as catalyst which is evidence by Zahan and Kano in (2018). To do so, all parameter impacting the overall biodiesel conversion such as methanol to oil molar ratio, catalyst loading, reaction time, reaction temperature were optimized using Taguchi method. The produced of biodiesel will be analyzed accordance to ASTM D6751 and EN14214 standard.

1.2 Problem Statement

Rising cost of petroleum product and contribution of carbon release from petroleum diesel that harmfull to environment and health, trigger the researcher to find another alternative way to replace non-renewable energy. Increasing number release emmision of greenhouse effect worsening the situation. High usage of vehicle on the road, release high emission of carbon dioxide that come from incomplete. The challenging in biodiesel industry was the the cost production of biodiesel still higher compare to petroleum based. The factor consist of cost of raw material and processing cost.

Untreated waste cooking oil was one of the sources that contribute to pollution. As a result, making biodiesel from used cooking oil was a great option, and more research on waste cooking oil characterisation is needed. Another issue with the usage of diesel is the worsening impact of rising greenhouse gas emissions in the environment. This is due to the significant carbon dioxide emissions caused by incomplete diesel fuel burning in automobiles. With many data to be analyse and sample to be produce. Taguchi method being used to optimized the parameter of methanol to oil molar ratio, catalyst loading, reaction time and reaction temperature.

1.3 Research Objective

The main purpose of this research is to enhance the production of biodiesel from waste cooking oil and optimization the transesterification parameter. Specifically, the objectives are follow

a. To produce biodiesel from waste cooking oil using potassium hydroxide (KOH) via batch conventional method.
b. To optimize all the variables such as methanol to oil molar ratio, catalyst loading, reaction, reaction temperature in order to produce optimum yield production using Taguchi Method.
c. To validate physical and chemical properties of produce biodiesel accordance to ASTM D6751 and EN14214.

1.4 Scope of Research

The scope of this study consist of four important element:

a. Collecting raw waste cooking oil from various industry resources and identifying the important properties of the raw oil.

b. Produce the biodiesel using conventional method via transesterification process with the aid of alcohol and potassium hydroxide as an alkaline catalyst.

c. Varying all important parameter involved such as methanol to oil molar ratio, catalyst concentration, reaction time, reaction temperature.

d. Optimize the production process by implmenting statistical analysis, Taguchi Method.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Biodiesel research is becoming a significant aspect of science society's future growth. As a result of the crisis and problems caused by petroleum-based fuel, biodiesel research has developed. With the growing interest in manufacturing biodiesel, characteristics and catalysts are being investigated in order to provide the finest possible diesel quality (Bhattarai, 2011). Agree by Ashnani (2014) to boost biodiesel demand, researchers are currently looking for low-cost, high-quality raw materials. The biggest problem at the moment was determining the most appropriate manufacturing phase for creating the highest-grade biodiesel. Furthermore, Esmaeili in (2019) state that the production and usage of fossil fuel in engine in internal combustion affecting environmental such as air pollution and increasing amount carbon dioxide release in the air and impacting on the global temperature.

In recent situation diesel still dominate the demand of fuel usage in transportation, agriculture, power that being generated and industrial appliances according to Rajalingam (2016). Biodiesel is a renewable energy source in this environment, and as a result, its market is expanding. Tavares in (2017) state that a wide range of feedstock are being used as raw materials in biodiesel manufacturing to meet the quality standard. Transesterification of triglycerides with short-chain alcohols such as methanol or ethanol, catalyzed by an acid or a base, to produces biodiesel.

2.2 Raw feedstock of oil

Biodiesel can be produce from any plant or animal derived oil. Throughout the year so many production of biodiesel being proven that every oil give a different properties and so many comparison being made to improve the quality of biodiesel follow by the standard (Bhattarai, 2011). Type of raw feestock oil was tabulated below in Table 2.1 and usually biodiesel produced from high fatty acid feedstock such asfats and recycled oil. Animal oil and vegetable fat are one kind of triglyceride molecule which is three fatty acid group were ester and attach to one glycerol molecule.

Table 2.1 Type of raw biodiesel feedstock oil (Babu, 2013)

Group	Oil Sources
Major Oil	Coconut (Copra), corn (maize),cottonseed, canola (a variety of rapeseed), olive, peanut (groundnut), sunflower, sesame, soybean, and sunflower.
Nut Oil	Almond, cashew, hazelnut, macadamia, pecan, pistachio and walnut.
Other Edible Oil	Amaranth, apricot, argan, artichoke, avocado, babassu, bay laurel, beech nut, ben, Borneo tallow nut, carob pod (algaroba), cohune, coriander seed, false flax, grape seed, hemp, kapok seed, lallemantia, lemon seed, macauba fruit (Acrocomia sclerocarpa).
Inedible Oil	Algae, babassu tree, copaiba, honge, jatropha or ratanjyote, jojoba, karanja or honge, mahua, milk bush, nagchampa, neem, petroleum nut, rubber seed tree, silk cotton tree, and tall.

2.2.1 Vegetable Oil

To begin with researcher Chen (2018) shown in his study that vegetable oil known widely as renewable energy, because the vegetable source was easy to get and can widely produced. Vegetable oil also predicted as inexhaustible with the energy content close to diesel fuel properties. One of the most content of fatty acid was refined oil and and fats.Using vegetable oil as a diesel oil have more advantages such as, liquidity, readily availability, renewability, low sulfur and aromatic content. By Yaakob in (2013) interprete the vegetable oil also has disadvantage which is high viscosity, votality, and rectivity to unsaturated hydrocarbon chains. United States has become the largest producer of biodiesel from soybean as shown in Figure 2.1. United State one of the country that has bulk production of soybean. Another reason was soybean is cheap because it can be easily found everywhere. Figure 2.1 also show another common feedstock that being produces in United State. The more it properties similar to existing diesel fuel with cheap price and production, the more it being comersialize and promoted.

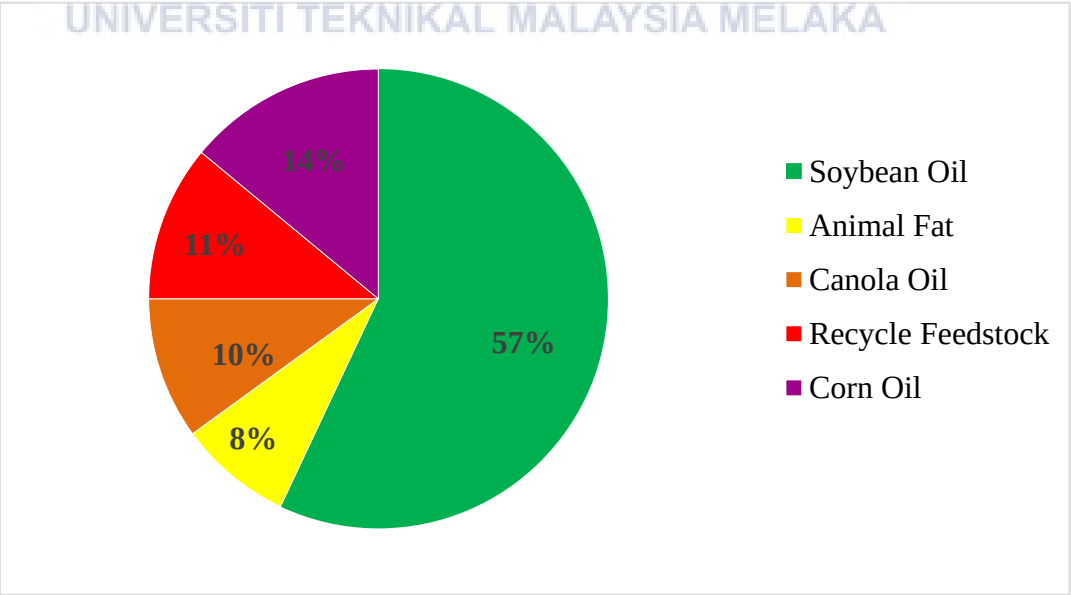


Figure 2.1 U.S biodiesel Production in 2019. Chen (2018)