

# Alternative Energy

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IIUM Press

Published by:  
IIUM Press  
International Islamic University Malaysia

First Edition, 2011  
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Perpustakaan Negara Malaysia

Cataloguing-in-Publication Data

A.K.M. Mohiuddin and Asif Hoda  
Alternative Energy  
A.K.M. Mohiuddin and Asif Hoda  
Include index  
Bibliography: p.

ISBN 978-967-418-158-1

Member of Majlis Penerbitan Ilmiah Malaysia – MAPIM  
(Malaysian Scholarly Publishing Council)

Printed by :  
**IIUM PRINTING SDN. BHD.**  
No. 1, Jalan Industri Batu Caves 1/3  
Taman Perindustrian Batu Caves  
Batu Caves Centre Point  
68100 Batu Caves  
Selangor Darul Ehsan

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## Chapter 25

### Preliminary investigation of biodiesel reactor optimization using combine CFD-Taguchi method

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#### Abstract

Biodiesel is currently produced from food and non food oil sources. The process is significantly constrained by reaction kinetics and mass transfer. In the present article, preliminary investigation of the effect of reactor configuration on yield is carried out using waste cooking oil (WCO) at different reaction parameter. The Taguchi design, with temperature, impeller speed and bottom distance as process variables at 3 levels, is used to plan, analyze and optimize the process. Optimum yield was predicted for 60°C, 600 rpm and 25 mm temperature. Statistical analysis reveals the impeller distance as most significant of the variables to affect yield and a 2D computational fluid dynamics (CFD) simulation of the mixing correlated an impeller bottom clearance of 25mm to the highest yield.

#### Introduction

Waste and non-food vegetable oils, from domestic and industrial palm oil activities is currently complementing raw material for the growing biodiesel industry as a result of increase in global palm oil production, with Malaysia's share of global palm oil market being over 45%. Reports in literature focus on the effects of temperature [1], ratio of alcohol to oil [2], catalyst type and amount [3], Free Fatty Acid (FFA) [4] and water content [5] and optimization methods [6-8] on biodiesel production from WCO. With particular reference to transesterification of WCO in stirred reactors for biodiesel production, the reaction terminates early as a result of mass transfer and kinetics limitation. This has been postulated to be partly due to the hydrodynamics during mixing for stirred reactors [9]. The traditional method of process study involves the consideration of one variable at a time, which requires a number of combinations of experiments that are time, cost and labor intensive [10].

Computational fluid dynamics (CFD) methods based on the Navier–Stokes equations have become powerful tools for studying fluid flow and reactive mixing in stirred tanks with complex flow structures for different reactor configuration [11]. An advantage of CFD-based methods is that effects of variables such as impellers number and positions, impeller diameter/ vessel diameter ratio, bottom clearance, bottom shape, baffles and mixing intensity can be obtained for complex geometries and thus the problems of scaling up/down are reduced in order to arrive at an optimum mix [12]. An example is the extension of CFD for reactive flow model for fast chemical reaction to describe the flow model coupled with the kinetic of reaction in turbulent liquid flows [13]. However, few reports