

RESEARCH PAPER

Project ID:

Project Title: Implementation of Automatic Transesterification Process for Bio-diesel from Cooking Waste Oil

Name of the Student: RUBIYA AAFREEN.S

Name of School: Safa Matriculation School

Address of School: 1, New Military Road, Masjid-E-Mubarak Campus, Avadi, Tamil Nadu 600054

a. Introduction

The increasing consumption of fossil fuels has resulted in environmental degradation and energy insecurity. Biodiesel is a renewable, biodegradable, and eco-friendly alternative that can be produced from waste cooking oil through a chemical reaction called **trans- esterification**.

This project will aim to implement an **automatic closed-loop biodiesel production system** where sensors and microcontrollers will be used to monitor and control the transesterification process. The automated approach will potentially increase efficiency, ensure consistent biodiesel quality, and enhance safety compared to conventional manual processes.

b. Selection of Problem and Background Information

Waste cooking oil is often discarded improperly, causing water and soil pollution. At the same time, dependence on fossil fuels contributes to climate change. By converting waste oil into biodiesel, both waste management and renewable energy generation problems will be addressed simultaneously.

Manual biodiesel production methods are prone to inefficiency, inconsistency, and safety hazards. Therefore, an **automated, sensor-based system** will be investigated to improve biodiesel production reliability and environmental benefits.

c. Objective

Research Problem / Question: How will an automatic, sensor-controlled transesterification process improve the efficiency and safety of biodiesel production compared to manual methods?

What will be found out:

- Optimum conditions of temperature, catalyst concentration, and reaction monitoring.
- Improvements in consistency and yield of biodiesel using closed-loop control.
- Reduction of safety risks and waste compared with manual processing.

Variables:

- Independent Variables: Type of feedstock (cooking oil batches), catalyst concentration, heating level.
- Dependent Variables: Yield of biodiesel, purity (measured by pH/viscosity), energy consumption.
- Controlled Variables: Reaction time, stirring rate, vessel volume, methanol ratio.

Control in the Study: Manual transesterification without automation will act as the control system for comparison.

d. Hypothesis

If waste cooking oil is subjected to an **automated transesterification process** with closed-loop monitoring, then the biodiesel produced will have higher yield, consistent quality, and improved safety compared to conventional manual processes.

e. Procedure

Design of Study: A small-scale biodiesel production unit will be assembled using a reaction chamber, sensors, and an Arduino/ESP32 microcontroller. The sensors will continuously monitor parameters and control heaters, stirrers, and pumps.

Materials Required:

- Waste cooking oil (feedstock).
- Methanol and NaOH/KOH (catalyst).
- Reaction vessel with heater and stirrer.
- Arduino Uno / ESP32 microcontroller.
- Temperature sensor (DS18B20/PT100), pH sensor, level sensors.
- Solenoid valves or pumps for reactant input.
- Separator tank for biodiesel and glycerol.

Stepwise Procedure:

1. Filter waste oil to remove impurities.
2. Heat oil to reaction temperature ($\approx 60^{\circ}\text{C}$) using heater controlled by temperature sensor.
3. Add methanol–catalyst mixture automatically through solenoid valves.
4. Maintain stirring during reaction while pH sensor monitors chemical changes.
5. After reaction completion, allow mixture to settle in separator tank.
6. Collect biodiesel (upper layer) and glycerol (lower layer).
7. Compare yield and quality with biodiesel produced via manual method.

Proposed Data Tables:

Table A: Experimental Trials

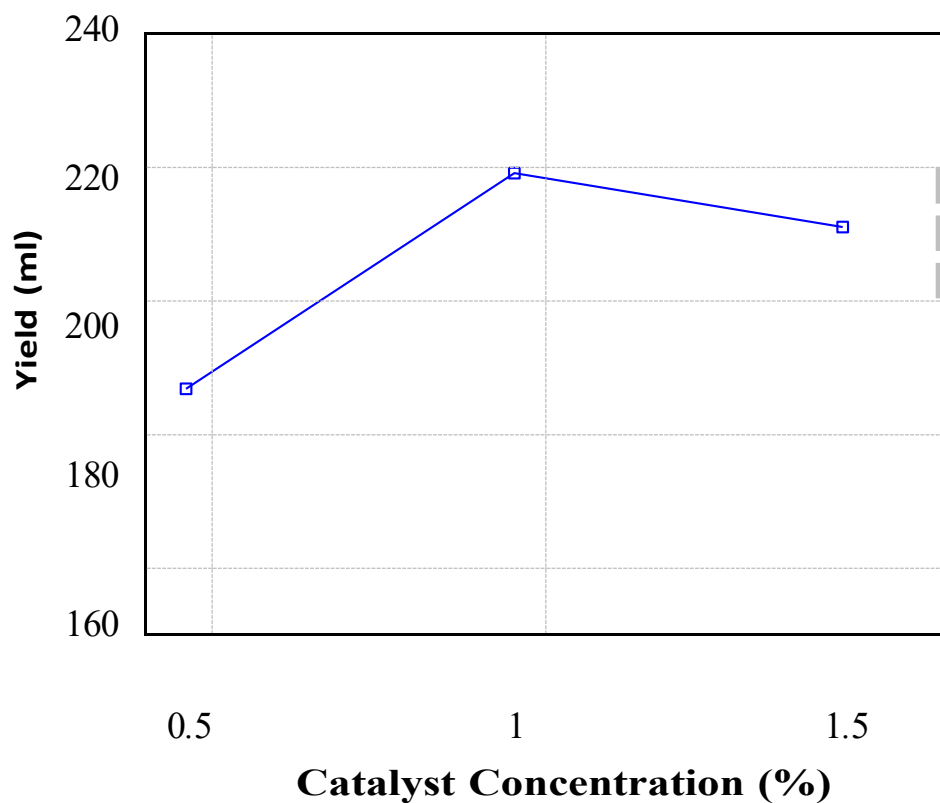
Trial No.	Catalyst Conc. (%)	Temp (°C)	Yield (ml)	Notes
1	0.5	55	180	Incomplete reaction
2	1.0	60	220	Good yield
3	1.5	65	210	Excess soap formation

Table B: Automation vs Manual Comparison

Method	Avg Yield (ml)	Consistency	Safety Rating
Manual	200	Low	Medium
Automated	220	High	High

Graphical Representation

Effect of Catalyst Concentration on Biodiesel Yield



f. Risk and Safety

- Methanol is flammable and toxic — handled under supervision with gloves and goggles.
- Reaction carried out in well-ventilated space.
- Electrical heaters and pumps will be insulated to prevent shocks.
- Small batch size will minimize hazards.

g. Data Analysis

- Yield data will be averaged and compared between manual and automated runs.
- Graphs of temperature vs yield and catalyst concentration vs yield will be plotted.
- Purity indicators (pH/viscosity) will be compared across batches.
- Statistical comparison of repeatability will be carried out to confirm consistency.

REFERENCE

1. Knothe, G., Van Gerpen, J., and Krahl, J. *The Biodiesel Handbook*. AOCS Press.
2. Demirbas, A. “Biodiesel production from vegetable oils via catalytic and non- catalytic supercritical methanol transesterification methods.” *Progress in Energy and Combustion Science*.
3. Gerpen, J.V. “Biodiesel processing and production.” *Fuel Processing Technology*.