Waste Cooking Oil Refinement Process Design

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FUNDED BY LAB FUND ENGINEERING STUDENTS

Problem Statement

- Biofuels source only 1% of Ontario's energy. Liquid biofuels are perfectly suited to provide energy to the transportation sector, which consumes the second most energy by sector (28%).[1]
- Biodiesel has reduced SOx, GHG, CO, and PM emissions compared to conventional diesel fuels.[2]
- Biofuel production costs are 60-80% dominated by the cost of feedstock. Conventional feedstocks, such as canola oil, are crop-based and require high water and land usage.[3]
- Using Waste Cooking Oils (WCO) as a feedstock for biodiesel provides a cost-effective and eco-friendly solution.

Objectives

- Design an industrial process to refine WCO feedstocks for biodiesel production.
- Results obtained from the design process can be used to recommend improvements for existing WCO refinement plants.

Experimental Methodology

Lab-scale experiments were used to test the processing capabilities of various industrial technologies. The technologies were evaluated for the following metrics:

- Final oil yield
- Final oil grade
- Processing time
- Waste production
- Robustness
- Process simplicity
- Capital, operating & maintenance costs

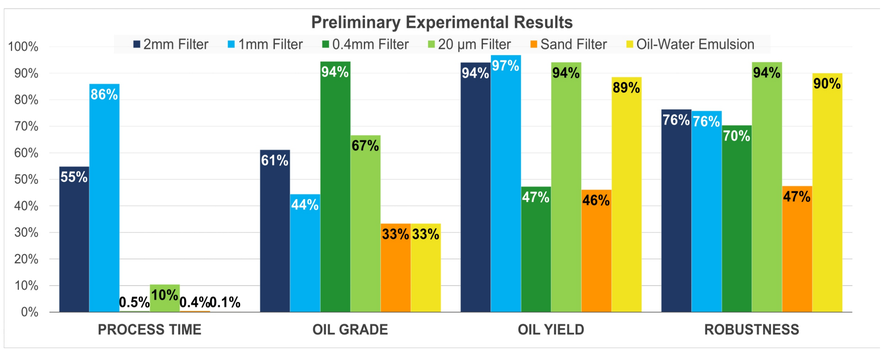
The following physical refinement technologies were tested:

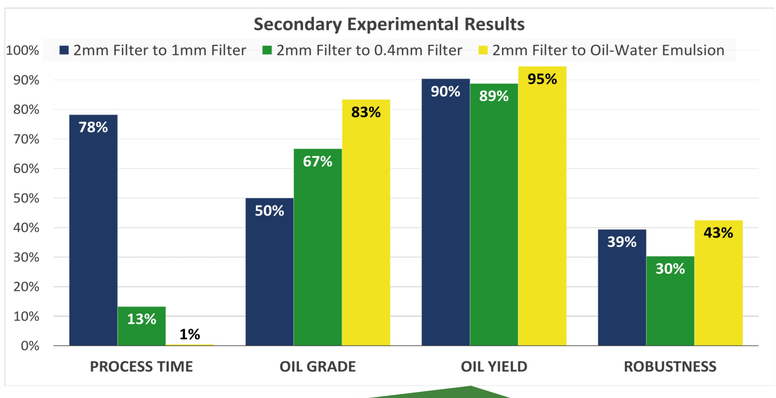
- Membrane filtration - four sizes ranging from 20um to 2mm
- Media filtration - slow and fast sand filters
- Sedimentation - oil/water emulsion tested with various parameters

Following initial testing, treatment methods were tested in series to explore more efficient combinations.

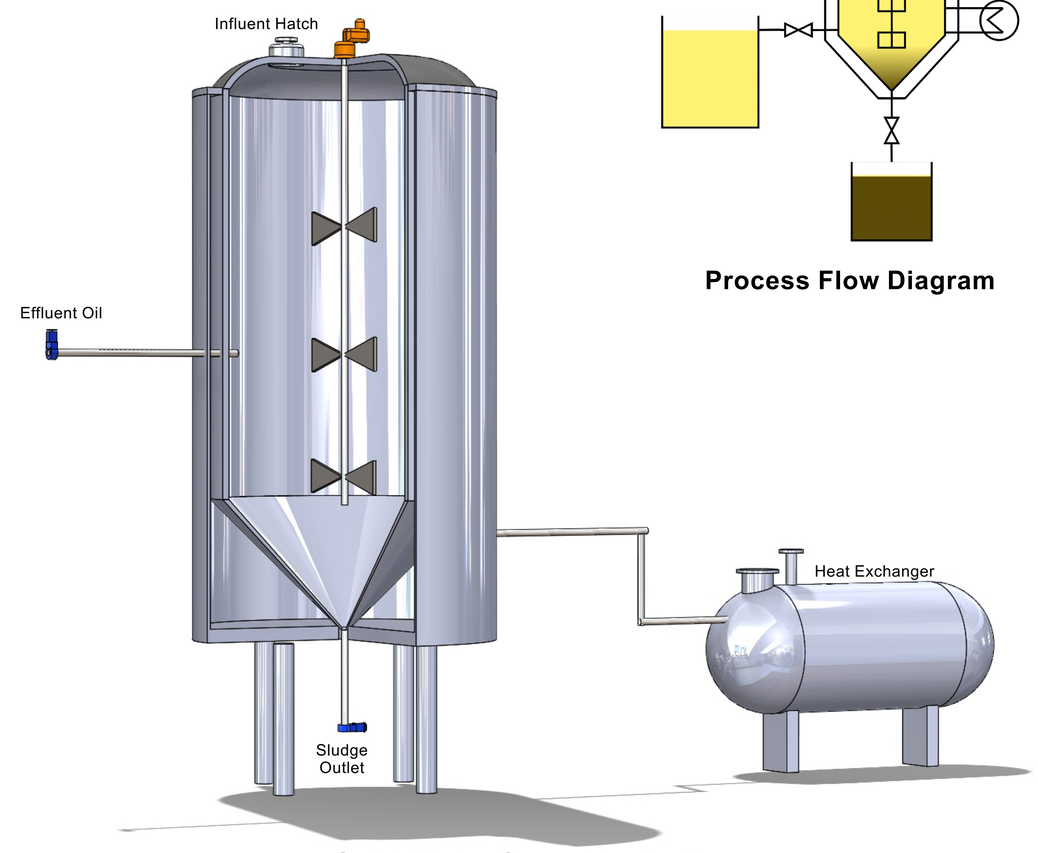
Results

WCO was simulated in lab, and refinement technologies were tested in two phases.





Proposed Process Design Schematic



Solid Works Conceptualization

Process Flow Diagram

Oil-water emulsification mixer with clarifier

- Stainless steel double-walled tank with heat exchanger for outdoor applications.
- 2mm stainless steel membrane filter for removing particulate loading (optional).
- Oil-water emulsification process performs best under variable particulate and grease loadings.
- Optimal operating parameters were determined through experimental results with actual WCO samples.

Operating Parameters

Oil/Water Ratio	20:1
Mixing Speed	1100 rpm
Mixing Time	~30 mins
Settling Time	6 hours
Mixing Temperature	25-35℃

This combination of parameters produced the highest oil grade, as well as 14%, 11% and 9% improvement in oil yield, processing time and wastewater production compared to the average parameters.

Summary & Next Steps

- Lab-scale experiments show oil-water emulsification provides best refinement of WCOs for biodiesel production.
- Operating parameters can be experimentally determined depending on WCO feedstock.
- Next steps involve testing the effects of adding binding agents (gypsum, clay) to destabilize emulsion and improve settling characteristics.
- Further study could quantify Free Fatty Acid (FFA) and water content of oil to evaluate refinement capabilities.

References
[1] Independent Electricity System Operator. (2018). *Ontario's Supply Mix*. Retrieved from IESO: https://www.eia.gov/todayinenergy/detail.php?id=32912
[2] Lai Fatt Chuah, J. (2017). Influence of fatty acids in waste cooking oil for cleaner biodiesel . *Clean Techn Environ Policy*, 859-868.
[3] Masoumeh Hajjari, I. T. (2017). A Review on the Prospects of Sustainable Biodiesel Production: A Global Scenario with an Emphasis on Waste-Oil Biodiesel Utilization. *Renewable and Sustainable Energy Reviews*, 445-464.

Advisor: Dr. Erica Pensini, Ph.D., P.Eng
Special Thanks to Joanne Ryks and Ryan Smith

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