Converting Locally Generated Waste Cooking Oil into Biodiesel

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Background

This research was prompted by an engineering capstone project that has been in progress for over a year. This research is unique in that it utilizes a highly mobile continuous flow reactor to produce biodiesel wherever it is required. The results will be used virtually anywhere there is a supply of waste cooking oil and a need for diesel fuel – reactor designs can be replicated if proper plans are provided.

Purpose

The main problem with the current method of quality biodiesel production is cost. The goal of this project is to minimize the cost of biodiesel production by generating biodiesel from locally collected waste cooking oil. By doing this, the transportation costs associated with current biodiesel production systems will be significantly reduced. The end deliverables of this project will be a mobile continuous flow reactor to fit the team's customer needs and a general reactor design equation that allows the optimal reactor design to be determined for a given set of customer needs.

Design/Method

Two issues with current biodiesel production processes that the team focused on improving through this project were transportation costs and mixing of reactants. The team chose to utilize a packed bed style reactor because, theoretically, it allowed for significantly better mixing of reactants than a traditional batch reactor. In addition, the packed bed reactor allows for continuous conversion of varying volumes of waste oil which resulted in a more compact and mobile final reactor design. Once the optimal type of reactor was determined, the team worked to create a general reactor design equation that could be tailored to calculate the ideal reactor volume required to meet a specific set of customer needs.

Results

The following equation calculates the minimal reactor volume for a given combination of customer needs and reaction conditions.

$$V_R = \frac{5Q_{WO}t_r}{4\varepsilon} = \frac{\pi(D_R)^2}{4} * L_R$$

Q_{WO} is waste oil input flow rate, t_r is the reaction time at STP (90 minutes), ε is the void ratio for a given packing material, D_R is the diameter of the reactor (limited by manufacturer), and L_R is the length of the reactor (limited by need for mobility).

Conclusions

A general reactor design equation that can be utilized to meet an infinite combination of customer needs was generated by the team. This equation was used in conjunction with defined physical constraints, experimentally determined packing material data, theoretical input ratios, and theoretical transesterification reaction time values to design and build a packed bed reactor of optimal size and to acquire pumps that provide variable flow rates that satisfy our needs.