

OPTIMIZATION OF PROCESS PARAMETERS FOR THE OPERATION OF A FLOW-THROUGH SUPERCRITICAL UNIT

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Abstract

Biodiesel (BD) is an environmentally friendly, alternative energy source. It has a number of advantages over petroleum diesel: it is fire-safe, has a higher flash point, and has minimal toxic emissions during combustion.

It is most promising to produce BD in supercritical (SC) conditions, above the critical point of methanol or ethanol. A mobile flow-through SC unit was designed, which included tanks for initial product, flow-through reactor (FTR) with a heating element, cooler, separator, high pressure pump, control unit, pressure regulator, FTR made of thick-walled stainless-steel tube bent in the form of a spiral. A gas burner was used as the heating element and was controlled by an HMI PLC SCADA automation system. HMI PLC SCADA system was used to input technological parameters, as well as to provide acquisition and processing of data of transesterification reaction. A significant advantage of the developed mobile flow-through SC unit was its small size, high capacity and environmental safety.

Investigations were conducted on optimization of technological parameters of OB production flow-through SC unit operation. At the description of processes occurring in an FTR, the kinetic model which included a number of assumptions has been accepted. As a model isothermal ideal displacement reactor (IDR) was considered as a model in which the volume of the reaction mixture did not vary along the entire length of the flow reactor and there was no reverse and radial transfer of substances. The substance flow in the IDR only proceeded in the longitudinal direction, similar to a piston. The residence time of all components of the reaction mixture in the IDR was constant. The simplified kinetic model did not take into account the formation of intermediate compounds. The reaction order in terms of alcohol pressure was taken as 1, and the transesterification process was described by one irreversible reaction of the first order.

As a result of calculations values of effective rate constants of transesterification reaction depending on molar ratio of alcohol to oil were obtained. The rate constant of reaction was determined by the method of least squares, by comparing experimental data on oil conversion with calculated data. Values of effective rate constants of reaction depending on temperatures in the interval 320-380 °C were used for determination of activation energy E_a of supercritical transesterification of oil at various ratios of mixture - ethanol/oil, using Arrhenius equation. It is obtained that the system has to overcome an energy barrier beyond which an increase in the reaction

rate constant occurs. The reaction rate constant increased by a factor of 85 when the temperature was raised from 200 °C to 350 °C. Thus, a high temperature was necessary to overcome the energy barrier. It was obtained that the rates of the transesterification reaction under subcritical conditions were two orders of magnitude lower than under supercritical parameters.

Keywords: biodiesel fuel, supercritical unit, flow-through reactor.

IEECP'21, July 29-30, 2021, Silicon Valley, San Francisco, CA – USA

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DAI : <https://sci-index.com/DAI/2021.99101/IEECP/14810268>