Process simulation in Biodiesel production

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Background & Description

Currently, the demand for renewable energy sources such as alcohols, vegetable oils and their derivatives has been significant, as they are environmentally acceptable. In 1895, Dr. Rudolf Diesel created the first engine used with vegetable oil, but with the low price of oil products, vegetable oil was replaced. Nowadays, due to environmental concerns, research has been carried out to use vegetable oils and their derivatives (for example, biodiesel) as fuels.

Biodiesel (Greek, bio, life + diesel by Rudolf Diesel) is the name given to alkyl esters of fatty acids derived from biological sources, such as plants and animals. This ester can be produced from the transesterification of acid catalysis, basic catalysis, enzymatic catalysis, conversion of oil into fatty acids and then into biodiesel and transesterification without catalyst. This fuel can be used in diesel engines directly or mixed. For example, B20 and B100 fuels that contain 20% and 100% biodiesel, respectively.

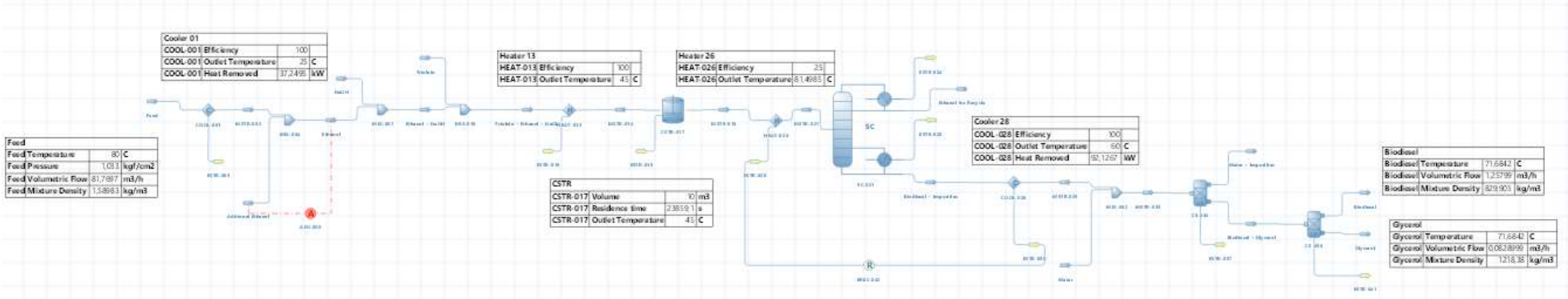
Chemical reaction kinetic

3CH3CH2OH + OOO ←→ HOCH2CH(OH)CH2OH + 3EtO

Process

The process is based on the recycling of ethanol that exchanges heat with a thermal cooler, afterwards we have three inlet streams to contribute to the chemical kinetic feed. In the CSTR reactor, the transesterification reaction occurs. The output stream from the reactor passes through a column where the products will be separated, passing through another thermal chiller that recycles with a heater at the entrance of the distillation tower and further on, two tanks perform the separation until reaching the biodiesel product stream. The thermodynamic model used was NRTL and the evaluation of the flash algorithm used was Nested Loops (VLE).

Flowsheet:



Results:

Biodiesel stream		Units
Temperature	71,6842	°C
Pressure	1,033	kgf/cm2
Mass Flow	1044,02	kg/h
Mixture Density	829,905	kg/m3
Mixture Molar Weight	310,721	kg/kmol

CSTR Results		Units
TriOlein (OOO): Conversion	99,8953	%
Sodium Hydroxide: Conversion	4,56E-05	%
Water: Conversion	4,56E-05	%
Ethanol: Conversion	51,9741	%
Outlet Temperature	45	C
Heat load	-16,098	kW
Volume	10	m3
Residence time	23859,1	s

ShortcutColumn Results		Units
Reflux Ratio	1,5	-
Minimun Reflux Ratio	8,80114	-
Condenser Duty	106,638	kW
Reboiler Duty	193,419	kW

Cooler Results

	COOL-028	COOL-001	Units
Heat Removed	92,1267	37,2495	kW

Heater Results

	HEAT-026	HEAT-013	Units
Heat Added	92,1267	5,71419	kW

Separator Results

	CS-038	CS-034	Units
Energy Balance	-1,22163	-20,061	kW

Conclusions

We can conclude that depending on the raw material used for the production of biodiesel, contaminants can be found in the fuel, such as phosphorus, sulfur, calcium and magnesium. According to the process, different amounts of free glycerin, unreacted glycerides, soaps, residual alcohol, catalyst residues and water that affect the quality of biodiesel.