

Costello, consulting engineers, explain its process that converts a wide range of feedstocks to biodiesel in under an hour, using multiple distillation columns

Bioflexplant technology provides full methanol recovery

The Bioflexplant consists of four process modules: degumming, esterification, transesterification and methanol recovery.

The esterification and transesterification processes require excess methanol in order for the chemical reactions to proceed to completion. This excess methanol should be recovered and recycled back to the front of the plant. Bioflexplant accomplishes this with multiple distillation columns.

Degumming

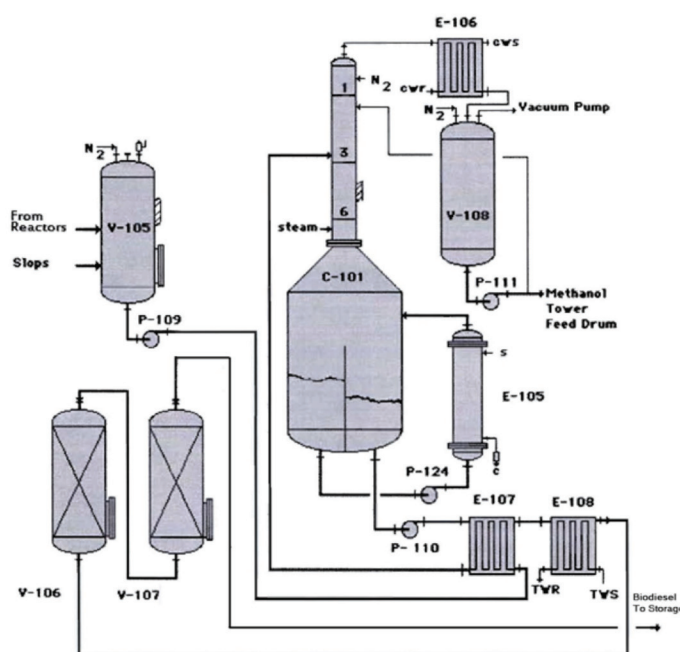
Degumming removes both hydratable and non-hydratable phospholipids. In addition, it removes metals such as magnesium and calcium that are associated with the non-hydratable phospholipids.

Esterification

The esterification section of the plant uses a solid catalyst for converting up to 15% free fatty acids (FFAs) to biodiesel and water. The triglycerides are unaffected by the esterification reaction. Methanol is fed to the system at rates of 10-15wt%, which is a substantial excess.

Since methanol partitions in the biodiesel/triglyceride phase and the water phase, the methanol in the water phase must be recovered and recycled back to the front-end of the plant. If not recovered, the methanol will leave the plant

Biodiesel distillation



with the wastewater, creating an environmental issue as well as increasing plant operating costs. This recovery is accomplished in the distillation section of the plant.

Transesterification

The transesterification system uses two ShockWave Power Reactors in series with phase separators after each reactor. Excess methanol is typically added to the reactors to drive the equilibrium reaction forward. The reactors provide intense mixing and can produce high conversion of the triglycerides to biodiesel. With high conversion, minimal amounts of unreacted triglycerides, and partially reacted mono and diglycerides, remain in the

finished biodiesel. The methanol needs to be stripped from the product stream, but the finished biodiesel may not need to be distilled to meet ASTM D6751 and EN 14214 requirements.

It is important to keep water out of the transesterification reactor system. Water converts triglycerides to FFAs. These fatty acids will react with the alkaline catalyst and form soaps. Soaps act as surfactants in the separation steps, complicating the separation of the biodiesel and glycerin phases. Soap forms a rag layer, rather than a sharp separation. Therefore, it is important to make sure water to the reaction section is minimised. It creates operational difficulties and lost product.

It is for this reason methanol

dehydration is important, as any water remaining in the methanol recycle stream will find its way into the reaction section.

Distillation train

The distillation train features three vacuum distillation columns. The first distillation column strips the methanol from the biodiesel. The second strips the methanol from the glycerin. In each of these columns, the wet methanol stream leaves the column as a vapour in the overhead stream where it is condensed.

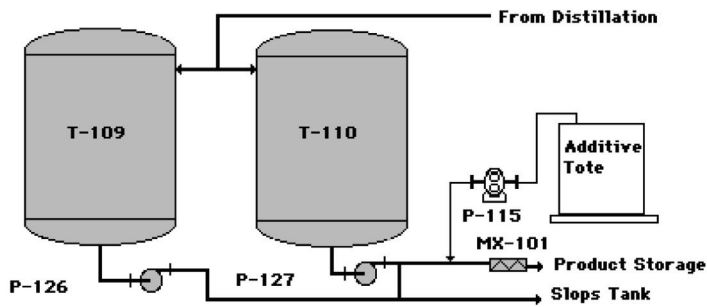
The stream is split into reflux, which is fed back to its respective column. The balance is then fed to the methanol dehydration column, which is the third column. The third column fully dehydrates the methanol. The total feed to this column consists of the methanol/water stream from the two distillation columns, and the wet methanol from the esterification section.

Biodiesel is pumped to column C-101 where the wet methanol is stripped and comes off the top of the column. The biodiesel comes off the bottom of the column where it undergoes final processing, flows to the check tanks and then to bulk storage.

In the second column C-102 glycerin is cleaned up.

The wet methanol is stripped and comes off the top of the column. The glycerin comes off the bottom of the column where it is pumped to bulk storage.

Biodiesel check tanks



The methanol from C-101 and C-102 is pumped to an intermediate storage tank (V-115). The methanol water mixture from the esterification section of the plant is also pumped into the intermediate storage tank. In the third and final column, C-103, wet methanol is pumped to the column. The methanol goes overhead, where it is condensed. Some is returned to the column as reflux. The remainder is returned to the front end of the plant as recycled. The purity of this methanol will be 99.9% or greater. The water comes off the bottom of the column where it is discharged to the sewer. It contains less than 100ppm methanol.

All three columns operate under partial vacuum and are of carbon steel construction; a major cost saving over stainless steel. All columns are fully automated and utilise a Programmable Logic Controller and a Human Machine Interface

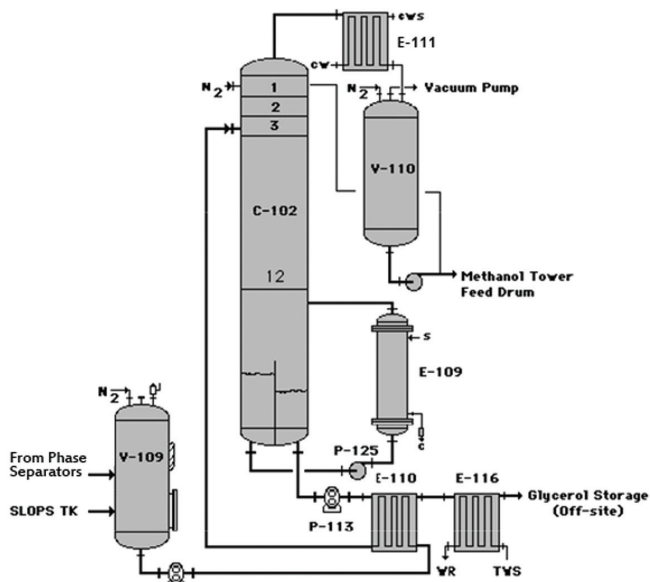
to control the complete facility.

Biodiesel distillation

After synthesis and separation in the transesterification reactor trains, the biodiesel and glycerol streams are sent through separate distillation columns to remove the excess methanol. At this point, the biodiesel stream consists of approximately 3% methanol and 97% biodiesel.

This stream is fed to a pre-heater (E-107), which recovers heat from the distillation tower bottoms, and is then fed into the biodiesel distillation column (C-101). In the column, the biodiesel passes over trays where the methanol vapours rise and the biodiesel falls to the bottom. To improve separation, a small amount of steam is added and the column operates under a slight vacuum. The overhead vapours pass through a condenser (E-106) and are sent off for further processing in the methanol distillation column (C-103). The biodiesel

Glycerol distillation



product is pumped through the pre-heater (E-107), where it loses some temperature, and then through a rundown cooler (E-108) which reduces the stream temperature to the storage temperature of 32°C.

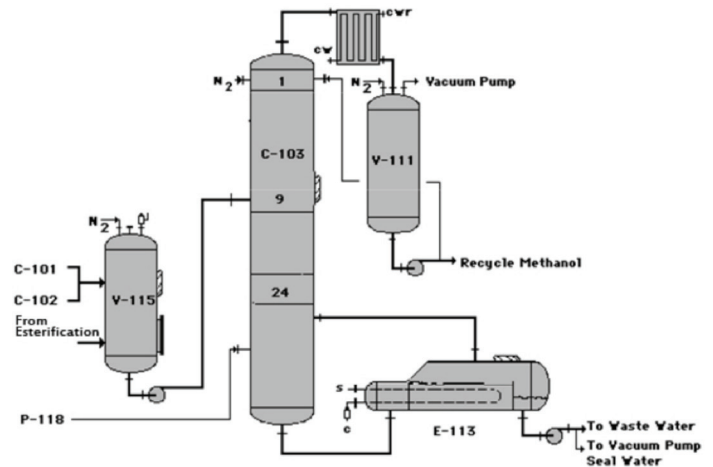
Finally, biodiesel product flows through an ion exchange bed where the excess catalyst is removed. The finished product is sent to one of two check tanks to confirm product quality. The final biodiesel product is pumped to storage where

pumped to storage. This stream contains the glycerol produced in the reaction, entrained catalyst and some water.

Methanol distillation

Methanol rich streams from the biodiesel column (C-101), glycerol distillation column (C-102) and esterification separators are sent to a methanol distillation column feed drum (V-115). A kettle-type reboiler provides the boil-up to separate methanol

Methanol distillation



appropriate additives such as antioxidants are added.

Glycerol distillation

The catalyst will preferentially partition into the glycerin phase. Trace amounts will stay with the biodiesel phase and the majority (>95%) will be in the glycerin phase. Methanol and water also prefer the glycerin phase. This stream is pumped through a surge drum (V-109) and then to a heat exchanger (E-110), where some heat from the bottom of the glycerol distillation column (C-102) is recovered. The stream is then pumped into the glycerol distillation column. In the column, the methanol and water vapours rise and the glycerol-catalyst mixture falls to the bottom. The methanol overhead vapours are condensed (E-111) and then sent off for further processing in the methanol distillation column (C-103). The bottoms will be cooled (E-110 and E-116) to approximately 60°C, and then

from water. The overhead methanol stream is condensed to provide reflux and to recycle methanol back to the reaction area. Once again, the column is operated under a slight vacuum to facilitate separation.

The methanol-water separation is the most difficult of the three separations. Because of the close volatilities, many trays are required, which results in a tall tower – the tallest of the three in the distillation train. It is also very energy intensive. However, to maximise plant efficiency and product quality, it is a necessary step for any large-scale biodiesel plant. The final distillation step allows full recycle of the methanol back to the front of the plant where it can be reused in both the esterification and transesterification steps. ●

For more information:

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