Control of an extractive distillation process to dehydrate ethanol using glycerol

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About Flowsheet:

Here simulation carried out for the ethanol separation from the water using glycerol as entrainer. Ethanol is widely used in industries as solvent and also its find application in energy sector also. But for pure ethanol which used as fuel or for other applications it's important to remove water content from that. However, ethanol-water mixture makes minimum-boiling homogenous azeotrope at 78.1℃ of composition 89mol% ethanol which may separate via azeotripic distillation using various solvents including cyclohexane, iso-octane, and benzene. Here, I used extractive distillation for the separation of ethanol and water taking glycerol as separating agent. Extractive distillation knows as technique which used non-volatile, high boiling point separating agent for the separation of mixture (which forms zoetrope) which called as entrainer [1].

- Here NRTL property package used and in simulation of distillation column also NRTL used for activity coefficient calculation, however for parameters are adjusted to get feasible results.
- Feed data are taken from the literature and simulated to get similar results , however during simulation its observed that resulted data

are quite similar to literature's result but with little variation in purity and molar flow of products.

- Two columns are used for the separation of ethanol-water mixture one of name extractive column and second one is entrainer recovery column. From the extractive column we get pure ethanol having purity of 97.67% here in flowsheet its named as D1 stream, and from bottom product stream we get mixture of glycerol and water which further separated in entrainer recovery column from that as top product water removed and as bottom product pure glycerol obtained which further recycled to extractive column with small addition of make-up having molar flow rate 0.045 kmol/h. However, to control purity of ethanol we also used cooler to maintain temperature of enrainer feed due to lower reflux operation. (it's observed that without cooler if enrainer feeds in column it's necessary to increase reflux for getting desired results due to water vaporizes stage wise which decrease purity of ethanol)
- Both columns pressure, reflux ratio and stages are mentioned as in below table,

Extractive Column	Entrainer recovery column
Pressure: 1 atm	Pressure: 0.02 atm
Total stages: 18	Total stages: 6
Feed stages: 3, 10	Feed stage: 4
Stage 3: Pure glycerol	Stage 4: water-glycerol mixture
Stage 10: Ethanol-water mixture	Reflux ratio: 0.28
Reflux ratio : 0.35	

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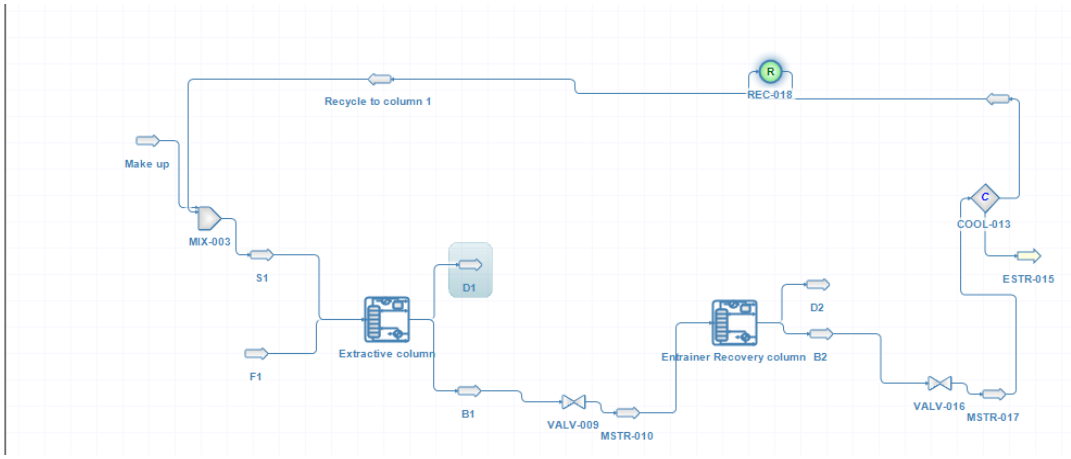
Feed stage			Feed stage
	Stage 3	Stage 10	stage 4
Ethanol	0	0.89	0.01466
Water	0	0.11	0.182
Glycerol	1	0	0.802

- Simulated flowsheet looks like as below;



Below unit system used during simulation;

Temperature; K
Pressure: Pa
Molar flow: mol/s

References:

[1] Gil, I. D., Gómez, J. M., & Rodríguez, G. (2012). Control of an extractive distillation process to dehydrate ethanol using glycerol as entrainer. *Computers & Chemical Engineering*, *39*, 129-142.