Simulation of High-Pressure Separator Used in Crude Oil Processing

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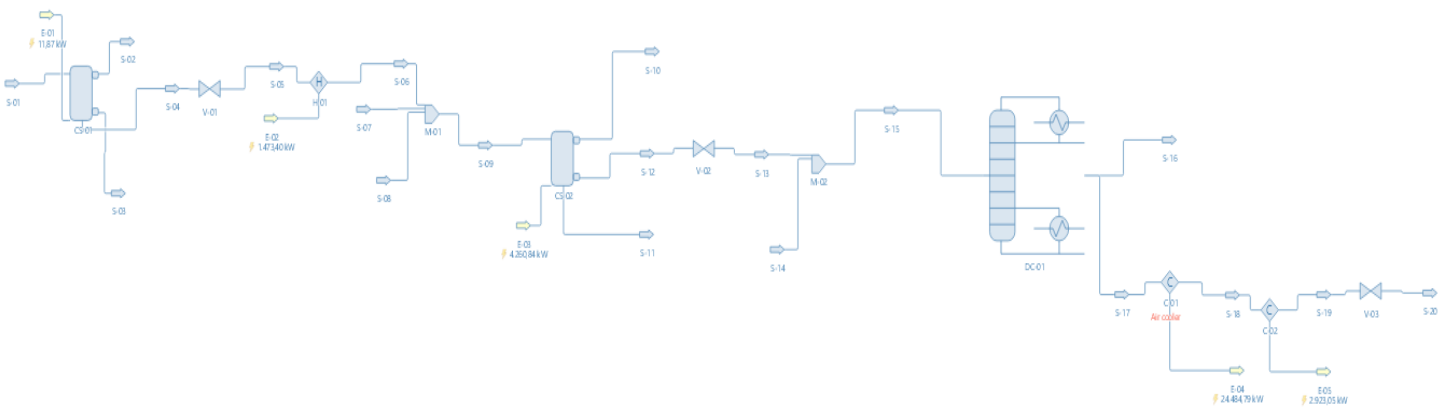
Background & Description:

The process simulation of a high-pressure separator is used in crude oil processing. Crude oil is separated into oil, gas and water, which facilitates further technical treatment, the separation process is carried out in a pressure vessel with a built-in gravity separator. The study uses DWSIM simulation software to investigate the effect of changing the operating conditions of the separator on the product properties, a sensitivity study was performed by changing the gas flow properties, such as temperature, pressure and flow rate, to investigate and optimize the process. The results show that increasing the inlet pressure of the separator from 30 to 80 bar decreased the outlet gas flow rate from 1202 to 871.15 kmol/h. In addition, the methane mole fraction increased from 0.69 to 0.74, however, the preheater heat load increased from 8.71 to 11.48 GJ/h. In addition, from the simulation they also show that increasing the separator feed flow temperature from 43 to 83 °C increased the flue gas flow rate from 871.15 to 1142.98 kmol/h. However, this temperature change reduced the methane concentration in the product gas and decreased the heat load on the heat exchanger. In conclusion, the study demostrates that simulation is a useful tool to optimize the crude oil separation process and improve process efficiency.

Thermodynamic package: Material Streams (Peng-Robinson), Distillation Column (Raoult's Law/Ideal gas law/Ideal solution/Antoine/None)

Flowsheet:



Results:

The results of the simulation obtained are shown in Table 1-2, they are in agreement with those obtained by Al Mhanna, (2018), who used CHEMCAD for the design and simulation of the process.

Table 1: Simulation results

Master Property Table			
Object	HP_Sep_Oil	HP_Sep_Gas	
Temperature	43	43	C
Pressure	79	79	bar
Molar Flow	879.113	868.595	kmol/h
Molar Fraction (Mixture) / Hydrogen sulfide	0.0176306	0.011705	
Molar Fraction (Mixture) / Carbon dioxide	0.0241566	0.0302176	
Molar Fraction (Mixture) / Nitrogen	0.00265594	0.0141484	
Molar Fraction (Mixture) / Methane	0.267854	0.752451	
Molar Fraction (Mixture) / Ethane	0.125631	0.115776	
Molar Fraction (Mixture) / Propane	0.112367	0.0479578	
Molar Fraction (Mixture) / Isobutane	0.0143816	0.0034962	
Molar Fraction (Mixture) / N-butane	0.0632275	0.0125243	
Molar Fraction (Mixture) / Isopentane	0.0195331	0.00229051	
Molar Fraction (Mixture) / N-pentane	0.04045	0.00398073	
Molar Fraction (Mixture) / N-hexane	0.0487805	0.00221772	
Molar Fraction (Mixture) / N-heptane	0.0431321	0.00101039	
Molar Fraction (Mixture) / N-octane	0.0410187	0.000497869	
Molar Fraction (Mixture) / N-nonane	0.0340773	0.000210274	
Molar Fraction (Mixture) / N-decane	0.0274801	8.99409E-05	
Molar Fraction (Mixture) / N-undecane	0.0236185	4.14616E-05	
Molar Fraction (Mixture) / N-dodecane	0.0186261	1.87789E-05	
Molar Fraction (Mixture) / N-tridecane	0.0163302	9.43992E-06	
Molar Fraction (Mixture) / N-tetradecane	0.0136282	4.44021E-06	
Molar Fraction (Mixture) / N-pentadecane	0.0113252	2.09281E-06	
Molar Fraction (Mixture) / N-hexadecane	0.00942183	9.67074E-07	
Mass Fraction (Mixture) / N-heptadecane	0.029473	5.57793E-06	
Molar Fraction (Mixture) / N-octadecane	0.00701663	2.38381E-07	
Molar Fraction (Mixture) / N-nonadecane	0.00681622	1.51028E-07	
Molar Fraction (Mixture) / Water	0.0025211	0.00134842	

After obtaining the results through the simulation in DWSIM, it is necessary to validate the results obtained with the scientific reference, by comparing the results to calculate the percentage error. The article used for the validation of the results was carried out by Al Mhanna, (2018). In the validation of the results, the most relevant results were considered. Table 2 shows the validation results.

Table 2: Simulation validation (% Error)

Variable	Description	Units	DWSIM	Al Mhanna, (2018)	Error (%)
MF_GAS	Molar flow at the outlet gas of the separator.	kmol/h	868.595	871.150	0.293
XMET_GAS	Methane: Molar fraction at the outlet gas of the separator.		0.752	0.756	0.469
XET_GAS	Ethane: Molar fraction at the outlet gas of the separator.		0.116	0.113	2.821
XMET_OIL	Methane: Molar fraction at the outlet oil of the separator.		0.268	0.241	11.374
XET_OIL	Ethane: Molar fraction at the outlet oil of the separator.		0.125	0.130	3.345

References:

AL MHANNA, N.M., 2018. Simulation of High-Pressure Separator Used in Crude Oil Processing. Processes, vol. 6, pp. 219. ISSN 18761070. DOI 10.3390/pr6110219. Disponible en: https://doi.org/10.3390/pr6110219