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OVERVIEW WORLD TECHNOLOGIES OF PYROLYSIS AND PERSPECTIVE OF DEVELOPMENT

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This article overview research and optimization propylene column K-17 EP-300 production JSC "SNOS" to produce propylene with polymer purity and to add additional propane-propylene cut from FCC.

Keywords: *propylene, gas fractionation, column, modeling, rectification, petrochemistry, monomers, optimization, tray*

In this work was made math model of propylene column K-17 production EP-300 JSC "SNOS" with Hysys. To calculate column it has been taken Peng-Robinson thermodynamic model. Adequacy of model has been checked up on experimental-industrial study of K-17 by Ltd Company "VNIIOS-nauka" from Moscow[1].

It has been determined efficiency of column trays with this math model. In the table 1 you can see summarized data which was finding during experimental-industrial study and with model.

Table 1

Comparison of experimental and calculated data

Name of value	Conditions 1		Conditions 2		Conditions 3	
	study	model	study	model	study	model
Feed-stock temperature, *ºC*	27	27	29	29	29	29
Feed-stock flowrate*, *t/h*	19.6	19.6	19.6	19.6	19.5	19.5
Reflux flowrate, *t/h*	226.3	225.3	236.1	236.1	240.7	240.1
Propylene in distillate, *%mol*	**98.68**	**98.68**	**99.05**	**99.05**	**99.18**	**99.12**
Propane in distillate, *%mol*	1.31	1.32	0.95	0.95	0.81	0.88
Propane in residue, *%mol*	84.02	84.03	84.52	84.52	85.34	86.83
Top temperature, *ºC*	22	24	23	25	23	25
Bottom temperature, *ºC*	34	34	35	35	35	35
Top pressure, *atm*	11.00	11.00	11.18	11.18	11.20	11.20
Bottom pressure, *atm*	11.87	11.87	12.12	12.12	12.13	12.13
Efficiency of trays	–	**0.492**	–	**0.535**	–	**0.555**
* Feed-stock have the same specifications for all conditions						

Experimental-industrial study which was made by Ltd Company "VNIIOS-nauka" has been shown impossibility to produce propylene with polymer purity because of low efficiency of trays [1]. Using model we determined efficiency of tray and this determination has shown necessity to change exist trays on more efficiency trays.

Next aim of our study was substitution of trays. To change exist trays we chose V-Grid tray technology utilizes a fixed valve MVG from Sulzer Chemtech [2]. Efficiency of this trays has shown in the figure 1. In addition we made optimization of column according to feed tray. Obtained tray quite far from project tray because of big difference between specifications of project and actual feed-stock[3]. In the figure 2 you can see changing quality of distillate in depend on feed tray with fixed reflux ratio and fixed residue quality.

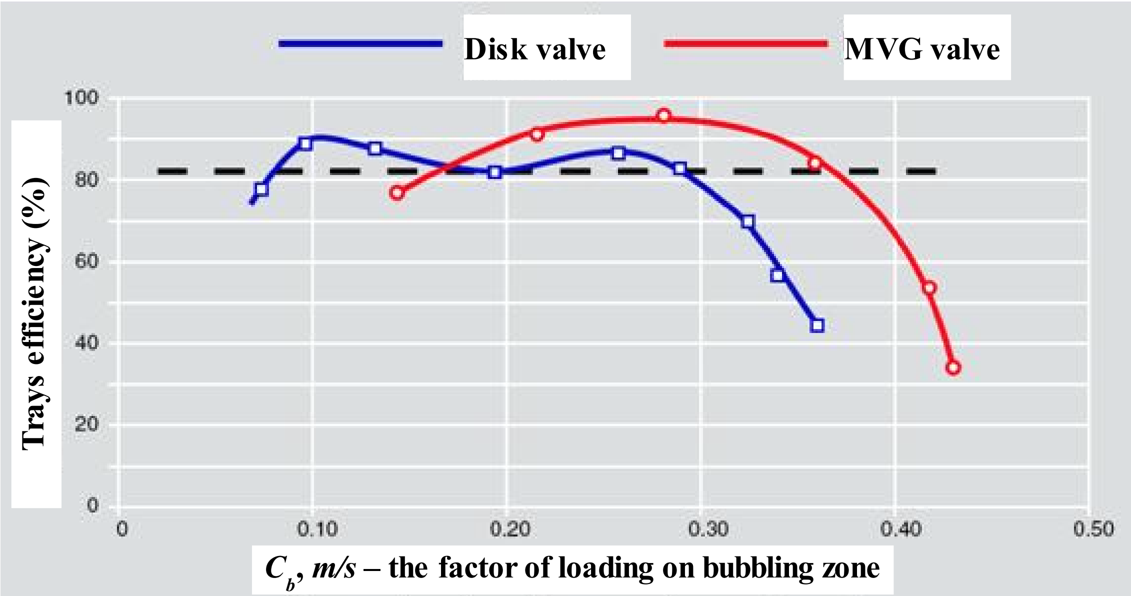


Figure 1. Tray efficiency in depend on loading on bubbling zone

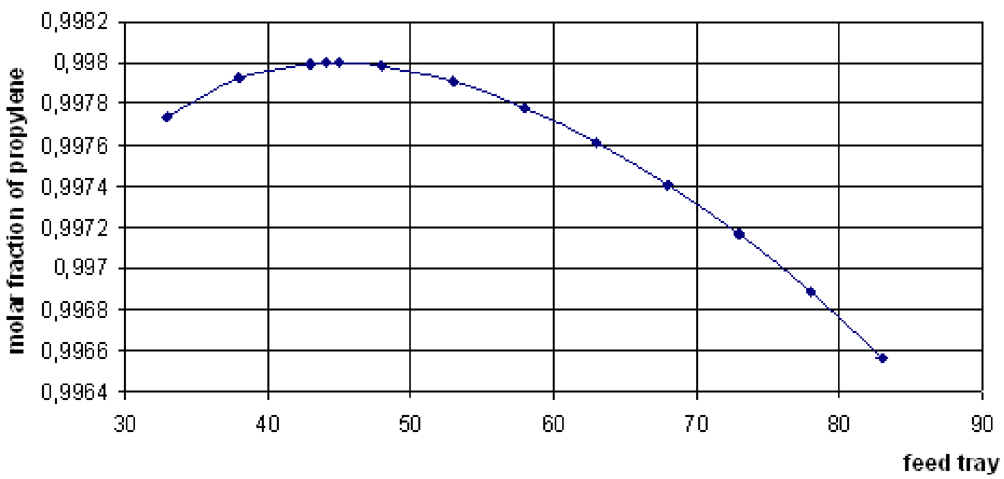


Figure 2. Dependence of molar fraction of propylene in distillate from feed tray

In the table 2 are demonstrated data of actual working of column and calculations of substitution of trays and optimization according to feed tray.

Calculations has shown that substitution of trays allow to produce high quality of propylene (99.8 % mol.) according to State Standard Specification 25043-87 [4]. From table 2 we can conclude that optimization of column according to feed tray allow decrease reflux rate and accordingly decrease loading on bubbling zone thus go to field of high efficiency for this trays. As a result we have reserve to increase reflux rate it means that we can be more flexible according to feed-stock or we can improve quality of distillate or residue.

Table 2

Comparison of actual and calculated data

Name of value	Actual	Hysys calculations	
		substitution of tray	substitution of tray + optimization
Feed-stock temperature, *ºC*	29	29	29
Feed-stock flowrate*, *t/h*	19.5	19.5	19.5
Reflux flowrate, *t/h*	240.7	232.1	209.9
Loading on bubbling zone, *m/s*	0.2480.364	0.2450.348	0.2230.321
Propylene in distillate, *% mol*	**99.18**	**99.80**	**99.80**
Propane in residue, *% mol*	85.34	84.00	84.00
Top temperature, *ºC*	23	24	24
Bottom temperature, *ºC*	35	36	35
Top pressure, *atm*	11.20	11.20	11.20
Bottom pressure, *atm*	12.13	12.59	12.59
Efficiency of trays	**0.56**	**0.900.94**	**0.93**
Quantity of trays	202	202	202
Feed tray**	**78**	**78**	**44**

* Feed-stock have the same specifications for all conditions
** Counting of trays from below

Next task of our study was optimization of column according to feed with different specification of feed-stock, because experience of work show that propylene contain into a feed-stock can be from 80 % mol. to 95 % mol. depending on feed-stock to furnaces and so on. It was taken three variants of feed-stock's specification and was determined optimal feed trays. You can see results in the table 3.

In the result of study we can recommend for this column to have three feed trays and depending on feed-stock specification change feed tray. It allow decrease reflux rate (decrease loading on the reboiler) and improve flexibility according to feed-stock.

Table 3

Comparison of different base cuts

Name of value	feed 1	feed 2	feed 3
Propylene in the feed, *% mol*	80.94	86.88	94.75
Propane in the feed, *% mol*	17.77	12.23	4.89
methyl acetylene and propadiene in the feed, *% mol*	0.94	0.65	0.26
C_4 in the feed, *%мол.*	0.35	0.24	0.1
Feed-stock temperature, *ºC*	29	29	29
Feed-stock flowrate*, *t/h*	19.5	19.5	19.5
Reflux flowrate, *t/h*	212.0	221.5	220.9
Distillate rate, *t/h*	15.3	16.6	18.4
Propylene in distillate, *% mol*	99.80	99.80	99.80
Propane in residue, *% mol*	84.00	84.00	84.00
Top temperature, *ºC*	24	24	24
Bottom temperature, *ºC*	36	36	36
Top pressure, *atm*	11.20	11.20	11.20
Bottom pressure, *atm*	12.59	12.59	12.59
Quantity of trays	201	201	201
Feed tray*	**44**	**50**	**66**
*Counting of trays from below			

So, in the first part of our study substitute trays in the column to produce high quality propylene according to State Standard Specification 25043-87. In addition we optimize column on feed tray with different feed-stock with different specifications.

In the second part we will try to process additional propane-propylene cut from FCC, with follow specification (table 4) [5].

Table 4

Specification of propane propylene cut from FCC

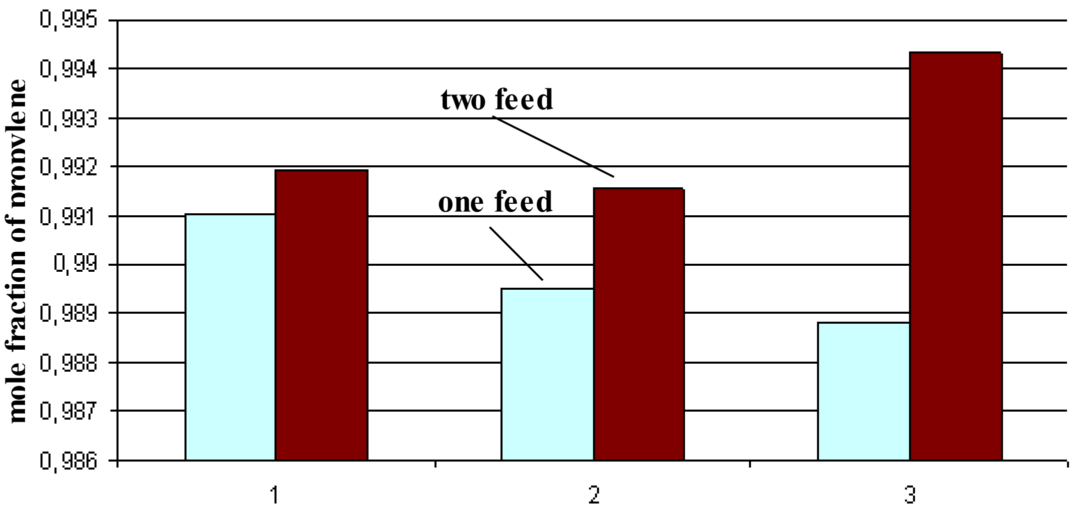
Name of value:	Cut from FCC
Ethane, *% mol*	0.09
Propylene, *% mol*	69.67
Propane, *% mol*	29.29
C_4, *% mol*	0.95
Temperature, *ºC*	45
Flowrate, *kg/h*	8956
Pressure, *atm*	25.5

For the reason that cut from FCC vary from base cut it arise question whether to enter this cut as a mixture with base cut or separately. To answer on this question we compared this two variant of entering with three base feed-stock. Together with it column has been optimizing according to feed tray similarly before. In the case when we have two feed trays firstly we had optimized feed tray relatively base cut, then relatively additional cut and step by step until both cut stopped.

During optimization according feed tray it was taken reflux rate (252.5 *t/h*) corresponding the maximal loading on bubbling zone. Because if we had given more reflux rate it would be too low efficiency of the trays. In the figure 3 you can see difference between mixing feed and if we will feed separately, we had the same reflux rate in each case.

From figure 3 obvious that the more the difference between cut specifications, the more preferably to feed column separately, it is absolutely corresponding with theory. So we can conclude that for this column more preferable separate feed.

After optimization we obtained best feed tray or trays for the each case. If it's only base feed-stock it's 44, 50, 66 tray (table 3). And for additional cut from FCC with separate feed it's couple of trays 51 and 31, 60 and 28, 80 and 25 accordingly to case 1, case 2 and case 3 according to figure 3.



1 – case 1 with base feed 1; 2 - case 2 with base feed 2; 3 – case 3 with base feed 3

Figure 3. Comparison of mixed and separate feed

If you look at the figure 3, you can see that if we process all additional cut from FCC (8956 *kg/h*) we can't produce propylene with high quality, so it means that next question of our study how much additional cut we can process without drop of quality of propylene. To determine maximum quantity of additional cut, in the each case, column worked with reflux rate which correspond maximum loading on bubbling zone (0.39 *m/s*) and maximal acceptable losses of propylene in the residue (< 10 *% mol*) [6]. To do this we used next way, we were decreasing quantity of additional cut and were increasing reflux rate up to maximal loading on bubbling zone, at the same time after each step we determined new optimal feed trays. Thus we determined for each case best conditions to process as much as possible quantity of additional cut, with maximal losses of propylene in the residue and with producing high quality propylene. As a result we determined optimal feed tray for each case which are shown in the figure 4.

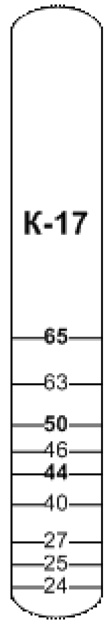


Figure 4

Next to minimize loss of trays in the real column we did column with five feeds only (25, 40, 44, 50, 65) because interval between trays in the feed zone more than between trays in general. During removing of column we used following criteria: preference for base cut and we removed trays which situated close to trays of feed of the base cut and removing of this tray haven't much influence on distillate quality. For ex-ample, if we remove 63 feed tray and give our feed-stock on the 65 tray, this action change quality of distillate very little because trays 63 and 65 situate quite close each other.

After all our column was calculated with selected feed trays and all results are shown in the table 5.

Our work demonstrate that substitution of trays allow us produce high quality propylene according to State Standard Specification 25043-87 and give flexible on feed-stock that allow process additional propane-propylene cut, but this question must be research according economical aspect.

Table 5

Work of column with additional propane-propylene cut from FCC

Name of value	feed 1	feed 2	feed 3
Base cut:			
Temperature, *ºC*	29	29	29
Flowrate, *t/h*	19.5	19.5	19.5
Additional cut:			
Temperature, *ºC*	45	45	45
Flowrate, *t/h*	**2.7**	**1.8**	**2.2**
Reflux rate, *t/h*	253.3	256.2	255.5
Distillate rate, *t/h*	17.0	17.8	19.8
Propylene in distillate, *% mol*	**99.80**	**99.80**	**99.80**
Propylene in residue, *% mol*	9.95	9.91	9.98
Propane in residue, *% mol*	84.50	84.50	85.10
Top temperature, *ºC*	24	24	24
Bottom temperature, *ºC*	34	34	34
Top pressure, *atm*	11.20	11.20	11.20
Bottom pressure, *atm*	12.59	12.59	12.59
Quantity of trays	200	200	200

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