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Capacity augmentation by structured packing revamp in stabilizer unit

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ABSTRACT

At the present investigation, capacity increase of stabilizer unit including two columns, debutanizer and splitter column, which are actually used in Shiraz Refinery Complex, has been studied. From distillation tower with structure of valve tray column, upstream flow goes into stabilizer unit. After passing through the debutanizer and splitter units respectively light straight run gasoline (LSRG) and Heavy straight run gasoline (HSRG) are produced. Regarding quality of final products and also capacity of explained unit, revamping has been applied in process simulation. Results of simulation illustrated that revamping of structured packing in the mentioned unit is an effective method to augmentation capacity. Debutanizer and splitter units have been particularly simulated with respect to intake and outlet flow rates, flooding, operational pressure and temperature. The simulation results were definitely compatible with operational data and experimental analysis. Using MELLAPAK 250X, as used structured packing in revamping process, led to decrease in pressure drop from 196 to 23 mBar. In addition, Sichlmair model has been proposed as the most feasible pressure drop estimator. With regard to packed tower flooding, 31 % capacity increase in feed flow rate and better quality productions have been definitively reported with total mean square error, about 4 percent.

KEYWORDS

Distillation;
Capacity;
Revamp;
Structured packing;
Quality.

INTRODUCTION

The Chemical Processing Industries look incessantly forward to gain better quality productions and high capacity of existing units simultaneously.

While capacity increase of existing distillation columns is not unusual, great care needs to be taken when a revamp is being considered. There is an obscure boundary between success and failure in mentioned goal. Using of structured packing in distillation tower has been developed in recent decades. High efficiency in separating processes such as absorption distillation is the most advantage of structured packing applied. The mentioned type of columns has more benefits than the tray and random packing columns. They are considerably smaller in dimension and pressure drop than tray columns. In comparison of tray columns, no void space in packed towers results better phases contact[1]. As regards of structured packing columns use, lower pressure drop, and higher capacity and efficiency are another advantages[2].

Koch-Glitsch Inc. in 1985 investigated on capacity increase of Ethylene quench unit; sieve tray has been replaced by combination/mixture of structured packing and random packing. In this revamp, HY-PAK #2 as random packing was located in upper section and in lower section FEXIPAC 3X, 4Y as structured packing. As it shown in TABLE 1, mentioned revamp resulted more effective in unit efficiency[3].

TABLE 1 : Results of Koch-Glitsch Inc. investigation[3]

	Unit	Before revamping	After revamping
Total pressure	mmHg	57	21
Feed flow rate	Lb/hr	502	818
Gas flow rate	Lb/hr	373	542
Temperature	°F	84	89

In 1990, Koch-Glitsch Inc. worked on similar revamp by structured packing in depropanizer column, to rech higher production capacity. Augmentation from 4000 to 16000 barrels has been reported by revamping of structured packing with 16 stages of tray column[3]. In this article, the applied conditions aspects that need to be considered in splitter unit have been discussed. By case study of available stabilizer unit of Shiraz Refinery Complex of Iran, a new method of capacity augmentation has been proposed. To reach better operational conditions, considering unit capacity augmentation, separation efficiency increase, pressure drop decrease and also low energy consumption, structured packing revamp has been proposed.

SIMULATION PROCESSING

Up-stream of atmospheric distillation column, as the intake flow, is fed to the stabilizer unit. In this process, after heating in heat exchanger, hot feed-stream is conducted into debutanizer from stage 16. LPG as the top product and heavier components as the bottom, are separated in debutanizer column. Consequently, bottom product of debutanizer is used as the splitter input flow to providing LSRG and HSRG as it shown in figure 1.

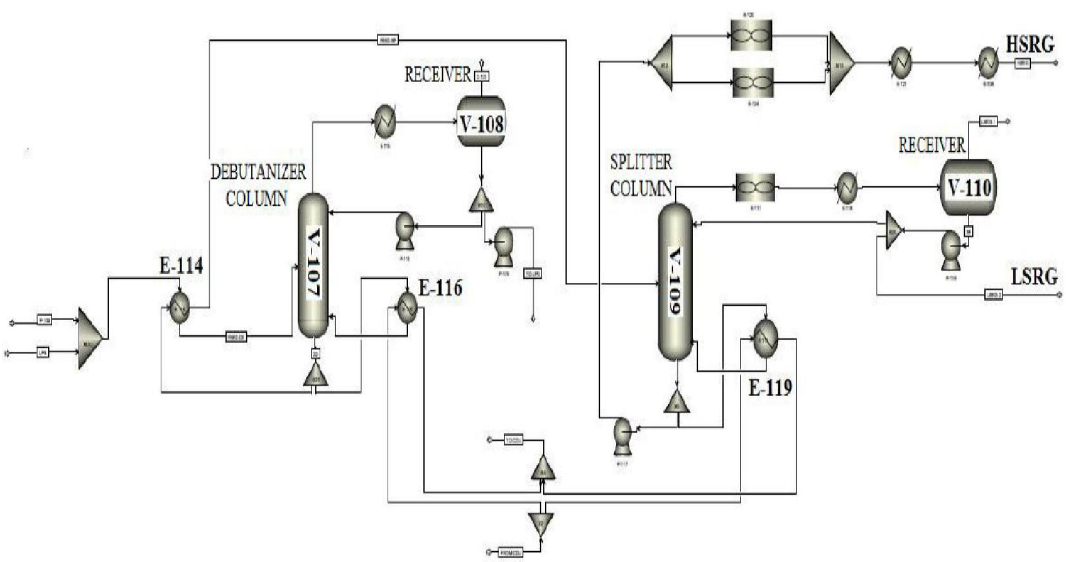

Figure 1 : Stabilizer unit of Shiraz refinery complex

In TABLE 2, splitter and debutanizer columns conditions have been shown. The splitter feed including of heavy components such as pentane, hexane and heptane, is taken into the system from stage 14.

TABLE 2 : Debutanizer and splitter columns specifications[4,5]

Specifications	Splitter column	Debutanizer column
Number of trays	26	30
Feed flow rate	85	98
Type of tray	Valve Tray	Valve Tray
Height	68	74

By using commercial software, explained process has been totally simulated in steady state condition. The purpose of analysis and process simulation was optimizing and predicting the performance of the process and its operational conditions.

A property method is a collection of equations which are used to calculate all physical properties in the simulator software. Each property method contains a specific equation to calculate a given property, such as enthalpy, density, etc.

In this simulation, the Chao-Seader equation of state has been chosen to predict pure component fugacity coefficient for liquid. This equation of state is applicable for crude towers, vacuum tower, etc in presence of hydrocarbon and light gasses such as carbon dioxide and hydrogen sulfide[6].

REVAMP BY STRUCTURED PACKING

In process simulation, effects of different packing has been studied and results of these investigations for several MELLAPAK packing have been illustrated in TABLE 3.

TABLE 3 : Pressure drop effect in MELLAPAK

Type of structured packing	Pressure Drop, mBar
MELLAPAK 250 X	23
MELLAPAK 250 Y	99
MELLAPAK 350 X	38

Regarding TABLE 3, two structured packing 250X and 350X result lower pressure drop in comparison with other kind of packing. Respecting their prices, 250X has been selected and proposed as the effective packing. By choosing MELAPAK 250X, the mentioned packing has been loaded in Splitter column. Simulation results before and after loading has been illustrated in TABLE 4.

TABLE 4 : Splitter tower condition: Before and after revamp[4]

Specifications	Original column	Revamp
Column Diameter, m	1.89	1.89
Bottom temperature °C	130	114
Pressure Drop, mBar	196	23

RESULTS AND DISCUSSION

In this project, stabilizer unit including debutanizer and splitter columns have been simulated and high compatible results have been reported. In addition, effects of pressure drop and flooding in splitter column, quality of LSRG and HSRG, as final products of splitter column, have been evaluated before and after revamping.

As important parameter in high-grade quality of LSRG is Reid vapor pressure (RVP).

For Reid vapor pressure, there is a maximum value as limitation parameter which has been compatible with experimental data as it shown in TABLE 5.

TABLE 5 : Comparison of experimental and simulation data for RVP in Psia[4]

Product	RVP TEST	Experimental RVP	RVP Before Revamping	RVP After Revamping
LSRG	MAX 12	9.1	9.54	8.87

Achieved result of RVP estimation using structured packing shows better applied conditions due to operational temperature decrease. Two models for pressure drop estimation, Eckert[7] and Stichlmair[8], have been checked and evaluated. Operational pressure drop was actually 23 mBar and simulation results by using Stichlmair model and Eckert, respectively have been evaluated as 28 and 61 mBar. Obviously Stichlmair model which was prepared for random and structured packing, can predict pressure drop value with higher accuracy.

In comparison, Eckert's model has low sensitivity in pressure drop estimation for high packed bed. Notably, flooding in packed beds is characterized by unstable operation and loss of efficiency. Flooding is causing liquid to be entrained in the vapor up the column and is known as negative phenomenon. The increased pressure from excessive vapor also backs up the liquid in the down comer, causing an increase in liquid holdup on the plate above. Depending on the degree of flooding, the maximum capacity of the column may be severely reduced. Flooding is detected by sharp increases in column differential pressure and significant decrease in separation efficiency.

Using simulator software for splitter unit, effect of flooding parameter in tray column and embedded type by using structured packing have been compared and results are available in TABLE 6.

TABLE 6 : Comparison of flooding parameter in splitter column

Flooding (structured packing)	Flooding (Tray)	Feed flow rate (m^3/hr)
67%	80%	85
79%	94%	112

Results of above comparison, generally shows that in structured packing tower probability of flooding is less than the tray column. Accordingly, 112 m^3/hr has been determined as maximum rate of feed-stream in existing splitter column. By pressure drop decrease in mentioned tower, considering flooding effect from 85 to 112 m^3/hr augmentation has been reported for feed flow rate.

Another difference between structured packing tower and tray column is final products quality. In figure 2 and 3, simulation data have been listed and consequently, structured packing has been elected regarding its performance.

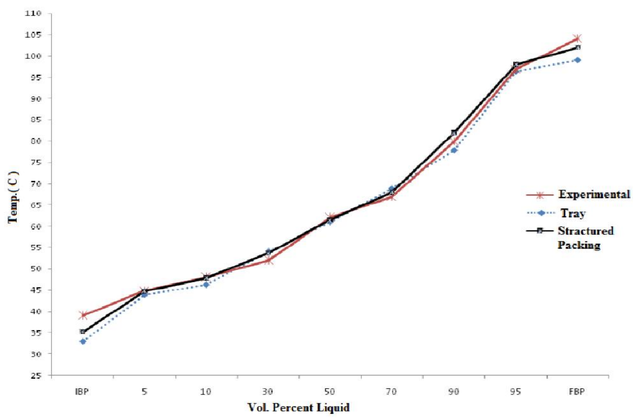

Figure 2 : Quality of LSRG

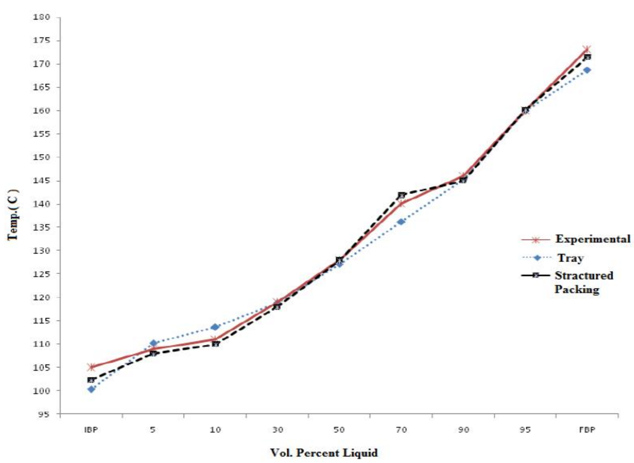

Figure 3 : Quality of HSRG

APPENDIX

In 1989, Stichlmair et al. proposed an empirical model to estimate the pressure drop in packed bed. The model has been prepared to apply for random and structured packing. The model has been presented as below:

$$\frac{\Delta p}{z} = 0.75 f_0 \left(\frac{1-sH}{1-s}\right)^{0.666} \frac{\alpha p}{6(s-H)^{4.65}} \rho_u u_g^2 \quad (1)$$

In above equation, f_0 is friction factor[8] where:

$$f_0 = \frac{C_1}{Rs} + \frac{C_2}{Rs^{0.5}} + C_3 \quad (2)$$

Packing constants to evaluating of friction factor have been given in TABLE 7.

TABLE 7 : Constants for friction factor evaluation

Packing Type	C_1	C_2	C_3
Rasching Rings (metal)	48	8	2
Rasching Rings (ceramic)	60	1	7.5
Pall Rings	33	7	1.4
Saddles	32	7	1
Structured Packing	18	4	0.2

CONCLUSIONS

As a practical method to capacity increase in atmospheric distillation tower is structured packing revamp instead of tray column application. Because of low pressure drop of structured packing, MELLAPAK 250 X can be so effective in capacity augmentation. In splitter column, Stichlmair model can accurately predict amount of pressure drop better than Eckert model. For stabilizer unit which is used in Shiraz Refinery Complex, structured packing revamp results 31 percent increasing in unit capacity in comparison with tray column apply.

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