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An increased production capacity by a retrofitted industrial deethanizer column

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ABSTRACT

The industrial ethane recovery column is modified by change in its operating conditions. In this contribution for the modified process, the influences of the reboiler temperature, column operating pressure and feed–inlet location are evaluated on the simulation results. Optimization of the retrofitted plant parameters is performed by using the practical method of response surface methodology (RSM) and the relevant cost estimation procedure. The best design is obtained and it is found that the production capacity is increased up to 18%, in comparison to the base case.

1. Introduction

Liquefied petroleum gas (LPG) is a mixture of propane and butane that it is a clean, high octane and eco-friendly fuel (Kumar et al., 2011). Since LPG is more valuable than natural gas and gas condensate, it is obtained using a series of distillation columns, in gas industry field, as shown in Fig. 1 (Vatani et al., 2013; Luyben, 2013a). Although there are many techniques to purify LPG such as dividing wall column, heat pump, debottlenecking and etc (Hirata and Kakiuchi, 2011; Van Duc Long and Lee, 2013; Sangal et al., 2014; Luyben, 2013b; Enríquez et al., 2014; He and Ju, 2014; Mehrpooya et al., 2006; Chebbi et al., 2010; Qeshta et al., 2015), LPG is always sold along with the methane and gas condensate or burnt by the flaring, in gas industry (Liu et al., 2015).

LPG is always considered as a key product in the gas refineries and a tight competition to recover more liquefied hydrocarbon for sale exists among gas processing owners. Due to the lowest temperature of −20 °C at the urban districts, the production objective will change at the cold season. In the other words, the production of LPG and other liquefied products is not a priority and exporting gas to the gas trunk pipelines is the first priority. To gain that purpose and for increasing capacity, the operating conditions of the deethanizer column are changed and the sale gas is diluted with LPG and ethane as this retrofit is shown in Fig. 2. As can be seen in the figure, the expensive refrigerant (propane refrigerant cycle) is no longer used at the top of (condenser) the deethanizer column and the flow rate of low pressure steam at the reboiler side is consequently enhanced. By this process modification, not only refrigerant is not used in the column, but also the production capacity increases. One of the drawbacks of this process retrofitting is supplying large amount of low pressure steam, which increases the operating costs. In order to modify the deethanizer column, we have considered three main scenarios. In the case of propane refrigerant compressors failure, due to the expensive costs of refrigerant and expanding demand for gas consumption in the cold seasons, modification in the deethanizer process can be a useful alternative in order to increase production rate (the first scenario). In the second case when the storage tanks are filled with LPG, the production unit could not send more LPG to the storage area at the previous flow rate and in this time they can consider this modification till the storage problem is resolved. Moreover, the mercaptan components especially methyl/ethyl mercaptans are always presented in the LPG stream and when the LPG treatment unit is unavailable, the deethanizer column might be modified, accordingly.

Up to now, no comprehensive research for the new condition of

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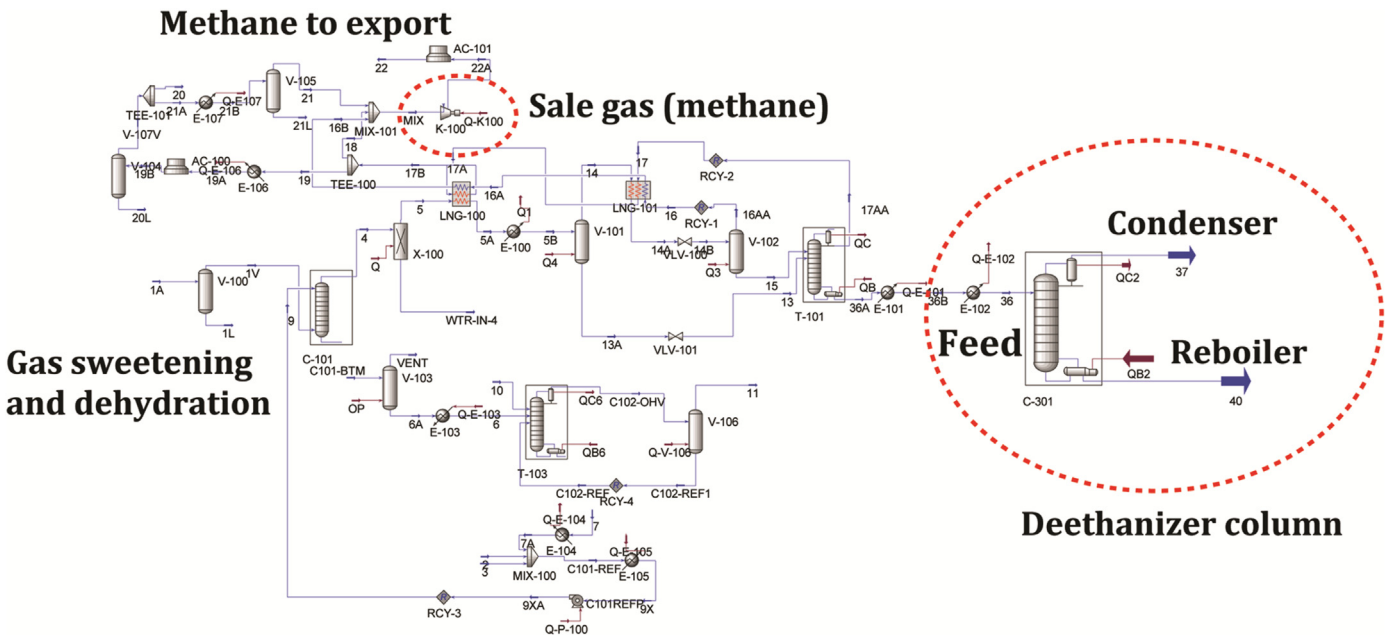

Fig. 1. An industrial process flowsheet for hydrocarbon recovery.

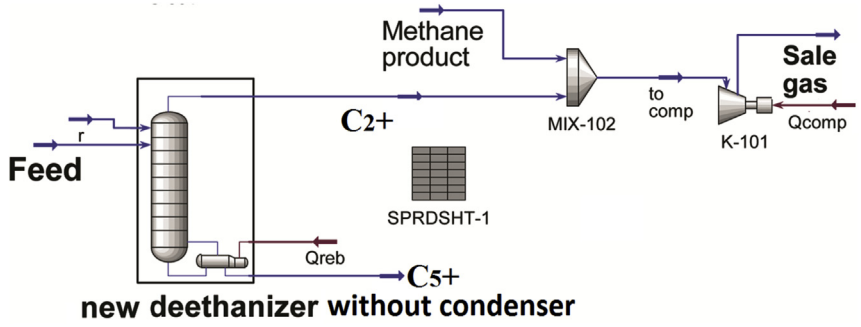

Fig. 2. The retrofitted process of the deethanizer column.

the deethanizer column and even no discussion for minimizing expenditures are reported in the literature, for this special case. Accordingly, in this research the effect of change in the reboiler temperature, the deethanizer operating pressure and the feed inlet stage are addressed using process simulator software and the practical method of response surface methodology (RSM) is used for optimization and cost estimation of the modified process retrofit design.

2. Simulation of the industrial process

Fig. 1 shows the conventional process of a gas refinery developed based on the industrial plant data of the South Pars Gas Complex (SPGC), Assaluye, Iran. Since, the process configuration is quite complex, just the deethanizer column simulation is studied here. The bottom stream of the demethanizer column enters at 10th stage from top of the deethanizer column. The demethanizer and deethanizer pressures considered here are 3516 kPa and 2827 kPa, respectively, in accordance with industry standards. In this design, the propane refrigerant cycle is not shown and considered as an internal program. The deethanizer column has 26 stages including condenser and reboiler with tray efficiency of 50% utilizing valve tray. The top product of the deethanizer column is "ethane" and it is sent to an adjacent petrochemical plant. The bottom product is called "LPG" consisting almost propane, i-butane and n-butane. The required heat input to derive the hydrocarbon separation is supplied by low pressure (LP) steam at the reboiler (steam in tube side). The run specifications for the deethanizer column in terms of condenser and reboiler temperatures are 6 °C and 95 °C, respectively. Table 1 summarizes the feed flow rate, composition and operating condition of the main streams of the industrial deethanizer column while the actual specifications of feed and product streams are taken into account.

The entire process is simulated by the Aspen HYSYS software. In the present research the PRSV equation of state is utilized. It should be emphasized that most of the previous studies have used this equation of state for the calculation of thermodynamic properties (He and Ju, 2014; Mehrpooya et al., 2006; Chebbi et al., 2010). The reliability of simulation is checked by comparing the actual data with the simulation results.

In order to retrofit the deethanizer column, the condenser is discarded and the process configuration reflecting this adjustment is shown in Fig. 2. In order of consistency, the proposed system shown in Fig. 2 is run with the same tray number (26 stages including reboiler) and just the feed tray location, column operating pressure and reboiler temperature vary from case to case.