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Analysis of SRX Ethane Recovery Process Characteristics

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Abstract: In order to improve the recovery rate of ethane in natural gas, the characteristics of the new SRX process have been studied, focusing on the reflux ratio of the external dry gas, the composition of the feed gas, the operating pressure of the demethanizer, and the amount of gas sideline extraction from the demethanizer, sideline The influence of the temperature after the gas phase is subcooled on the recovery rate of ethane and the energy consumption of the main device system. The results show that the ethane yield can be effectively increased by increasing the recirculation flow of the external dry gas, reducing the operating pressure of the demethanizer, appropriately increasing the amount of gas extracted from the demethanizer, and reducing the subcooled temperature of the gas phase extracted from the side line. In addition, the SRX process has good adaptability to feed gas composed of different temperaments, and the ethane yield and propane yield can reach 88% and 99.99% respectively.

Keywords: Natural gas processing; ethane recovery process; HYSYS; SRX process flow.

1. Introduction

In addition to methane, natural gas usually contains a certain amount of ethane and above heavy hydrocarbons. The process of recovering these hydrocarbon components in liquid form is called natural gas condensate recovery [1-2]. The recovery of natural gas condensate can improve the quality of natural gas, control the hydrocarbon dew point of natural gas, prevent natural gas from condensing and block the pipeline during pipeline transportation, and reduce oil and gas loss.

The production capacity of the domestic ethylene industry is growing rapidly, and the structure of ethylene raw materials is showing a trend of lightweight and diversified development. Ethane is a high-quality raw material for ethylene cracking. The yield of ethane to ethylene is as high as 78%, while naphtha is only 28.2~31.1%, and the production cost of ethane to ethylene is only two-thirds of naphtha to ethylene.

Actively carrying out research on ethane recovery technology can not only promote the diversification of natural gas sales products, reduce oil and gas losses, and improve the comprehensive utilization of resources, but also promote the lighter and higher quality of ethylene raw materials in my country to realize oilfields Maximize the benefits of the entire upstream and downstream industry chain.

At present, most of the domestic condensate recovery devices are only used to recover propane, not ethane, and the general characteristics of these devices are large numbers, small scale, low condensate recovery rate, high energy consumption, and low economic benefits. In China, only Daqing Oilfield, Liaohe Oilfield and Zhongyuan Oilfield have ethane recovery devices operating, mainly recovering ethane and above condensate products in oilfield associated gas. In addition, the ethane recovery process is improved on the basis of foreign processes. For example, Daqing Oilfield introduced the technology of the German Linde natural gas cryogenic device based on the LSP process, and designed the LSP process of propane precooling + expander refrigeration [3] .

Since the 1980s, foreign companies have made a series of improvements to the process methods of natural gas condensate recovery devices for the purpose of saving energy, reducing consumption, increasing condensate yield, reducing investment and operating costs, and cost repayment time. Many new ethane process technologies. In mid-2000, Ortloff Company optimized the RSV ethane recovery process and proposed the Supplemental Rectification with Reflux (SRX) process. The SRX ethane recovery process is very flexible in the ethane recovery mode and has an ultra-high ethane recovery rate [4]. This process is more adaptable than the RSV process, and the device consumes less energy and production costs.

2. SRX Process Flow

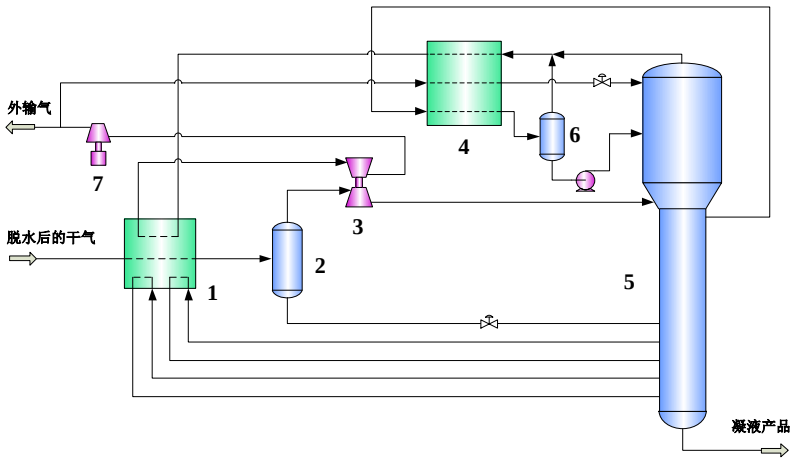

Fig. 1 SRX process flow

The SRX process is an optimized and improved process of the RSV process which retains the most distinctive external dry gas of the RSV process and recirculates it back to the top of the demethanizer, and discards the use of a low-temperature separator for partial gas-phase subcooled recirculation. Part of the gas phase is extracted from the middle of the demethanizer, and after cooling, liquid hydrocarbons are separated by the overhead separator as the reflux in the upper part of the tower. The two additional refluxes installed at the top of the tower achieve the ability to obtain an ultra-high ethane recovery rate and maintain a propane recovery rate of more than 99%. In addition, this process is more adaptable to CO2 in the feed gas than the GSP and RSV processes.

The SRX process has the following characteristics[5]:

(1) Due to the addition of the reflux of the external dry gas and the reflux of the demethanizer, the ethane yield is higher than that of the GSP process, and the obtainable ultra-high ethane yield can exceed 99%.

(2) The gas phase of the low-temperature separator of this process enters the expander for expansion and refrigeration, which enables the demethanizer to obtain more cold capacity, and enables the turboexpander coaxial compressor to recover more energy, thereby reducing the external gas compressor Power consumption. This process has lower power consumption than RSV process system under the same recovery rate.

(3) The SRX process has better adaptability to richer feed gas, and the rich gas feed may need to add an external refrigeration system. This process has the best adaptability to raw gas above 4.0MPa.

(4) The process is very flexible in operation. This flexibility allows the operator to "seamlessly" switch the operation mode of the device: including ethane recovery or propane recovery mode [6].

3. SRX Process Characteristic Analysis

This paper uses Aspen HYSYS software to simulate the SRX ethane recovery process, and analyzes the amount of dry gas that is fed to the top of the demethanizer, the pressure of the demethanizer, the amount of extraction from the sideline of the demethanizer, and the extraction from the sideline of the demethanizer. The position and the influence of the subcooling temperature of the gas phase extracted from the side line of the demethanizer on the recovery rate of ethane and the unit energy consumption of the device [7]. The raw material gas enters the processing unit at a pressure of 6.0MPa, a temperature of 22°C, a processing capacity of 1500×104m3/d, and a pressure of 6.17 MPa for the external dry gas. The mole fraction of C2+

components in lean gas and rich gas are 8.43% and 11.73% respectively. The composition of the two temperaments is shown in Table 1 and 2.

Table 1 Lean gas composition of feed gas/%

N_2	CO_2	C_1	C_2	C_3	i-C_4
0.0143	0.009	0.8924	0.0629	0.0139	0.0015
n-C_4	i-C_5	n-C_5	C_6	C_7	C_8^+
0.0027	0.0008	0.0006	0.0005	0.0004	0.001

Table 2 Raw gas rich gas composition/%

N_2	CO_2	C_1	C_2	C_3	i-C_4
0.0619	0.0171	0.8034	0.0693	0.0259	0.0043
n-C_4	i-C_5	n-C_5	C_6	C_7	C_{8+}
0.0076	0.0018	0.0015	0.0016	0.0017	0.0039

3.1 The Influence of the Reflux ratio of External Dry gas on the Recovery Rate of C2

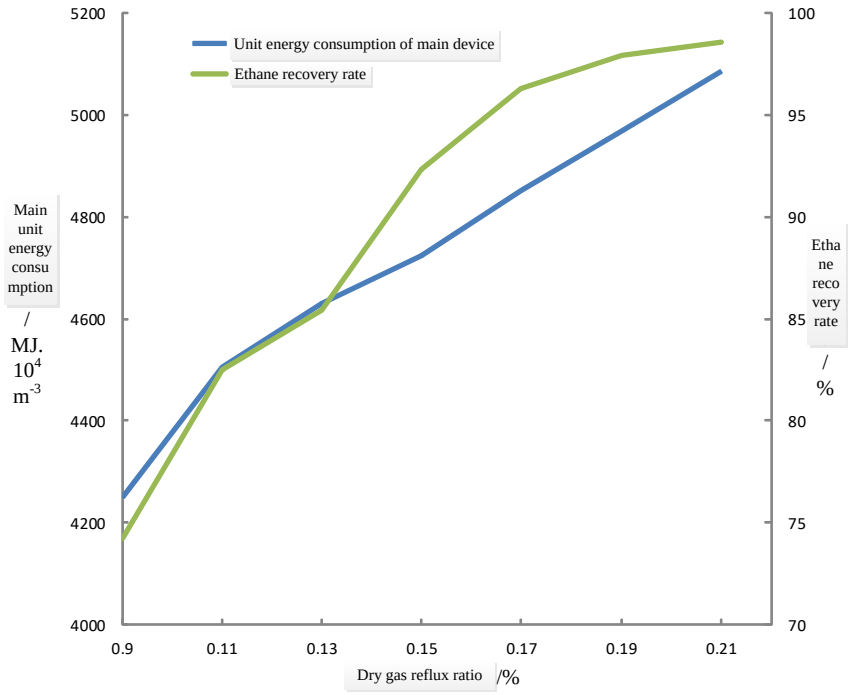

Fig. 2 The change curve of unit energy consumption and ethane yield and reflux ratio of external dry gas

The mathematical model established this time is mainly to describe the problem accurately. At the same time, when the model is established, the answering process of the model needs to be very simple. Therefore, although the model established above can achieve an accurate description of the problem, However, the process of solving equations is relatively complicated and therefore does not meet the relevant requirements. Therefore, it is necessary to simplify the mathematical model on the

basis of the mathematical model established above, so as to obtain a solution that can describe the problem accurately and simply Solve it.

With the increase of the reflux ratio of the external dry gas from 0.09 to 0.21, the ethane recovery rate of the SRX ethane recovery process reached 98.61%. This is because the reflux flow at the top of the demethanizer increases with the increase in the reflux ratio of the external dry gas, and this reflux (almost pure methane) is in countercurrent contact with the bottom-up gas phase inside the demethanizer at the top of the demethanizer[8] , Continuously absorb ethane and above heavy components, thereby greatly improving the recovery rate of ethane. However, with the increase in the return flow of the external dry gas, the compression work of the external dry gas compressor will increase, which will increase the unit energy consumption of the device. Therefore, within a certain range, the ethane yield of the SRX process can be increased by increasing the reflux ratio of the external dry gas. Because the reflux ratio of the external dry gas is too large, the energy consumption of the device is too large, and the whole process is uneconomical.

To every function need, we do paired comparison of the satisfied degree of all alternatives, and build paired comparison matrixes, then by using the optimization model, we get the satisfied degree. The thermal efficiency showed significant variations between the different isohel mixtures and pure diesel for the Ethanol-Diesel and Methanol-Diesel mixtures [3-4].

3.2 Determination of Initial and Boundary Conditions

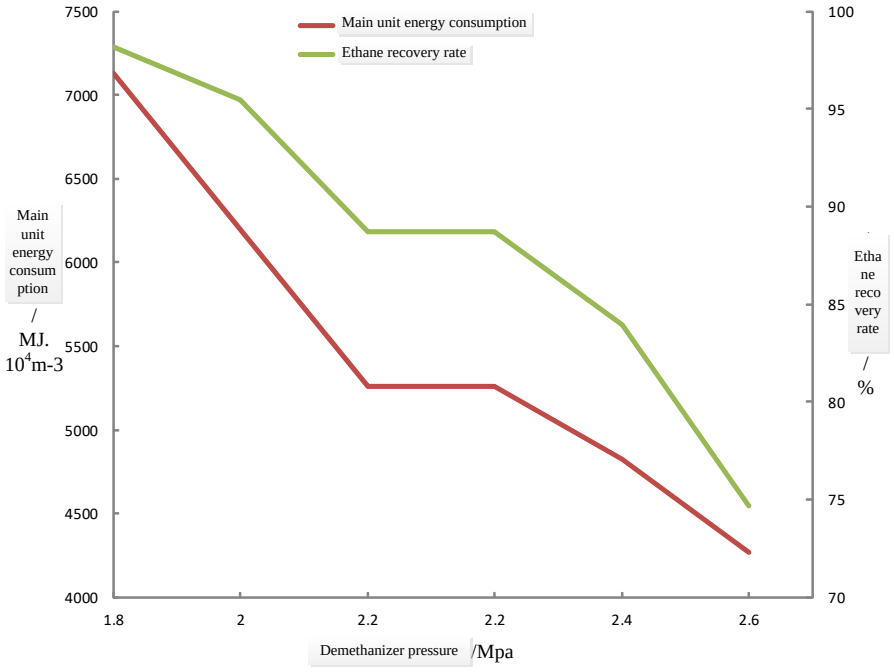

Fig. 3 The change curve of unit energy consumption and ethane yield and pressure of demethanizer

With the reduction of the operating pressure of the demethanizer from 2.6MPa to 1.8Mpa, the ethane yield increased from 74.66% to 98.16%, and the ethane recovery rate reached an extremely high level. The main reason is that by reducing the pressure of the demethanizer, the expander and throttle valve produce enough cold, thereby reducing the temperature of the upper part of the cryogenic separator and the demethanizer, and increasing the ethane recovery rate. However, if the pressure of the demethanizer is too low, it will increase the compression work of the external gas transmission (generally accounting for 30% to 50% of the main unit), the unit energy consumption of the main unit has increased by 66.9%, and the energy consumption has increased significantly. If the pressure of the demethanizer is too high, according to the gas-liquid balance principle of the upper part of the demethanizer, the relative volatility of the key components in natural gas will be reduced, thereby weakening the separation effect of the demethanizer, which will affect the separation effect of the key components and the recovery rate of ethane. The reduction will also reduce the compression work of the external gas transmission, thereby reducing the unit energy consumption of the main device. Therefore, to sum up, the choice of demethanizer tower pressure must consider the main energy consumption and ethane recovery rate [9].

3.3 The Effect of the Amount of Demethanizer Sideline Extraction and the Temperature of the Sideline Extraction Gas Phase After Subcooling on the Recovery Rate of C2

In this study, the pressure of the demethanizer is 2.6MPa, and the gas extraction position of the demethanizer is the eighth tray from top to bottom. It can be seen from Figure 4 that with the continuous increase of the molar flow rate of gas phase extraction from the eighth tray, the gas phase extraction rate has increased from 1000 kmol/h to 6000 kmol/h, and the ethane recovery rate has also been continuously improved, with the ethane recovery rate reaching 95.04 %. At this time, because the gas phase of the demethanizer is extracted and subcooled by the cold box, it flashes once and then the liquid phase (mainly ethane) enters the upper part of the demethanizer, which minimizes the loss of ethane and heavier components from the top of the tower. Therefore, the greater the amount of gas extracted, the more heavy components of ethane and above will flow into the upper part of the demethanizer, and the higher the recovery rate of ethane. However, the amount of gas extracted is limited by the amount of gas on the tray itself. Too little gas phase on the plate causes the demethanizer to not converge, and the operating parameters are extremely unreasonable.

With the continuous decrease of the subcooling temperature of the gas phase extracted from the side line of the demethanizer, the gas-liquid equilibrium constant

also decreases, so the recombination component of ethane and above in the reflux liquid phase continues to increase, and the recovery rate of ethane continues to increase. When the subcooling temperature reaches -98 At °C, the gas-liquid equilibrium constant is 0.502, and the ethane recovery rate reaches 98.05%. When the cold temperature cannot be too low, otherwise the actual operation can not provide so much cooling [10].

In summary, in the SRX process simulation, first select the appropriate demethanizer side-line extraction gas volume and side-line extraction subcooling temperature according to the process parameters. Too low or too large gas extraction volume cannot obtain higher ethane Yield, too low subcooling temperature will deviate from the actual working conditions unreasonable.

3.4 Influence of Feed Gas Composition on C2 Recovery Rate

Compared with the rich gas and the lean gas, the ethane recovery rate is very similar, indicating that the SRX process is very adaptable to the raw gas quality, but the energy consumption of the main unit of the rich gas is greater than that of the lean gas. This is because the content of heavy components in the rich gas is higher than that in the lean gas, and the amount of cold required for pre-cooling of the feed gas increases, and the amount of condensate produced after being cold increases, and the heat required at the bottom of the demethanizer increases, resulting in a propane refrigeration cycle The work of medium compression is significantly increased, which in turn causes the increase in energy consumption of the main device unit of the system.

4. Conclusion

Through the research of SRX ethane recovery process, the following conclusions are summarized:

(1) The main feature of the SRX process is that there are two. The first one is to separate a stream from the compressed external dry gas for condensing and throttling as a reflux at the top of the demethanizer, and The bottom-up gas phase countercurrent contact in the methane tower conducts rectification, continuously absorbing ethane and heavier hydrocarbon components in the gas phase, thereby greatly increasing the ethane yield. The second is to extract a gas phase from the upper part of the demethanizer, after being subcooled by the cold box, enter the reflux tank at the top of the tower for flash evaporation, and return the liquid phase (more heavy components of ethane and above) to the upper tray of the demethanizer. It can improve the ethane yield and can also solve the problem of CO2 freezing at the top of the tower.

(2) In the SRX process, the amount of gas extracted from the side line of the demethanizer and the subcooling temperature have a greater impact on the ethane recovery rate. The gas phase of the upper tray of the demethanizer is extracted, and the liquid phase is refluxed as the upper part of the demethanizer after cold flash evaporation. The more the gas extracted or the lower the reflux supercooling temperature will increase the content of ethane and heavy hydrocarbons in the reflux liquid phase, so that the ethane yield (>95%) will reach a higher level.

(3) The SRX process has a good adaptability to the quality of the raw gas. Studies have shown that the process can reach a high level of ethane yield under the conditions of different rich and poor temperaments. However, when the gas quality is rich, the energy consumption of the main ethane recovery device is higher than when the gas quality is poor.

4.1 Cellular Automation by Traffic System

In the operation and maintenance process, operators needs go along the sweep and go from the root to the front in order to find the potential safety hazard in tower crane. Generally, this work can be done in two ways. First one is to drive the cart in which there is basket that can move with the vehicle. Second is that operators climbs along the sweep to do the work.

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