Development and modeling of a resource-saving methanol recovery process diagram

Karina Bayazitova*, *Artem* Salimov, *Alexander* Ponomarev, *Nikolay* Shutov, and *Nadezhda* Vadulina

Ufa State Petroleum Technological University, Ufa, Russian Federation

Abstract. This article discusses the problem of hydrate formation in the development of gas fields. The authors describe the methanol recovery technology. The study examined and modeled the methanol regeneration unit in the medium of the UniSim program, justified the insufficient degree of regeneration according to the current scheme. The purpose of this article is to increase the degree of methanol regeneration at the complex gas treatment plant to reduce the concentration of methanol in industrial effluents and its reuse.

1 Introduction

Natural gas is one of the most economical sources of fuel and energy resources, which occupies a special place in the raw material base of the world. The reasons for this are its high consumer properties, low production and transportation costs, as well as widespread use in many areas of human activity. The advantage of natural gas over other fuels is its low cost.

The Russian gas industry is an important source of income, so a large amount of money is allocated for its development and modernization. The development of resource-saving technologies is an important area for the gas industry. When developing gas fields in cold climate conditions, it is necessary to take into account the possibility of hydrate formation. In order to prevent the formation of hydrates in the gas stream, it is necessary to eliminate at least one of the conditions of their existence. The main methods of hydrate control are pressure reduction, temperature increase and introduction of antihydrate inhibitors. Today, the most effective and common is the latter method. The most commonly used hydrate formation inhibitor is methanol. The low freezing temperature of the water methanol solution and its ability to break down hydrates provide a stable working process in a wide range of temperatures and pressures. The need to regenerate methanol is dictated by a harsh climate that requires large volumes of methanol to prevent hydrate formation, as well as the distance of gas deposits from transport highways and industrial centers, which leads to a high cost of delivering methanol to fishing areas.

* Corresponding author: karina.bayazitowa@mail.ru

2 Methanol recovery methods

2.1 Methanol regeneration by rectification

An increase in the concentration of the aqueous methanol solution can be achieved by rectification, adsorption or chemical purification. Consider in more detail the reduction of methanol by rectification.

Rectification is a type of distillation based on the countercurrent interaction of steam and liquid in a column. It allows to achieve the most complete separation of components, and it is also used for purification of crude methanol in methanol synthesis plants and under commercial conditions. Consider the regeneration of aqueous methanol solutions as a conventional rectification process. Methanol is a low boiling component which is vaporized in a methanol-water mixture. It condenses to form a so-called distillate. Water, as a component with a higher boiling point, does not evaporate and is called a residue.

The main unit of the methanol recovery unit is the distillation column. It is in it that methanol separates from water. To start the plant with saturated methanol, the distillation column is filled to a certain level with simultaneous supply of steam to the riboiler. This methanol recovery process provides a significant reduction in methanol losses and the possibility of further use of purified water for various process needs.

During rectification, two types of columns are used: poppet and packing. Poppet columns are column vessels. The internal devices of the poppet columns in the working area are trays. Trays are bubbling devices in which the mass exchange process occurs. In other words, the transition of a component from one phase to another as a result of direct contact between working media. In the chemical and oil refining industries, plate columns are used.

Packing columns are widespread in the processes of absorption, purification, cooling and humidification of gases, sometimes rectification.

2.2 Methanol regeneration by blow-off

At the methanol regeneration plant, the process of its absorption from the aqueous solution is carried out by the method of blowing off the volatile inhibitor in a special section of the gas pipeline. The main difference of this method is that methanol is "extracted" without using additional regeneration sites and filters during gas transportation. This substantially eliminates the flow chart.

The amount of methanol contained in the gas that will prevent hydrate formation is taken to be twice its theoretical value when the blow-off method is applied. This provides hydrate-free conditions in the gas. True, they are believed to be close to the threshold at which hydrate formation begins. Until recently, the blow-off method was considered ineffective, because inhibition is recommended in low-temperature technology to prevent hydrate formation. In the initial period of operation of deposits in the Far North conditions, there is a need to supply methanol to gas collection headers in the winter. Because of this, the formation gas that enters the initial separation stage contains a certain amount of methanol, which is not quite enough to recycle the inhibitor. As a result, the absorption system of the water-methanol solution for further blow-off becomes ineffective. The increased loss of methanol is also due to the need to maintain a stable level of liquid in the tanks involved in the works implementing the circulation technology.

3 Development and modeling of a resource-saving methanol recovery process diagram

Consider a typical rectification unit for regenerating aqueous methanol solution as shown in Figure 1.

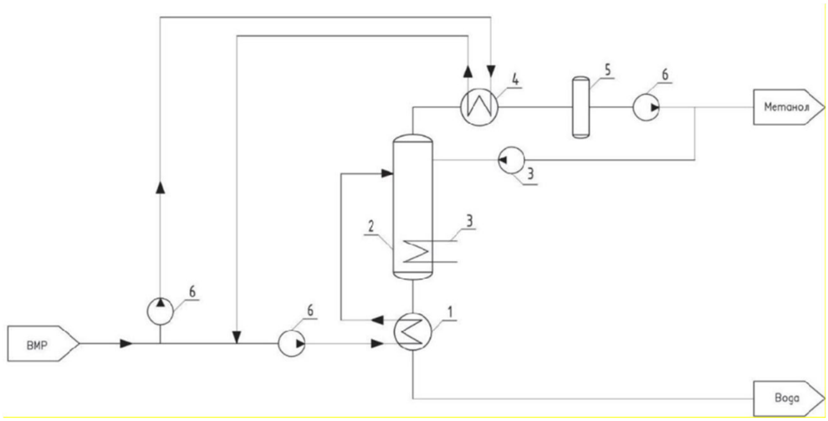

Fig. 1. Methanol Recovery Unit Flow Chart. 1 - heat exchanger; 2 - rectification column; 3 - steam heater; 4 - condenser-refrigerator; 5 - intermediate capacity; 6 - pumps.

The unit operates according to the following flow chart. The water-saturated methanol is pumped from the tank and fed to the distillation column via the tubular heat exchanger 1. In heat exchangers, saturated methanol is heated by the heat of hot water leaving the bottom of the column. The constant temperature of the top of the column is maintained by supplying methanol for reflux from the tank. Methanol vapors from the top of the distillation column at a temperature of 65-68 °C enter the condenser-cooler 4, where they are cooled to a temperature below 30 ° C with saturated methanol. The liquid methanol then enters the intermediate tank 5 from which it is pumped to the tank 6.

3.1 Methanol regeneration unit simulation by rectification method

According to the process diagram, the water-methanol solution from the blow-off columns passes through the liquid separator, the gas weathering agent, is supplied to the treatment facilities, and then is discharged to the purified effluent injection unit. Due to insufficient methanol recovery from the aqueous methanol solution, the methanol concentration does not meet the requirements.

The methanol recovery unit shown in Figure 2 was simulated to obtain clean industrial effluents, which are then suitable for injection into the formation, and saturated methanol solution using the software package UniSim. The proposed plant is designed for post-treatment of industrial waste water from methanol by rectification and bringing its concentration to the requirements of regulatory documents.

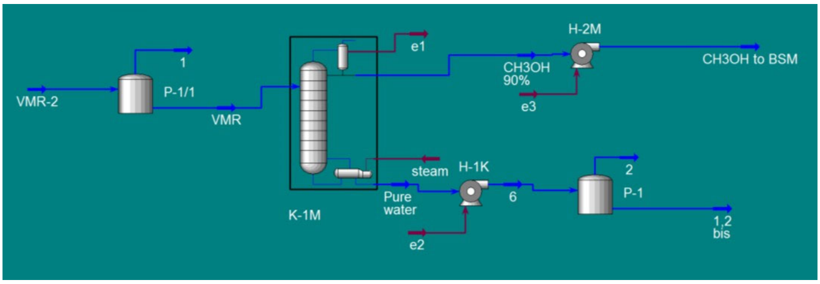

Fig. 2. Model of methanol recovery unit of treated effluent injection unit.

The unit consists of such parts as:

– buffer capacity R-1/1;
– Fractionation column with twelve reticulated plates;
– condenser, which is an air refrigerator with reflux capacity;
– reboiler heated by steam from a boiler house with a temperature of 130 °C;
– buffer tank with internal coil, which is intended for cooling and removal of high-boiling component (bottom sediment) - water from rectification column;
– six sealed pumps of type TG 25/20 K-3-3 (Q-25 m3, h-20 m N = 3 KW) (3 are in operation, 3 standby);
– buffer capacity storage R-1.

When comparing the efficiency of various types of distillation columns, a type was chosen that has a lower cost, but is quite effective. Typically, the weight of the packing columns is higher than the total weight of the poppet columns at the same productivity. In this case, the poppet columns are more suitable for methanol regeneration. This process is accompanied by temperature fluctuations, which provokes periodic expansion and compression of the column body, such operating conditions can destroy the nozzle.

In order to provide the highest concentration of methanol in the vapor phase exiting the top of the column and the lowest concentration of methanol in the liquid withdrawn from the bottom, it is necessary to determine the optimum operation parameters of the distillation column. The separation quality improves as the number of trays in the column increases. The number of trays was determined to be the lowest at which a methanol solution with a concentration of at least 90% could be obtained. The number of trays is taken as n = 12.

The efficiency of the distillation column is characterized by a reflux number. To achieve the best concentration value, the reflux value should be 4, since the total condensed saturated methanol flow rate is 1.5 t/h.

As a result of the distillation process, the feed is divided into two products: a vapor phase with a content of methanol of 95%, coming from the top of the column, and a liquid with a high content of water of 98%, coming from the bottom of the column. Vapour methanol enters the condenser, in which it is cooled to a temperature of 51 ° C by a stream of air and condenses in a reflux vessel. A portion of the flow is then pumped to the 12 tray as reflux.

The constant temperature in the bottom of the column is maintained due to the circulation of liquid through the reboiler. Water purified from methanol from the buffer tank of the column block is pumped to the storage tank using a pump.

4 Conclusions

When studying a typical methanol recovery unit, the main problem was identified, which was to reduce the efficiency of the existing methanol recovery unit. As a result, the methanol concentration in industrial wastewater exceeded the permissible standards.

When modeling the existing methanol blow-off scheme, we found an insufficient degree of regeneration. In order to improve the regeneration efficiency, it is necessary to supplement the existing process diagram with an additional stage.

We have simulated an additional regeneration stage in the UniSim program. We have determined the optimal technical and technological parameters of the distillation column. The products of the regeneration unit are: saturated 95% methanol solution, water with a methanol content of 23 g/dm^3.

The implementation of this installation allows us to solve two problems at once. Due to the production of an additional amount of saturated methanol solution, the total cost of using a fresh inhibitor is reduced. Treatment of industrial effluents to methanol content of 23 g/dm3 will allow their disposal into absorbing wells without violation of environmental standards.

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