Gas distributor for ultra-large air blow-out bromine extraction plant

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Abstract. The initial distribution of gas and liquid is one of the key factors that determine the operation efficiency of packed towers. The development of a gas distributor for ultra-large air blow-out bromine extraction plant can improve operation efficiency, save energy and reduce consumption. In order to develop the gas distributor for ultra-large air blow-out bromine extraction plant, the guidelines for evaluating gas distributors are clarified in this paper, and six kinds of commonly gas distributor are compared in detail. Considering gas distribution inhomogeneity, liquid foam entrainment rates and distributor pressure drop, the double tangential circulation type gas distributor is the first choice in the ultra-large air blow-out method bromine extraction plant.

key word: Bromine; Gas distributor; Air blow-out method

1. Introduction

Bromine is an important fine chemical raw material. At present, there are more than 4500 bromides that can be synthesized artificially, among which more than 1800 are commonly used. Bromine flame retardants account for more than 40% of the consumption of organic flame retardants, and the commonly used ones include TBBPA, DBDPO, HBCDD, etc. [1]. High efficiency and low toxicity pesticides containing bromine are used to kill a variety of microorganisms, and the commonly used ones include bromomethane, bromopropylate, DBDMH, etc. [2-3]. As medical intermediates, more than 80 brominated drugs can be produced, among which ambroxol, ciprofloxacin, cefapirin and bronopol are common [4]. In the petroleum industry, dibromoethane is used as an antiknock agent for petroleum fuels and calcium bromide is used as a solid filling fluid for petroleum drilling. In the rubber industry, butyl bromide rubber is gradually replacing ordinary butyl rubber. According to statistics, the average annual growth rate of apparent consumption of bromine from 2007 to 2019 was about 2.57%, and the consumption of bromine exceeded 200,000 tons in 2019, with a year-on-year growth of 7.08%.

China's bromine industrial technology was developed from the underground brine in Laizhou Bay in the 1980s. About 90% of the domestic factories are uses the “Air blow-out method”. The production process is that the brine input into the pipeline by the brine pump, the acid and chlorine gas are added to the pump outlet pipeline, so the bromine ion oxidizes to free bromine. Acidizing oxidation solution further reacted by the oxidation tower to be sent to the blow-out tower, and sprayed from the top of the tower. The blower blows air from the bottom of the tower to complete the gas-liquid exchange on the surface of the packing. The bromine in the brine is desorbed and blow-out, and the waste liquid is discharged from the bottom of the tower. The bromine-containing air is discharged from the top of the tower, mixed with sulfur dioxide gas and fresh water spray added in the top air passage, and absorbed downstream, and formed small droplets of hydrobromic acid, which are enriched by the absorption tower and the trap to form bromine content. The higher hydrobromic acid completion liquid is passed through chlorine gas oxidation, steam distillation, condensation, washing and separation to obtain the finished industrial bromine. The simplified process flow of bromine by acid method is shown in Figure 1. [5]

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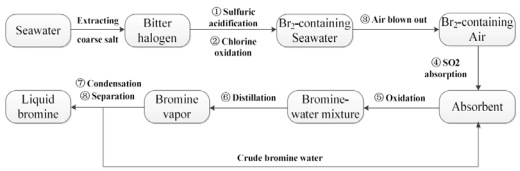

Figure 1. Bromine extraction process by air blowing.

The blow-out tower is the main equipment for the analysis and enrichment of "Air blow-out method", and is the core of the whole process. The blow-out towers in China are mainly 6.5 m in diameter, and there are some small towers of about 5 m. According to statistics, the 6.5 m diameter blow-out tower whose rated flow capacity is usually not greater than 1260 m^3/h, and the 5 m diameter blow-out tower whose rated flow capacity is about 700 m^3/h. Compared with other industries, the single tower rated flow capacity is small and energy consumption is high. The packed tower separation technology is a relatively mature process, drawing on the experience of other industries can completely increase the single tower processing capacity, so as to play the scale effect, to reduce energy consumption, improve the yield and capacity of the purpose.

For an excellent packed tower, the performance of the packing is a very important factor, but the matching tower internals (especially liquid distributor and gas distributor) also play a vital role in the performance of the packing. If there is no excellent performance of the tower interior to match, the performance of the packing will not be fully played. Especially for the large diameter and shallow bed packed tower, the initial distribution of gas and liquid is very important and often becomes the key factor for the successful application of packed column. Poor gas-liquid distribution can reduce the performance of the packing by 50%-70%.

2. Guidelines for evaluating gas distributors

In recent years, the research on packed towers has continued to make breakthroughs, and the maximum application diameter of regular packed towers in modern chemical production can reach 14-20 m. Gas distributor is an important gas initial distribution device in the packed tower, the performance of which directly affects the efficiency of the packed tower and product quality. Gas phase bias flow will cause uneven local gas-liquid distribution, reducing the separation efficiency; too much liquid entrained in the updraft will also affect product quality and yield, the poor structure of the feed distributor, will also affect the whole tower pressure drop. With the development of large void rate, low pressure drops, new high-efficiency packing and large diameter, shallow bed packed towers, the initial gas flow distribution in packed towers is receiving more and more attention.

After referring to a number of reports [6-7], we believe that a good gas distributor should have the following requirements at the same time:

- Good homogeneous distribution performance;
- Low flow resistance;
- Occupy a small space in the tower;
- Effectively prevent gas-liquid entrainment;
- Easy installation and maintenance;
- Low Cost

In the above requirements, good distribution performance and low resistance is the key indicator, the rest of the requirements in different occasions have different focus. Such as occupying a small space in the tower, in the old tower renovation is likely to be the first condition that must be met, while in the new tower design is not very important.

3. Commonly used forms of gas distributors and their performance

Domestic and foreign researchers pay more and more attention to the development of gas distributor, developed a wide range of styles, excellent performance gas distributor. In the industrial production of the common distributor are porous straight tube type, straight tube baffle type, single tangential circulation type, tangential horn type, double column blade type, double tangential circulation type, etc.

3.1 Porous straight tube type

The porous straight tube type is currently the most commonly used form of refinery pressure reduction tower, the inlet pipe extends to the center of the tower, the tube below the opening of a long hole, the gas from the hole ejected by the bottom of the tower rebound upward. At this time, the tower wall at the higher gas velocity, airflow along the mouth of the tube down the spray, in the feed tube above the formation of vortex, flow resistance is very large.

3.2 Straight tube baffle type

Straight pipe baffle type is an improvement of the porous straight pipe type, in order to reduce the impact and in the straight pipe with downward curved baffle, reducing the fluid flow resistance, gas velocity distribution and porous straight pipe similar, but if the gas-liquid two-phase feed, the liquid falls more at the entrance.

3.3 Single tangential circulation type

Single tangential annular flow inlet pipe tangential into the tower, and set the deflector, the gas-liquid fluid into the annular flow channel, in turn by the arc-shaped blade guide flow down, meet the bottom of the tower after the air flow back up into the sleeve. The center of the gas velocity is higher, the liquid is centrifugal force along the tower wall flow down, liquid foam entrainment is zero, the distributor resistance is small, while the inlet tube in the high-speed two-phase flow resistance is larger.

3.4 Tangential horn type

Tangential horn type inlet pipe tangential into the tower, the mouth of the pipe has a downward sloping horn-shaped guide hood, under the action of the guide hood downward circling flow, the gas mixture at high speed tangential into the gradually expanding horn, into the tower along the tower wall downward rotation to the bottom of the tower and then folded upward movement circling to the bottom of the tower and upward. When the gas flow contains liquid droplets, under the action of centrifugal force, the liquid droplets are separated and the mist entrainment is almost zero. The resistance is low. However, it is necessary to design a suitable angle, otherwise it will cause vibration.

3.5 Double column blade type

Double column blade type gas distributor, fluid radial into the tower, the inlet on both sides of the two guide arc vane, the top and bottom are closed, the airflow along the two vane left and right separate, rushing to the tower wall and folded upward. Because the double-row vane gas distributor tower occupies a small space, gas distribution is uniform, the flow resistance is small, in recent years the application is very widespread.

3.6 Double tangential circulation type

Double tangential circulating gas distributor is similar to single tangential circulating gas distributor, the material enters the tower in radial direction and is divided into two strands by the guide plate, which enter the annular channel along the inner cylinder and are guided to the bottom of the tower by the curved blades in turn, and folded upward. The distributor resistance is smaller, the liquid foam entrainment is smaller, the airflow distribution is more uniform.

3.7 Gas distributor performance comparison

Pan et al. [8] had systematically studied the performance of several gas distributors in terms of gas flow, gas distribution inhomogeneity M, liquid foam entrainment rates e_L and distributor pressure drop ΔP. The performance comparison of various distributors is shown in Table 1.

Table 1. Performance comparison of gas distributors.

	Porous straight tube type	Straight tube baffle type	Tangential horn type	Single tangential circulation type	Double tangential circulation type	Double column blade type
M	2.0	2.0	1.97	0.52	0.37	1.8
e_L	5.3	1.3	0	0	0.1	0.6
ΔP (Pa)	2740	843	10	49	15	30

4. Conclusion

Ultra-large air blow-out tower is of great significance to reduce production energy consumption and achieve economies of scale. As an important part of tower interior, gas distributor is indispensable. Considering the process flow and material properties of bromine extraction by air blow-out method, the support structure in the tower and the differences in the distribution inhomogeneity, pressure drop and liquid foam entrainment rates, the double tangential circulation type gas distributor is the first choice in the ultra-large air blow-out method bromine extraction device.

In the future, we will use the numerical simulation method to simulate the double tangential circulation gas distributor. A series of structural indexes such as the distance between the tower wall and the inner cylinder, the height of the inner cylinder, the height of the baffle plate, the number of baffle plates, and the opening condition of the roof were optimized by taking the distribution inhomogeneity and pressure drop as indexes.

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