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Study on the Hydrodynamic Performance of Modified Packing Tower

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Abstract

The horizontal baffle plates were installed in the ordinary packing tower to form modified packing tower. The relationship between the fluid mechanics of the spacing of baffle baffles were studied. When the volume of liquid was constant, the absorption rate decreases with the increased of gas flow rate. When the liquid phase was constant, the larger the gas flow rate, the smaller the absorption force, the smaller the absorption rate was in the packing tower.The effects of different plate spacing on pressure drop were observed and compared in common packing tower and modified packing tower. The results showed that the flow of gas-liquid two phases all affected the pressure drop, and the pressure drop increased with the increase of gas and liquid flow, and the pressure drop in the modified packing tower was more obvious.

Keywords: modified packed tower, baffle plate, hydrodynamic performance

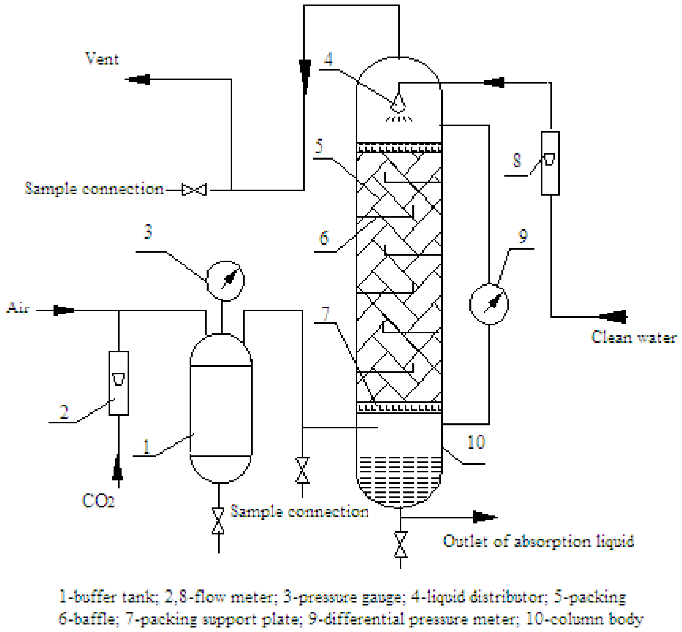
1. INTRODUCTION

The packing tower is one of the most common equipment items in chemical processing. Characterized by easiness in fabrication and replacement, wide range of material selection, strong adaptability, small pressure drop and liquid hold-up and high mass transfer efficiency, the packed tower has experienced great development over the past twenty-odd years. It is mainly applied in the petrochemical, fine chemical, pharmaceutical, foodstuff and environmental protection fields [1 – 4]. Presently researchers have conducted extensive study on the operation conditions [5-6] of the packed tower and the influence of column internals [7-10] on the absorption effect. However, there is little reporting coverage with respect to enhancing the turbulivity of the gaseous and liquid phases by changing the contacting mode of the gaseous and liquid phases and thus improving the mass transfer effect. In this research, baffles were installed inside the packed tower at a certain interval along the height, with neighboring baffles laid out in a staggered manner in the horizontal direction to change the flowing mode of the gaseous and liquid phases from the conventional counter flow to cross flow. The experiment examined the mass transfer performance of the cross flow packed tower and made comparison with the ordinary packed tower.

2. EXPERIMENTAL

2.1 Experimental devices

The experiment was conducted in an experiment devices as shown in Figure 1. The packed tower was of organic glass material, with an inside diameter of Ø100mm and a packed height of 1.8m. The packing was of Ø10×10mm stainless steel wire mesh Raschig rings, and baffles were installed inside the packed tower at a certain interval along the height. The baffle was a bow plate with a notch height of 25%. The outlet outlet of the baffle exit was 15mm height to maintain the thickness of the liquid layer on the plate. The baffle used special porous material and staggered two adjacent baffles in horizontal direction. The liquid flowed through the baffle, and the gas flowed upwards through the packing layer between the two baffles and the arch cut of the baffle, so that the flow direction of the gas and liquid in the tower changes from the traditional countercurrent to the cross flow.



1-buffer tank; 2,8-flow meter; 3-pressure gauge; 4-liquid distributor; 5-packing
6-baffle; 7-packing support plate; 9-differential pressure meter; 10-column body

Fig. 1 Flow of experiment apparatuses

2.2 The influence of the gas flow rate on the absorption rate

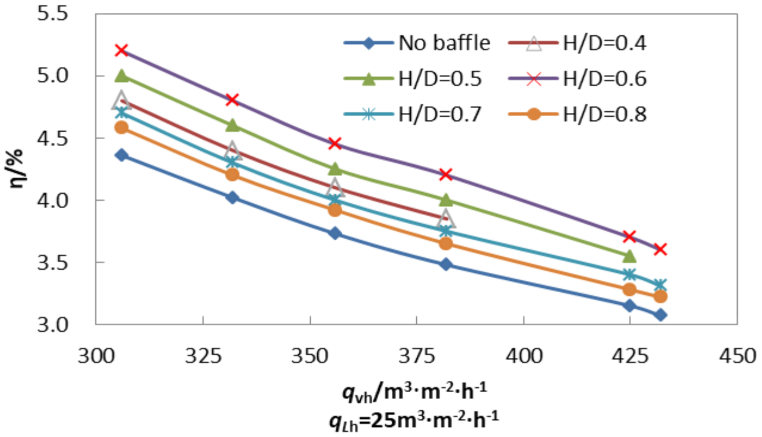


Fig.2 The influence of the gas flow rate on the absorption rate

The experiment was conducted at atmospheric pressure and a temperature of 25℃, and fresh water was used to absorb CO_2 in the mixture of air and CO_2. When the experimental conditions were not changed, the phase equilibrium coefficient was a constant.

The inlet and outlet concentrations of the gaseous phase were measured by gas phase chromatography SP6801, inlet concentration kept 5%, and the flow rate of the gaseous and liquid phases was read from rotameters.

$$\eta = \frac{Y_1 - Y_2}{Y_1}$$

Absorption rate refered to the ratio of absorption to intake. It can be seen from Fig. 2 that when the volume of liquid was constant, the absorption rate decreases with the increased of gas flow rate. When the liquid phase was constant, the larger the gas flow rate, the smaller the absorption force, the smaller the absorption rate was in the packing tower.

2.3 The influence of baffle on wall flow effect

Baffles were installed inside the packed tower at a certain interval along the height. The liquid phase flowed down vertically from the baffles while the gaseous phase flowed through the baffles in the horizontal direction and then flowed upward vertically along the arched notches. The cross current flowing of the gaseous and liquid phases inside the tower intensified the stirring of the gaseous phase to the liquid film.

Baffles were installed at a certain interval along the height inside the packed tower. The liquid phase flowed down vertically by gravity, and the gaseous phase flowed through the packing layer between two baffles in the horizontal direction under the effect of pressure difference.

By means of experiment, it was observed that the wall flow effect of the cross flow packing tower was obviously smaller that that of the ordinary packing tower.This was because the good permeability of baffles had enabled the liquid phase to have good distribution on the packing surface. As a result, a cross flow packing tower provided with baffles did not need installation of redistribution devices. In the case of an ordinary packed tower, as the liquid phase would flow to the column wall during dropping, when the ratio of the height of packing bed to the diameter of column exceeds a certain set value, in order to diminish the wall flow effect, it was necessary to sectionalize the column and install liquid redistribution devices.

2.4 The influence of baffle on the absorption rate

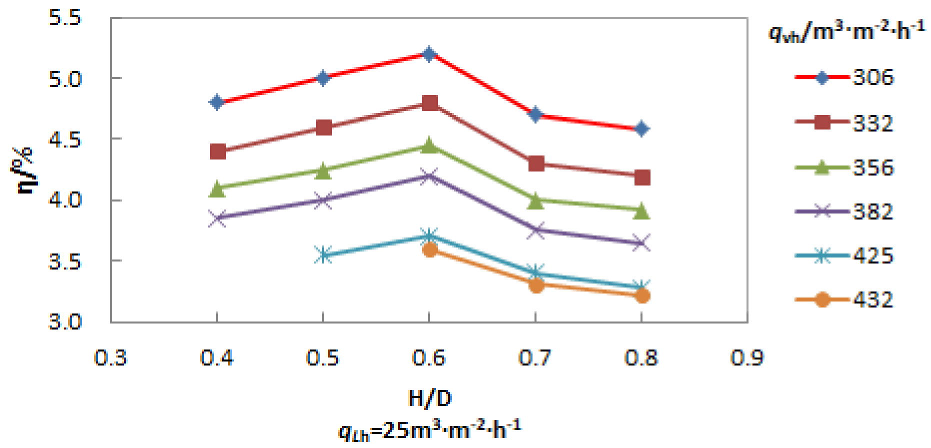


Fig.3 The influence of baffle on the absorption rate

For the cross flow packing tower, the influence of baffle spacingon the absorption rate was studied. As shown in Figure 3, under the same gas-liquid flow rate, the absorption rate increased with the increase of H/D, and then decreased. At H/D=0.6, the absorption rate was the largest.

The baffle plate was set in the packed tower, and the absorptivity increased. When the liquid flow rate was constant, the greater the gas flow rate, the greater the influence of baffle baffles. When the gas flow rate reached $432m^3{\cdot}m^{-2}{\cdot}s^{-1}$, the packed column was flooded at H/D>0.6. When the gas flow rate reached $425m^3{\cdot}m^{-2}{\cdot}s^{-1}$, the packed column was flooded at H/D>0.5. Therefore, the suitable flow rate of gas phase was $306m^3{\cdot}m^{-2}{\cdot}s^{-1}$~$382m^3{\cdot}m^{-2}{\cdot}s^{-1}$.

2.5 The influence of liquid flow rate on the absorption rate

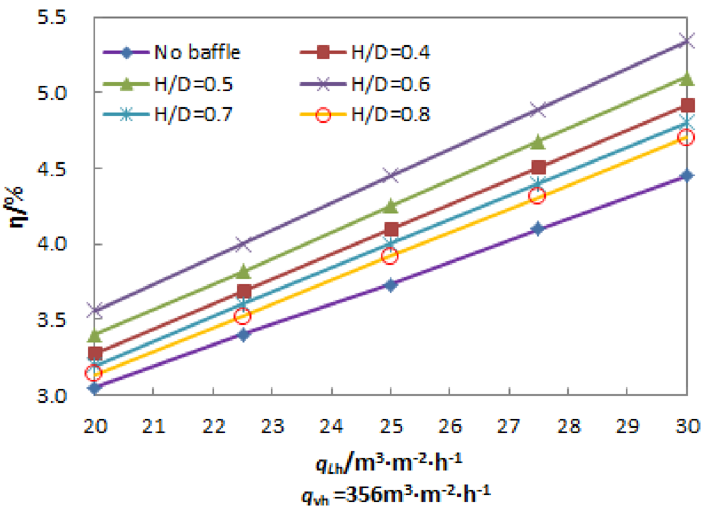


Fig.4 The influence of the liquid flow rate on the absorption rate

The influence of liquid flow rate on absorption rate of modified packing tower was similar to ordinary packing tower. The absorption rate increased with the increase of liquid flow rate. From the experiment, it was found that under the suitable flow rate, the influence of the plate spacing on the absorptivity was H/D= 0.6>0.5>0.4>0.7>0.8. The best plate spacing was H/D=0.6.

2.6 The influence of liquid flow rate on pressure drop

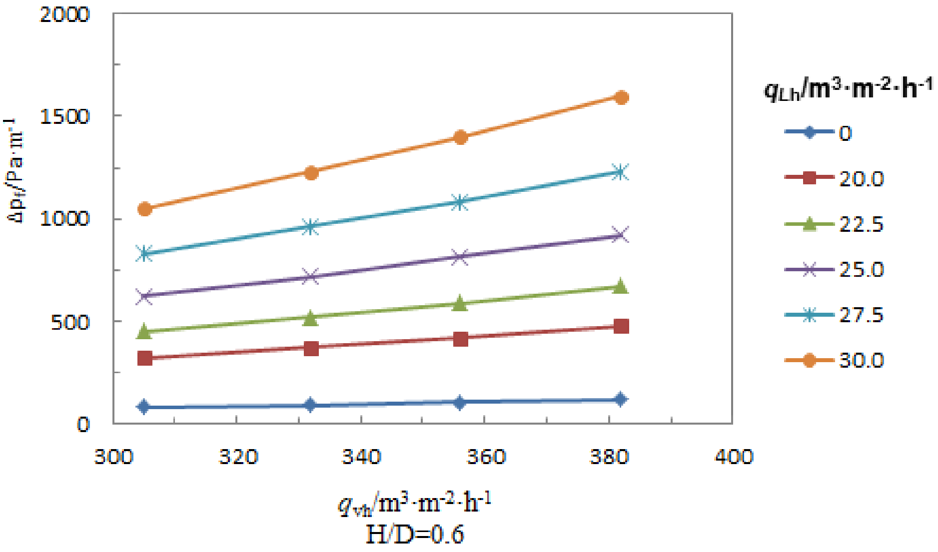


Fig.5 The influence of liquid flow rate on pressure drop

The influence of gas-liquid two relative pressure drop was similar between modified packing tower and ordinary packing tower. The pressure drop increased with the increase of the flow rate of gas and liquid. Fig. 5 showed the relationship between the gas flow rate q_{Vh} from 306m^3·m^{-2}·h^{-1} to 432m^3·m^{-2}·h^{-1}, the liquid flow rate q_{Lh} from 0 m^3·m^{-2}·h^{-1} to 30 m^3·m^{-2}·h^{-1} and the pressure drop in the modified packing tower of H/D=0.6.

2.7 The influence of baffle on pressure drop

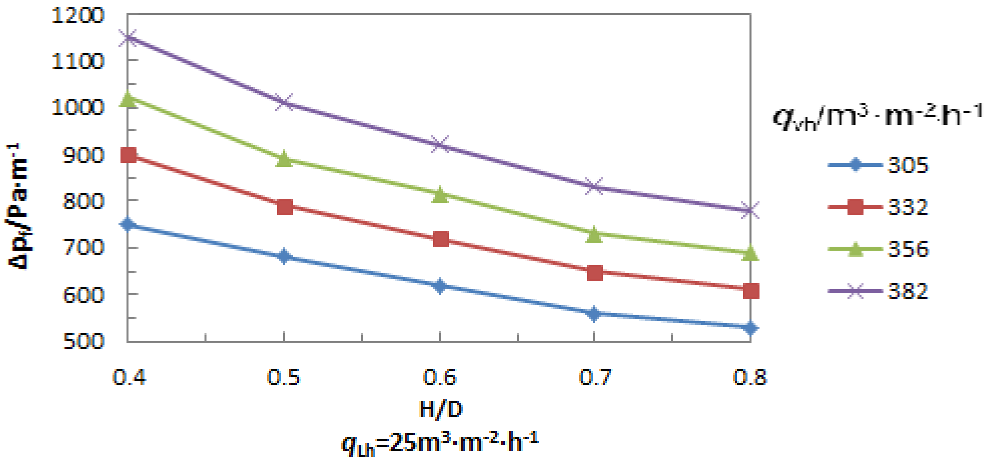


Fig.6 The influence of baffle on pressure drop

Under the same gas-liquid flow rate, the pressure drop decreased with the increase of plate spacing (H/D)in the modified packing tower. In the packing tower, after installing baffle baffles, the path of gas phase flow increased, resulting in an increase in pressure drop.

3. CONCLUSION

3.1 The wall flow effect of modified packing tower is obviously better than that of ordinary packing tower. A cross flow packing tower provided with baffles did not need installation of redistribution devices.

3.2 When the volume of liquid was constant, the absorption rate decreases with the increased of gas flow rate. When the liquid phase was constant, the larger the gas flow rate, the smaller the absorption force, the smaller the absorption rate was in the packing tower.

3.3 When the liquid flow rate was constant, the greater the gas flow rate, the greater the influence of baffle baffles. When the gas flow rate reached 432m^3·m^{-2}·s^{-1}, the packed column was flooded at H/D>0.6. When the gas flow rate reached 425m^3·m^{-2}·s^{-1}, the packed column was flooded at H/D>0.5. Therefore, the suitable flow rate of gas phase was 306m^3·m^{-2}·s^{-1}~382m^3·m^{-2}·s^{-1}. At H/D=0.6, the absorption rate was the largest.

3.4 The influence of gas-liquid two relative pressure drop was similar between modified packing tower and ordinary packing tower.

3.5 Under the same gas-liquid flow rate, the pressure drop decreased with the increase of plate spacing (H/D) in the modified packing tower.

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