Study on the Relationship between the Fractal of Packing Surface and Absorbility

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Abstract

The fractal of the liquid on the surface of the packing was related to the property of the liquid. The smaller the surface tension of the liquid, the better the fractal of the liquid on the surface of the packing and the higher the absorbility. The fractal of the liquid on the surface of the packing was related to the property of the packing. The greater the critical surface tension of the packing was, the rougher the surface of the packing was, and the better the fractal dimension of the liquid on the packing surface, the greater the absorbility. When the gas flow rate was 40Kmol•m⁻²•h⁻¹ and the liquid flow rate was 10 m³•m⁻²•h⁻¹, the absorbility of the stainless steeling ring was increased by about 14% than that of the ceramic ring. After the ceramic ring was modified, the absorbility was increased by about 20%, and the absorbility of the modified stainless steel ring increased by about 30%. With the increase of gas flow rate, the absorption force decreased and the absorbility decreased. As the spraying density of liquid increases, the absorption force increased, and the absorbility increased.

Keywords: Property of the Liquid, Property of the Packing, Fractal, Gas Flow Rate, Spraying Density of Liquid

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1. INTRODUCTION

Packing tower is an important gas-liquid, liquid-liquid heat transfer and mass transfer separation equipment, it is widely used in petroleum refining, fine chemicals, pharmaceutical, biological[1,2], chemical industry [3-6], environmental protection. Packing is the core component of packing tower, and the surface of packing is the place of gas-liquid heat transfer and mass transfer. The characteristics of packing directly affect absorption effect, pressure drop and tower load[7-9].

In this paper, the fractal condition on the surface of different packing surface was investigated. The influence factors of the fractal of the packing surface were analysed, and the relation between the fractal and the absorbility on the packing surface was determined.

2. EXPERIMENTAL

2.1 Experimental Apparatus

The flow chart of the experimental device was shown in Figure 1. The main equipment was a packing tower, the inner diameter of the tower is 60mm, the height of the packing layer is 1m, and the interior was equipped with $10 \times 10$mm ceramic ring and a stainless steel ring. The mixture gas entered from the bottom of the tower and was discharged from the top of the tower. The absorption liquid entered from the top of the tower and was discharged from the bottom of the tower by the flowmeter. The liquid storage tank and packing tower had constant temperature control system.

2.2 Experimental Method

The reagents used in the experiments were analytical pure. A series of solutions of different components and concentrations were configured. A certain amount of absorption liquid was sent to the top of the tower at 25.0 ℃, and the gas phase entered...
the bottom of the tower and carried out mass transfer with the liquid counter current contact. When the absorption process was stable, the gas concentration was measured at the entrance and exit of the tower. The fractal condition of different packing and absorbility were investigated by changing liquid spray density and gas flow.

3. RESULTS AND DISCUSSION

3.1 Fractal of Liquid on the Surface of Packing

The liquid fractal of packing surface depends on the interaction of liquid and solid. The liquid fractal of packing surface was related to the properties of packing, liquid, uniformity of gas-liquid distribution and operation. The larger the critical surface tension of the solid, the smaller the surface tension of the liquid and the rougher the packing surface, the better it was to fractal.

3.2 Effect of Solution Properties on Absorbility

K$_2$CO$_3$/ organic amines were used to absorb CO$_2$, and the effect of the properties of the solution on the absorbility was investigated.

\[ \eta = \frac{Y_1 - Y_2}{Y_1} \times 100\% \]

\( Y_1 \)-gas inlet concentration; \( Y_2 \)-gas outlet concentration

Figure 2 and Figure 3 showed the effect of the 25%K$_2$CO$_3$ solution and the addition of 5% MEA(monoethanol amine), DEA(diethanol amine) and PZ(piperazine) activators on the absorbility. The absorbility of K$_2$CO$_3$ for CO$_2$ was low, and the absorbility was increased obviously after adding a small amount of activator.
Moreover, the effect of adding a small amount of PZ was the best, and the effect of adding DEA was better than that of MEA, the effect was PZ>DEA>MEA. The reason was that the surface tension of PZ(35.6 mN/m, 25℃)<DEA(47.2 mN/m, 25℃)<MEA(49.0 mN/m, 25℃) respectively. The smaller the surface tension was, the smaller the contact angle between the liquid and the filler was, the better the fractal dimension of the liquid on the packing surface was, and the greater the mass transfer area.

3.3 Effect of Gas Flow Rate on Absorbility

As can be seen from figure 2 and Figure 3, the absorbility decreased as the gas flow rate increased regardless of what material the packing was and what the absorbent was. As the gas flow rate increased, the absorption driving force decreased, and absorption became difficult, therefore, the absorption rate decreased.

3.4 Effect of Packing Properties on Absorbility

The effect of the ceramic ring and the stainless steel ring on the absorbility was investigated. We can see the same gas-liquid phase flow and absorbent from Figure 4. The absorbibility of stainless steel was greater than that of ceramic material. The main reason may be the critical surface tension (75mN/m) of stainless steel>ceramic material (61mN/m). The greater the critical surface tension of the packing was, the easier the wetting of the liquid was and the better the absorption effect was. When the gas flow rate was 40Kmol•m⁻²•h⁻¹ and the liquid flow rate was 10 m³•m⁻²•h⁻¹, the absorbibility of the stainless steeling ring was increased by about 14% than that of the ceramic ring.
3.5 Effect of Modified Packing on Absorbility

The stainless steel ring and the ceramic ring were ground and modified to form a modified filler. As can be seen from Figure 5, the absorbability was obviously improved. This was because the surface roughness of the modified packing increased, the contact angle between the liquid and the filler surface decreased, the packing was easy to be wetted, and the fractal of the liquid on the packing surface became better, so the absorbability increased. After the ceramic ring was modified, the absorbability was increased by about 20%, and the absorbability of the modified stainless steel ring increased by about 30%.

3.6 Effect of Liquid Spray Density on Absorbility

The effect of liquid spray density on absorbability was shown in Figure 6 and Figure 7. The greater the liquid spray density, the greater the absorbability. As the liquid spraying density increased, the absorption force increased, so the absorbability increased.

4. CONCLUSIONS

4.1 The fractal of the liquid on the surface of the packing was related to the property of the liquid. The smaller the surface tension of the liquid, the better the fractal dimension of the liquid on the surface of the packing and the higher the absorbility.

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the packing surface, the greater the absorbility.

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4.4 As the spraying density of liquid increases, the absorption force increased, and the absorbility increased.

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