Efficient Removal of SO_2 with Novel Gas-liquid Mass Transfer Intensification Reactor Using N, N'-bis (2-hydroxypropyl) piperazine Solution

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Highlights

- A new diamine piperazine agent has been applied in SO_2 removal.
- The absorption process is intensified by novel RPB reactor.
- The mass transfer performance is greatly intensified.
- A reaction-equilibrium-mass transfer model is built.

1.Introduction

Combustion of fossil fuels such as coal, petroleum and natural gas, in power plants, boilers and incinerators results in the emission of sulfur dioxide (SO_2). SO_2 emissions are known to cause harmful impacts on human health and ecological environment.

Among the lots of desulfuration technologies, the organic amine scrubbing procedure arouses more and more interesting due to its high desulfurization efficiency, high utilization of SO_2 recovery and excellent selective for SO_2. However, there are some disadvantages for the conventionally used organic amines, such as ethylenediamine and alkanolamines, which can bring out secondary contamination. For example, the relatively high vapor pressure of the common organic amines leads to lots of (volatile organic compounds) VOC, while thermal and oxidation degradation of the them can easily generate toxic byproducts. To overcome these drawbacks of ethylenediamine and alkanolamines, a new diamine piperazine agent named N, N'-bis (2-hydroxypropyl) piperazine (HPP), which has low vapor pressure and high chemical stability, has been proposed to apply in the desulfuration process. Moreover, to get well desulfurization efficiency a novel intensification technologies, Higee (High gravity), has been proposed here to intensify the reaction process between SO_2 and HPP solution, which is limited by the gas-liquid mass transfer.

The motivation of this study focuses on the mass transfer performance of the SO_2 absorption process using HPP solvent in RPB. The effects of temperature, RPB rotating speed, gas flow rate, liquid flow rate, and SO_2partial pressure on the volumetric overall mass transfer coefficient (K_Ga) and height of mass transfer unit (HTU) are studied. In addition, a model is proposed to describe the mechanism of gas-liquid mass transfer between SO_2 and HPP solution in RPB.

2.Method

In this article, SO_2 absorption experimental research was conducted in rotating packed bed (RPB) reactor with HPP absorbent. The effects of absorbent initial pH value, gas-liquid

ratio, gravity level of RPB, absorption temperature on K_Ga and HTU were investigated.

3.Result and discussion

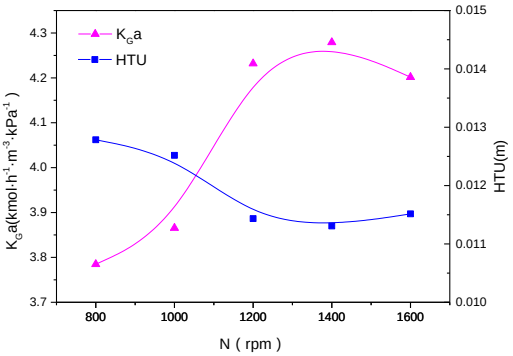

Figure 1. Effect of rotating speed on K_Ga and HTU.

Figure1 shows the effect of rotating speed on K_Ga and HTU in the RPB. It is evident that K_Ga increased while HTU decreased with an increase in rotating speed. The reason is that higher rotating speed leads to smaller liquid elements including smaller liquid droplets and thinner films, resulting in a larger gas-liquid contact surface.

4.Conclusions

This work systematically investigated the effects of operation conditions on the mass transfer performance of a SO_2 absorption process in RPB. It is evidenced that that K_Ga in RPB is up to 4.3 kmol h^{-1} m^{-3} kPa^{-1} and HTU is only about 0.01 m of the reactor, which shows the well intensification performance of the RPB. In addition, a reaction-equilibrium-mass transfer model is developed to describe the absorption process.

References

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Keywords

SO_2 removal, rotating packed bed, mass transfer intensification, model.