Chemistry Journal
Vol. 4, No. 3, 2018, pp. 56-59
http://www.aiscience.org/journal/cj
ISSN: 2381-7674 (Print); ISSN: 2381-7682 (Online)

Empirical Study of Mass Transfer Coefficient and Desulfurization Mass Flux from Sour Gas

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Abstract

The mechanism of sulphur absorption by nano fluid in a packed bed under the magnetic field is considered, in this study. The experimental and theoretical investigation is done to obtain the outlet amount of sulphur in gas stream. Experimental results show, increase in initial concentration under the higher emerged temperature caused by magnetic field increases the effective mass transfer coefficient from 2.1 to 7.9. In addition, changing 0.1 mol/m^3 in the initial concentration of hydrogen sulfide increases mass flow rate effective factor from 2 to 5.9. This shows the positive effect of magnetic field on the amount of gas absorption. The experimental results show, emerging 1.5 (A) current around the vessel affects aluminium oxide nano particle which is dissolved into the nano fluid only. In addition, changes in the amount of initial concentration of hydrogen sulphide at constant inlet temperature of 40 C and gas flow rate of 0.22 m^3/min is positively. In addition, the increase in the effective mass transfer coefficient is obtained and indicates on the increase in the amount of difference between magnetic mass transfer coefficient and simple mass transfer coefficient.

Keywords

Absorption, Gas, Packed Bed, Aluminium Oxide Nano Fluid, Sulphur

Received: June 25, 2018 / Accepted: August 14, 2018 / Published online: August 31, 2018

1. Introduction

The elimination of sulphur compounds is essential for refinery companies. Sulphur can threat the facilities and pipelines in all of the industries [1, 2]. So, sulphur removal is a basic unit which will be considered in the all of the factories and chemical industries [3, 4]. In addition, the hydrodynamic of flow can relative with components of flow. The sulphur can be effective in the friction factor and also pressure drop items [5-8]. So, the regime flow of the sweetening process is so important that must evaluate for requirement power for transporting of fluid [7-10]. In addition, the type of sweetening process is so essential in the economical investigation of any factories [11-14]. Therefore, investigation of these processes from economic and technical view is so important [15-17]. So, mass flux of sulphur removal is described and evaluated in this experimental research. So, the electric current around the vessel makes magnetic field which attracts the aluminium oxide nano particles which are mixed in the pure water. The effect of magnetic field on mass flow rate is shown as an effective factor for mass flow rate. The changes in the amount of effective mass transfer coefficient are investigated in this paper.

2. Materials and Method

Sour gasses which contain different amounts of hydrogen sulphide are reactor bed feed. Two gray 20 lit of volume

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pressurized vessel contain sour gas can be joint to the experimental line. For laminar flow, where only viscous drag forces come into play, $(N_{\mathrm{Re},p} \le 20)$, experimental data may be correlated by means of the Kozeny-Carman equation, Equation 1 [1]:

$$f_b = \frac{150(1-\varepsilon)}{N_{\mathrm{Re},p}\varphi_s} \tag{1}$$

Note: According to chemical engineering hand book [5], the factor of 150 was originally given by Carman as 180 for the case of laminar flow. Ergun later suggested a better value was 150 when the particles are greater than about 150 m in diameter. In addition, for highly turbulent flow where inertial forces predominate, $(N_{\mathrm{Re},p} \ge 1000)$ experimental results may instead be correlated in terms of the Blake-Plummer equation, Equation 2 [7]:

$$f_b = 1.75 \tag{2}$$

While both equations 8 and 9 have a sound theoretical basis, Ergun empirically found that the friction factor could be described for all values of the Reynolds number by simply adding the right hand sides of equations 8 and 9 [7]. Thus Equation 3 will be formulated as below.

$$f_b = \frac{150(1-\varepsilon)}{N_{\mathrm{Re},p}\varphi_s} + 1.75 \tag{3}$$

That $N_{\mathrm{Re},p}$ can be defined as, Equation 4 [5],

$$N_{\mathrm{Re},p} = \frac{\rho V_o D_p}{\mu} \tag{4}$$

The flow of a fluid, either liquid or gas, through a static packed bed can be described in a quantitative manner by defining a bed friction factor, fp, and a particle Reynolds number, NRe,p, as follows Equation 5 [1]:

$$\Delta P = \frac{f_b V_0^2 L(1-\varepsilon)}{g_c \varphi_s D_p \varepsilon^3} \tag{5}$$

Where,

ΔP = pressure drop across the fluidized bed

L = bed depth or length

gc = conversion constant (= unity if SI units are used)

Dp = particle diameter

ρ = fluid density

ε = bed porosity or void fraction

Vo = superficial fluid velocity

μ = fluid viscosity

φ_s = sphericity

The superficial fluid velocity at which the fluidization of the bed commences is called the incipient or minimum fluidization velocity, Vo. The incipient fluidization velocity may be determined by combining Equations 6 with the following result for the case of small particles.

$$V_0 = \frac{g(\rho_p - \rho)\varepsilon^3 \varphi_s^2 D_p^2}{150(1-\varepsilon)\mu} \tag{6}$$

Changes in the amount of bed porosity are evaluated by measuring pressure drop and minimum velocity. The experiments are done more than minimum velocity values. Pressure drop between top and bottom of fluidized bed is considered. The Equation 7 state the relation of mass transfer coefficient with mass flux of sulphur removal flux.

$$dN_A/dz = R_A(1-\varepsilon) \tag{7}$$

Where N_A is the rate of sulphur transfer from gas, z is the packed bed height direction, R_A is sulphur reaction rate, V is the total bed volume and e denotes the bed porosity. Bed length is divided into element with height of dz. The related boundary condition is as Equation 8. C_{A0} is the H_2S concentration in feed stream.

$$C_A(z=0.0) = C_{A0} \tag{8}$$

Emerging the magnetic field introduces new definition as mass flow rate effective factor and mass transfer coefficient effective factor. These define the influence of magnetic field. Equations 9 and 10 show the definitions of effective mass transfer coefficient and effective mass flux of sulphur removal process.

3. Results and Discussion

Bed porosity, inlet gas temperature, inlet concentration of H_2S, magnetic field which influences the mass transfer area, mass transfer coefficient and rate of reaction are considered here.

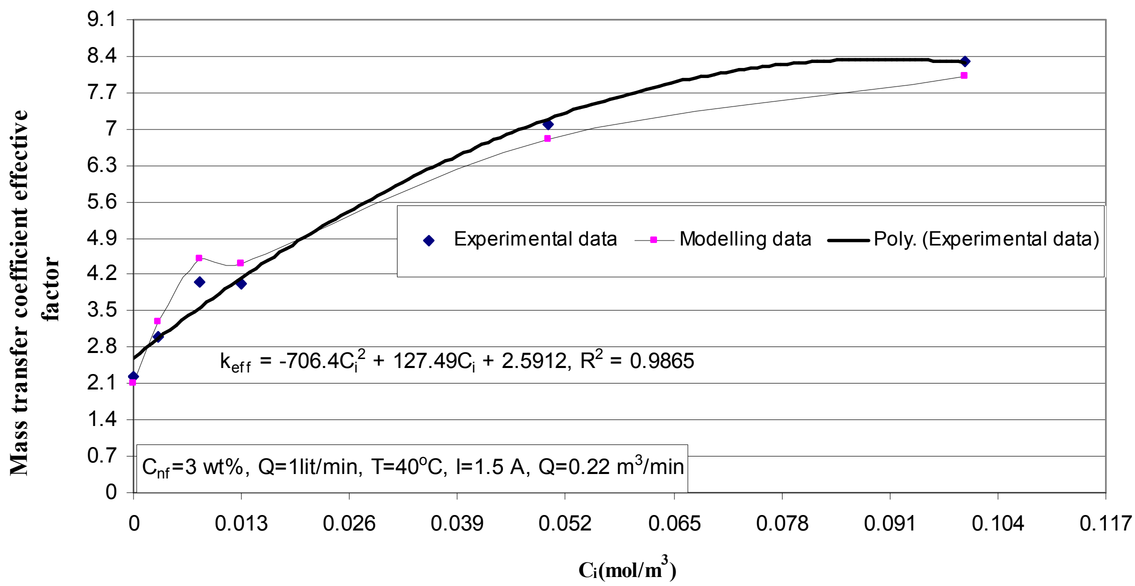

Figure 1. Mass transfer coefficient effective factor due to magnetic field.

The electric current around the vessel makes magnetic field which attract the aluminium oxide nano particles which are mixed in the pure water. The effect of magnetic field on mass flow rate is shown as effective factor for mass flow rate. The changes in the amount of effective mass transfer coefficient are shown in Figure 1. Emerging 1.5 (A) current around the vessel affects aluminium oxide nano particle which is dissolved into the nano fluid only. Changes in the amount of initial concentration of hydrogen sulphide at constant inlet temperature of 40 C and gas flow rate of 0.22 m^3/min is presented in Figure 1. The increase in the effective mass transfer coefficient is obtained and indicates on the increase in the amount of difference between magnetic mass transfer coefficient and simple mass transfer coefficient. The magnetic field has thermal effect and increases the temperature of process media. The increase in initial concentration under the higher emerged temperature caused by magnetic field increases the effective mass transfer coefficient from 2.1 to 7.9. This indicates on the significant influence of magnetic field on the mass transfer coefficient.

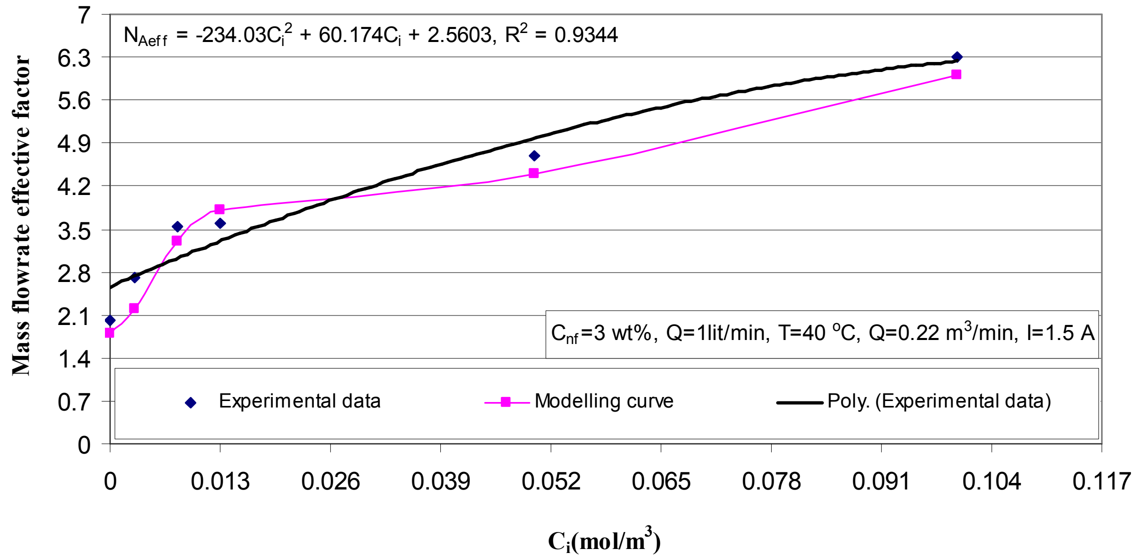

Figure 2. The effect of magnetic field on mass transfer flow rate.

The increase in the amount of mass transfer coefficient consequently causes the mass transfer flow rate. The Figure 2 presents the effect of initial concentration of hydrogen sulphide and magnetic field on the value of mass transfer effective factor. The increase in the amount of mass transfer coefficient effective factor increases the mass transfer rate. Also, the increase in the amount of initial concentration of hydrogen sulphide increases the driving force due to the absorption capacity of aluminium oxide nano fluid. The defined ratio introduces the effect of magnetic field. So, approximately changing as 0.1 mol/m^3 in the initial concentration of hydrogen sulphide increases mass flow rate effective factor from 2 to 5.9. This shows the positive effect of magnetic field on the amount of gas absorption.

4. Conclusion

Combination of absorption mechanism and magnetic field are used to remove hydrogen sulphide from sour natural gas. Mass transfer rate and mass transfer coefficient is measured and calculated experimentally and theoretically. The rate of mass transfer is introduced as function of gas temperature, initial concentration of hydrogen sulphide, gas flow rate, magnetic field, nano fluid flow rate and weight concentration of aluminium oxide nano particle in the pure water. Two effective factors for mass flow rate and mass transfer coefficient are introduced to show the effect of magnetic field. Results show, magnetic field has thermal effect and increases the temperature of process media. The increase in initial concentration under the higher emerged temperature caused by magnetic field increases the effective mass transfer coefficient from 2.1 to 7.9. In addition, changing 0.1 mol/m^3 in the initial concentration of hydrogen sulphide increases mass flow rate effective factor from 2 to 5.9. This shows the positive effect of magnetic field on the amount of gas absorption.

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