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Empirical Study of Fundamental Parameters in Sweetening Process of Sour Gas

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Abstract

The mechanism of sulfur absorption by nano fluid in a packed bed under the magnetic field is considered, in this study. Environmental regulations have increasingly restricted sulfur dioxide emissions, forcing fuel processors to remove the sulfur from both fuels and exhaust gases. The experimental and theoretical investigation is done to obtain the outlet amount of sulfur in gas stream. Some parameters which show the amount of sulfur removal like rate of mass transfer and mass transfer coefficient, also effective rate of mass transfer and effective mass transfer coefficient are considered. In addition, the experimental results show, increase in the amount of nano zinc oxide from 0 to 0.013 vol% increases the amount of NA about 5.1%. The increase in the amount of nano zinc oxide from 0.013 to 0.1 (vol%) increases the amount of NA about 10%. Comparison between the results of NA when using amount of 0.21 and 0.24 (lit/min) of gas shows that the increase in the amount of gas flow for about 0.03 (lit /min) shows about 20% increase in the amount of NA, using 10 (vol%) of nano zinc oxide. Experiments show that the increase in vloume percentage of nano zinc oxide from 0 to 10% increases the amount of NA from 0.118 to 0.136 (mol/m^3.s). The experimental results show, increase in the amount of nano zinc oxide may increase the turbulency under the magnetic field in absorbent liquid and may increase effective contact and the mass transfer. The obtained Figures are shown in the results and discussin section.

Keywords

Absorption, Gas, Packed Bed, Zinc Oxide Nano Fluid, Sulfur Removal

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1. Introduction

Many different processes are used to treat raw natural gas to pipeline quality. Sulfur is commonly present as an impurity in fossil fuels [1-6]. Burning fuels, the sulfur is released as sulfur dioxide—an air pollutant responsible for respiratory problems and acid rain [6-10]. Environmental regulations have increasingly restricted sulfur dioxide emissions, forcing fuel processors to remove the sulfur from both fuels and exhaust gases. The cost of removing sulfur from natural gas and petroleum in the United States was about $1.25 billion in 2008. In natural gas, sulfur is present mainly as hydrogen sulfide gas (H_2S), while in crude oil it is present in sulfur-containing organic compounds which are converted into hydrocarbons and H_2S during the hydro desulphurization [11-17]. In both cases, corrosive, highly-toxic H_2S gas must be converted into elemental sulfur and removed for sale or safe disposal [18-22]. Formation fluids that contain Hydrogen Sulfide-By-product from anaerobic bacterial action on sulfur compounds present in the mud (i.e. Sodium Sulfite)- Thermal degradation of mud additives containing sulfur (i.e. Lignosulfonates)-Chemical reactions with tool joint

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lubricants containing sulfur [23-25].

The mass flux of gas sweetening is evaluated in this paper, experimentally and theoretically. In addition, comparison between the results of NA when using amount of 0.21 and 0.24 (lit/min) of gas shows that the increase in the amount of gas flow for about 0.03 (lit /min) shows about 20% increase in the amount of NA, using 10 (vol%) of nano zinc oxide.

2. Materials and Method

Sour gasses which contain different amounts of hydrogen sulfide are reactor bed feed. Two gray 20 lit of volume pressurized vessel contain sour gas can be joint to the experimental line. However, both feed vessel cannot be used simultaneously. Stainless Steel vessel with inside diameter of 8 cm and height of 60 cm is the reactor vessel. The electric current is conducted in one circular coil around the vessel to produce the magnetic field and affect the movement of nano carbon tubes. The process temperature in vessel is adjusted by gas flow temperature and heat loss can be ignored since of the insulated Stainless Steel vessel. One polymeric weir with mesh size of 0.02 cm is on the top of vessel as a holder to let the only treated gas stream. The water is applied to enhance the amount of absorbed H_2S in to the nano fluid. Nano carbon tubes with 3% wt are mixed with pure water for 180 min and 4000 Watt. This time is considered for stability of nano carbon into the pure water. This step is an exothermic process. The water helps oxidation of H_2S and also increases the nano carbon capacity for H_2S absorption. The equation 1, 2, and 3 show the related mechanisms in H_2S adsorption.

$$H_2S\ (g) \rightarrow H_2S\ (aqua.) \quad (1)$$

$$H_2S\ (aqu.) \rightarrow H_2S\ (aqua\text{-}absorp.) \quad (2)$$

$$H_2S\ (aqua\text{-}\ absorp.) \rightarrow HS^-(ads.) + H^+ \quad (3)$$

The concentration of sulfide hydrogen in inlet and outlet gas stream is measured by gas chromatography device. The difference of these values can determine the mass flux of sweetening process, experimentally. Also, the void fraction of the catalytic bed is considered 30%. This is a main parameter in calculation of desulfurization process, theoretically. In addition, the mechanism of removing of hydrogen sulfide is considered as first one order. So, these items can calculate the mass flux of sweetening process. The obtained results from theoretical investigation are compared with experimental data.

3. Result and Discussion

3.1. Process Definition

The influence of different amount of magnetic field, liquid flow rate, and process temperature and nano particle in the fluid on the sulfur removal from the gas stream is investigated. The results of experiments are analyzed through graphs in this section.

3.2. The Effect of Amuont of Gas Flow Rate and Nano Zinc Oxide Concentration

The Figure 1 shows the effect of different amounts of nano zinc oxide by volume percentage on the amount of mass transfer, NA. Flow rate of absorbant is 0.35 lit/min, operation temperature is 18 C and magnetic field is 4.5 W. The gas flow rate of nano fluid is 0.21 (lit/min). Experiments show that the increase in vloume percentage of nano zinc oxide from 0 to 10% increases the amount of NA from 0.118 to 0.136 ($mol/m^3.s$). The increase in the amount of nano zinc oxide may increase the turbulency under the magnetic field in absorbent liquid and may increase effective contact and the mass transfer. Also, the increase in amountt of nano zinc oxide in absorbent helps the temperature homogenity in liquid. The simillar value of viscosity, thermal conductivity and other parameters which are related on the temperature in the liquid is helpful in uniform mass transfer through the packed bed. The theoretical data also show the increase in the amount of NA with the increase in the amount of volum percentage of nano zinc oxide in the fluid. However, at the amount of nano zinc oxide at 1.8 and 10 (vol%), the deviation between the experimental value and theoretical data of NA is more than that is obtained on the another amounts of used nano zinc oxide.

Figure 2 Shows the effect of increase in the amount of nano zinc oxide on the absorbant when the iquid flow is 0.24 (lit/min). This is obtained that, the increase in the amount of nano zinc oxide increases the amount of NA, experimentally and theoretically. The increase in the amount of nano zinc oxide from 0 to 0.013 vol% increases the amount of NA about 5.1%. The incraese in the amount of nano zinc oxide from 0.013 to 0.1 (vol%) increases the amount of NA about 10%. Comparison between the results of NA when using amount of 0.21 and 0.24 (lit/min) of gas shows that the increase in the amount of gas flow for about 0.03 (lit /min) shows about 20% increase in the amount of NA, using 10 (vol%) of nano zinc oxide.

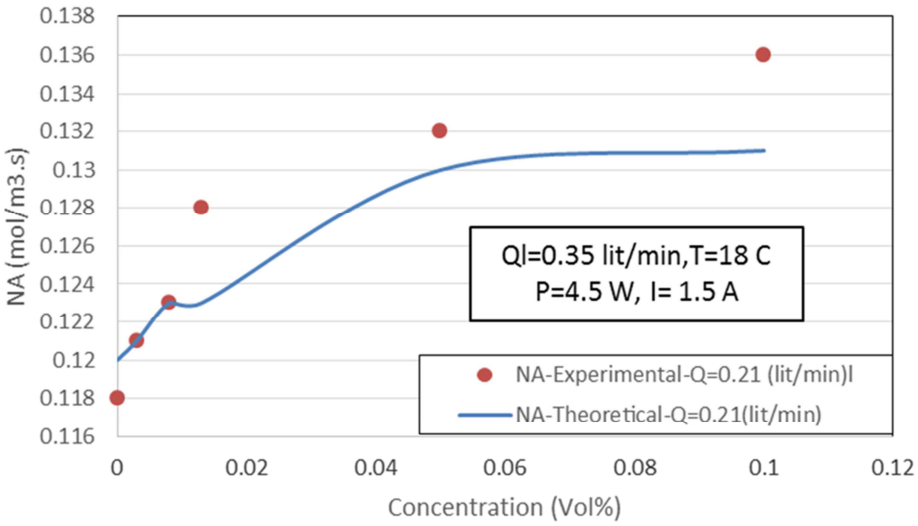

Figure 1. Mass transfer versus nano concentration at gas flow rate of 0.21 (lit/min).

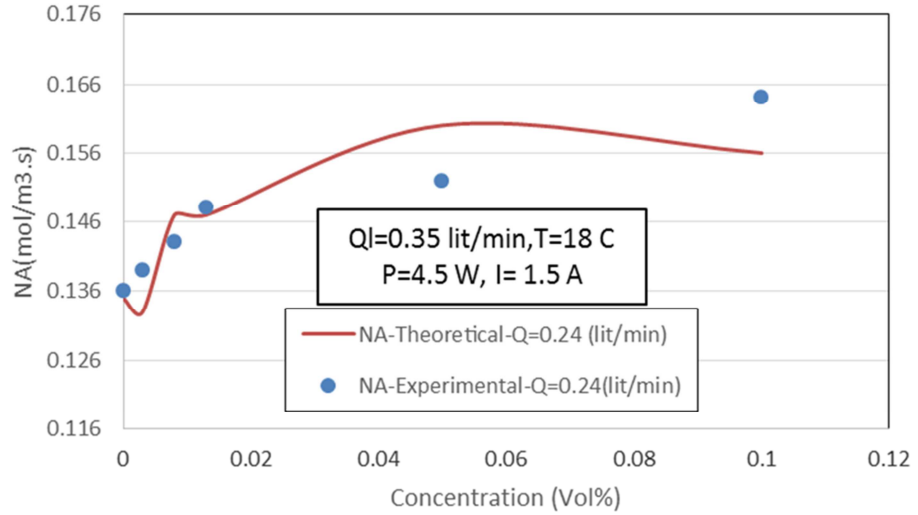

Figure 2. Mass transfer versus nano concentration at gas flow rate of 0.24 (lit/min).

4. Conclusions

The multi effects of magnetic field, fluidized bed and nano fluid on sweetening of natural gas in three phase of solid-liquid-gas vessel is investigated. The adsorption process of H_2S on the nano fluid is evaluated experimentally and theoretically. Results are presented in graphs. The experiments show that the increase in vloume percentage of nano zinc oxide from 0 to 10% increases the amount of NA from 0.118 to 0.136 (mol/m^3.s). The increase in the amount of nano zinc oxide may increase the turbulency under the magnetic field in absorbent liquid and may increase effective contact and the mass transfer. The theoretical data also show the increase in the amount of NA with the increase in the amount of volum percentage of nano zinc oxide in the fluid. However, at the amount of nano zinc oxide at 1.8 and 10 (vol%), the deviation between the experimental value and theoretical data of NA is more than that is obtained on the another amounts of used nano zinc oxide. In addition, the experimental results show, increase in the amount of nano zinc oxide from 0 to 0.013 vol% increases the amount of NA about 5.1%. The incraese in the amount of nano zinc oxide from 0.013 to 0.1 (vol%) increases the amount of NA about 10%. Comparison between the results of NA when using amount of 0.21 and 0.24 (lit/min) of gas shows that the increase in the amount of gas flow for about 0.03 (lit /min) shows about 20% increase in the amount of NA, using 10 (vol%) of nano zinc oxide.

References

[1] D. Eow, S. John, Recovery of sulfur from sour acid gas: A review of the technology Environmental Progress. Americ. Institut. Chem. Eng., 2002; 21: 143 - 162. Cordoba Patricia, C. Staicu Lucian, Flue gas desulfurization effluents: An unexploited selenium resource, Fuel, Volume 223, 1 July 2018, Pages 268-276.

[2] Kumar Sunil, Bajwa N. S., Rana B. S., Nanoti S. M., Garg MO., Desulfurization of gas oil using a distillation, extraction and hydrotreating-based integrated process, Fuel, Volume 220, 15 May 2018, Pages 754-762.

[3] Zhang Rui, Wu Hao, Si Xiaodong, Zhao Lingling, Yang Linjun, Improving the removal of fine particulate matter based on heterogeneous condensation in desulfurized flue gas, Fuel Processing Technology, Volume 174, 1 June 2018, Pages 9-16.

[4] Pan Peiyuan, Chen Heng, Liang Zhiyuan, Zhao Qinxin, Desulfurized flue gas corrosion coupled with deposits in a heating boiler, Corrosion Science, Volume 131, February 2018, Pages 126-136.

[5] Wang Jinman, Yang Peiling, Potential flue gas desulfurization gypsum utilization in agriculture: A comprehensive review, Renewable and Sustainable Energy Reviews, Volume 82, Part 3, February 2018, Pages 1969-1978.

[6] Tseng Chien-Chou, Li Cheng-Jui, Eulerian-Eulerian numerical simulation for a flue gas desulfurization tower with perforated sieve trays, International Journal of Heat and Mass Transfer, Volume 116, January 2018, Pages 329-345.

[7] Wang Dongpeng, Lu Yonghong, Li Zhe, Wang Xiaoli, Xu Haibo, Integrated electrochemical-aerating oxidation in recovery system of seawater flue gas desulfurization, Chemical Engineering Journal, Volume 338, 15 April 2018, Pages 184-190.

[8] Zhao Yonggan, Wang Shujuan, Li Yan, Liu Jia, Zhuo Yuqun, Chen Hongxiang, Wang Jing, Xu Lizhen, Sun Zhentao, Extensive reclamation of saline-sodic soils with flue gas desulfurization gypsum on the Songnen Plain, Northeast China, Geoderma, Volume 321, 1 July 2018, Pages 52-60.

[9] Fang Dean, Liao Xiang, Zhang Xuefei, Teng Aijun, Xue Xiangxin, A novel resource utilization of the calcium-based semi-dry flue gas desulfurization ash: As a reductant to remove chromium and vanadium from vanadium industrial wastewater, Journal of Hazardous Materials, Volume 342, 15 January 2018, Pages 436-445.

[10] Neubauer Raphael, Weinlaender Christof, Kienzl Norbert, Bitschnau Brigitte, Schroettner Hartmuth, Hochenauer Christoph, Adsorptive on-board desulfurization over multiple cycles for fuel-cell-based auxiliary power units operated by different types of fuels, Journal of Power Sources, Volume 385, 1 May 2018, Pages 45-54.

[11] M. Živković Emila, V. Živković Nikola, M. Majstorović Divna, M. Stanimirović Andrej, Lj. Kijevčanin Mirjana, Volumetric and transport properties of binary liquid mixtures with 1-ethyl-3-methylimidazolium ethyl sulfate as candidate solvents for regenerative flue gas desulfurization processes, The Journal of Chemical Thermodynamics, Volume 119, April 2018, Pages 135-154.

[12] Pan Peiyuan, Chen Heng, Liang Zhiyuan, Zhao Qinxin, Deposition and corrosion characteristics of liquid-solid droplets on tubular corrosion probes in desulfurized flue gas, Engineering Failure Analysis, Available online 16 March 2018, In Press, Accepted Manuscript.

[13] Li Chunfeng, Duan Yufeng, Tang Hongjian, Zhu Chun, Li Ya-ning, Zheng Yiwu, Liu Meng, Study on the Hg emission and migration characteristics in coal-fired power plant of China with an ammonia desulfurization process, Fuel, Volume 211, 1 January 2018, Pages 621-628.

[14] Saeedirad Raheleh, Taghvaei Ganjali Saeed, Bazmi Mansour, Rashidi Alimorad, Effective mesoporous silica-ZIF-8 nano-adsorbents for adsorptive desulfurization of gas stream, Journal of the Taiwan Institute of Chemical Engineers, Volume 82, January 2018, Pages 10-22.

[15] Gu Hui, Cui Yanfeng, Zhu Hongxia, Xue Rui, Si Fengqi, A new approach for clustering in desulfurization system based on modified framework for gypsum slurry quality monitoring, Energy, Volume 148, 1 April 2018, Pages 789-801.

[16] Taheri-Shakib Jaber, Shekarifard Ali, Naderi Hassan, The influence of electromagnetic waves on the gas condensate characterisation: Experimental evaluation, Journal of Petroleum Science and Engineering, Volume 166, July 2018, Pages 568-576.

[17] Fu Hailu, Jia Caiyun, Chen Qiaoshan, Cao Xueting, Zhang Xiaomin, Effect of particle size on the transformation kinetics of flue gas desulfurization gypsum to α-calcium sulfate hemihydrate under hydrothermal conditions, Particuology, Available online 1 February 2018, In Press, Corrected Proof.

[18] Wang Lidong, Wu Siyu, Liu Shuang, Cui Shuai, Liu Jie, Zhang Shihan, Cobalt impregnated porous catalyst promoting ammonium sulfate recovery in an ammonia-based desulfurization process, Chemical Engineering Journal, Volume 331, 1 January 2018, Pages 416-424.

[19] Ji Haiyan, Sun Jia, Wu Peiwen, Wu Yingcheng, He Jing, Chao Yanhong, Zhu Wenshuai, Li Huaming, Silicotungstic acid immobilized on lamellar hexagonal boron nitride for oxidative desulfurization of fuel components, Fuel, Volume 213, 1 February 2018, Pages 12-21.

[20] Tilahun Ebrahim, Sahinkaya Erkan, Çalli Bariş, A hybrid membrane gas absorption and bio-oxidation process for the removal of hydrogen sulfide from biogas, International Biodeterioration & Biodegradation, Volume 127, February 2018, Pages 69-76.

[21] Huang Xuechi, Li Baokuan, Liu Zhongqiu, A coupled mathematical model of oxygen transfer in electroslag remelting process, International Journal of Heat and Mass Transfer, Volume 120, May 2018, Pages 458-470.

[22] Yuan Yuejin, Zhang Jin, Wang Dong, Xu Yingying, Bhandari Bhesh, Molecular dynamics simulation on moisture diffusion process for drying of porous media in nanopores, International Journal of Heat and Mass Transfer, Volume 121, June 2018, Pages 555-564.

[23] Ramachandralal Rajkumar Mattacaud, Praveen Arjunan, Arun Krishnan Radhakrishnan, Godson Asirvatham Lazarus, Wongwises Somchai, Experimental study of condensation heat transfer on hydrophobic vertical tube, International Journal of Heat and Mass Transfer, Volume 120, May 2018, Pages 305-315.

[24] Tao Zhi, Cheng Zeyuan, Zhu Jianqin, Lin Dasen, Wu Hongwei, Large eddy simulation of supercritical heat transfer to hydrocarbon fuel, International Journal of Heat and Mass Transfer, Volume 121, June 2018, Pages 1251-1263.

[25] Heon Han Sang, Seung Lee Yeon, Cho J. R., Ho Lee Kyun, Efficiency analysis of air-fuel and oxy-fuel combustion in a reheating furnace, International Journal of Heat and Mass Transfer, Volume 121, June 2018, Pages 1364-1370.