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Empirical Investigation of Treatment of Sour Gas by Novel Technology: Introduction of a Novel Method for Optimization of Energy and Process

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Abstract

The sour gas sweetening is one of the main processes in gas industrials. Since the gas sweetening is performed through chemical, so it needs high cost and energy. Therefore, Nano fluid and magnetic field were used in this research for sour gas desulfurization. The mechanism of hydrogen sulphide absorption using nano fluid in filled bed under magnetic field was investigated in this study. The current study was performed as laboratorial using mathematical model for finding the rate of sulphur in exhaust gas flow. Therefore, some related parameters for sulphur rate such as mass transfer rate and mass transfer coefficient and effective rate of mass transfer and effective coefficient of mass transfer were investigated in this research. Increasing the amount of zinc oxide nanoparticles increases the percentage of sulphur removal per unit volume of time in vitro and theory. Increasing the amount of nanoparticles of zinc oxide from 0 to about 0.013% by volume increases the percentage of removal of sulphur per unit volume of time by about 6%. Also, increasing the amount of nanoparticles of zinc oxide from about 0.013 to 0.1% by volume will increase the percentage of removal of sulphur per unit volume of time by about 10.85%. The empirical results show the increase in trend in the amount of sulphur removal per unit time with increasing nano concentration. The experimental results prove that the presence of magnetic field can improve the sweetening process, severely. This value for the determined operating conditions is about 17%.

Keywords

Oil and Gas Industries, Optimized Energy, Treatment Process, Empirical Investigation

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1. Introduction

The desulphurization is a group of technologies based on the separation of sulphur dioxide from the sour fluid. Sulphur dioxide is mainly resulted from activities such as coal burning or power plants, as well as copper melting industries. It is also produced in nature by the volcanic activities. Due to the use of petrol or Mazut in some power plants, the exhaust gas of power plants should be desulphurized. In recent years, sulphur dioxide separation methods and sulphur compounds from sour gas and sour oil and exhaust gases have received considerable attention. The hydrogen sulphide gas is widely used in various industries, especially the oil, gas and petrochemical industries, and has caused many events globally [1]. This gas is one of the most dangerous gases in the environment, so when dealing with this gas, certain rules and regulations should be considered. Initial ideas about the power plant and the desalination of sour gas, flue gas and oil in England are back to the 1920s. After constructing large power plants in the England in the 1920s, the issues related to the amount of sulphur dioxide released from a common site became popular [2]. The problem of sulphur dioxide

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contamination hasn't been attracted much attention until 1929, when the rich man's homeowner claimed the landowner's claim to Barton's electric works from the Manchester Union for harming land caused by sulphur dioxide contaminants. Shortly thereafter, a press campaign was established against the construction of a power plant in the London [3]. This rush created and established controls for sulphur dioxide from such plants. So, the first major unit of sulphur was built in 1931 at the Batres Power Plant, a London-based company. In 1935, a desulphurization system similar to what was built in Batresa was operated at the Swansea power plant. The third major desulphurization system was built in 1938 at Fulham [4]. These three major desulfurization plants were shut down during world war II. Until the 1970s, no major desulfurization unit was built on the facility, while most of these structures were in the United States and Japan. Desulfurization of crude oil and gas is an important process used in the oil refineries to reduce the concentration of sulphur in fuel products such as gasoline, jet fuel, kerosene, oil and kerosene. The production of fuel products is in accordance with environmental standards. The challenge is to meet the need for energy transfer, and the production of hydrocarbon fuels is not a simple issue. Instead, the need to address this challenge becomes more prominent with complex issues of process and environmental issues. The environmental issues include the social demand for removing liquid hydrocarbons and achieving less polluting rate [5]. The importance of new refining processes and the increased use of new forms of energy production, such as fuel cells, have provided operational models. All of these make a need for sulfurization of diesel and jet fuel very important. Therefore, this research focuses on the structure of zinc oxide nano fluid that affects the process of sour gas sweetening. The gas refinement has changed considerably over the past two decades, and especially hydrogen refinement has seen a lot of change [6]. The hydrogen purifiers now have a central role in modern refineries, and more than 50% of the total refinery flows pass through the path of hydrogen-refining through conversion, refinement and pre-treatment purposes. The hydrogen desulphurization is widely used in terms of catalytic technology and amount of processed material. Based on the used volume, the catalysts used in HDS hydrogen sulfurization processes are ranked third in terms of automotive pollution control and catalytic thermal failure of the FCC. The commercial catalysts in refining with hydrogen are usually molybdenum or zinc. The molybdenum is known for its many hydrogenation activities and is used as a process accelerator when the feed contains large quantities of nitrogen and aromatic. Nanoparticles such as metal oxides appear to accelerate the process of cooling and heating and sweetening. For example, Nano scale materials, such as metal oxides, increase the thermal stability of some materials. In this research, zinc oxide nano fluid has been used for the treatment of sour gas. Therefore, geometric and operational parameters have been evaluated for this problem [7].

1.1. Nano-Technology

In the last two decades, the technologic progresses have been achieved for tools and materials with very small dimensions and will lead to a tremendous evolution will transform human civilization by the end of the century. For understanding the infrared dimensions, consider the diameter of the human hair, which is one tenth of a millimetre, a nanometre (10 to 9 meters) a hundred thousand times smaller. The technology and engineering will deal with equipment, measurements and products that will have such infrared dimensions in the incoming century. At present, molecular-sized processes can be designed and controlled. Also, Mechanical chemical, electrical, magnetic and optical properties of the materials in the layers are understandable and measurable in terms of nanometre dimensions. Technology has made remarkable progress in making the finer seeds larger in the past century, the new technology in the current century has travelled along the way. That is, the infrared material should be combined to produce more efficient particles [8]. The same is true of the way in which nature is created to produce. Natural collections are a mixture of detectable infrared beads with similar or different properties to Nano-sized proportions [9]. The effects of research into infrared technologies are now emerging in the treatment of illnesses or the achievement of new materials. There are many cases in the applied and experimental research phase. Now making computers is much smaller and millions of times faster on the agenda of research firms. In short, nanotechnology is a molecular production process. As the nature of the collections is automatically assembled into molecules by molecules, researchers also have to find ways to produce new products, believing that whatever is produced in nature can also be found in the lab, such as nature [10]. Of course, it's not about how many cores of materials they have found and by building up energy and feed after a few years, a power plant will build it out of the city, but also for the combination and evolution of infrared products that somehow use in larger sets. In infrared sizes, conventional physical methods and tools, such as shaving, bending and piercing, are not responsive [11-14].

1.2. Investigation of Hydrogen Sulfide Solution Process

The different processes are used to refine raw natural gas and bring it to the quality needed for transmission pipelines [15]. The sulphur is commonly existing as an impurity in fossil fuels. By combustion of fuels, sulphur is released in the form of sulphur dioxide as an air pollutant which is itself a source of respiratory problems and acid rain [16]. The environmental regulations have created increasing limits for sulphur dioxide emissions, which has led to a lot of attention to the removal of sulphur from fuels and exhaust gases in fuel recovery processes [17]. The cost of removing sulphur from natural gas and oil in the United States was about $ 1.25 billion in 2008. In natural gas, sulphur is essentially hydrogen sulphide gas while in crude oil as sulphur-containing organic compounds, the cost of removing sulphur from natural gas and oil in the United States was about $ 1.25 billion in 2008. In natural gas, sulphur is mainly in the form of hydrogen sulphide gas, while in crude oil it is in the form of organic compounds containing sulphur that during hydrogen sulphide removal to hydrocarbons and hydrogen sulphide [18]. In both cases, the highly toxic and corrosive hydrogen sulphide gas should be sulphur is an elemental element that can be separated safely [19]. Formation fluids containing a sulphide, containing hydrogen product from the microbial anaerobic reaction to the sulphur compounds in the flower or the thermal decomposition of sulphur-containing mud additives or from chemical reactions with lubricants used for joints are trends [20-24]. The hydrogen sulphide is a weak acid which produced by the following two steps, by dissolving it in water or mud. In this process. both steps are reversible and depend on acidity [25-27].

In the process of sour gas sweetening, a magnetic field with different intensities and also various volumetric percentages of nanoparticles of zinc oxide in water are used. Since the mass transfer fluid of removing sulphur compounds from sour gas is dependent on various parameters, in this research, various operational and non-operational factors have been addressed.

2. Materials and Methods

The sour gases containing various amounts of hydrogen sulphide are used as the feed of the reactor. Two pressure tanks of ten litters contain sour gas, which can be connected to the laboratory equipment. But, both feeds tanks cannot be used, simultaneously. The reactor is a stainless steel tank with an internal diameter of eight centimetres and a height of sixty centimetres. The top and bottom of the reactor are ten centimetres without filling, which contains a distributor on top and a holder on the bottom of the reactor. The measurement and control instruments are used to evaluate the operating pressure, operating temperature and flow rate in the line. All used valves, pipes and equipment are resistant to corrosion and are insulated to prevent energy dissipation. After absorbing hydrogen sulphide within the nano fluid, an increase in temperature in the exhaust gas is observed. Also, the temperature increase is due to the use of magnetic fields applied to the reactor bed. Because there are some limitations to protect the immune system, the low range suitable for feed temperatures below forty centigrade degrees, along with the use of magnetic fields of varying intensity, has been selected. The basic parameters in the application of the bed filled in the laboratory and the theory in this study have been evaluated. In general, oxygen can react with hydrogen sulphide, and elemental water and sulphur molecules are produced from the sour gas in the process of absorption in the process of sulphur removal.

3. Results and Discussion

The effect of different values of the gas flow rate, magnetic field, fluid flow rate, process temperature and volumetric percent of nanoparticles distributed in pure water on sulphur removal from sour gas have been reported in this study. Then the results of the experiments were analysed by plotting the graphs. Also, the optimal conditions for the highest sulphur removal efficiency are presented according to the results. The amount of sulphur transfer from gas to liquid phase was considered according to the force of the chemical potential difference, the percentage of removal of sulphur per unit volume of time, and the mass transfer coefficient in the liquid phase as dependent parameters.

3.1. Effect of Gas Flow Rate and Zinc Oxide Concentration

The Figure 1 shows the effect of increasing the volume percentage of nanoparticles of zinc oxide in a nano fluid when the gas flow rate is 240 ml per minute. Increasing the amount of zinc oxide nanoparticles increases the percentage of sulphur removal per unit volume of time in vitro and theory. Increasing the amount of nanoparticles of zinc oxide from 0 to about 0.013% by volume increases the percentage of removal of sulphur per unit volume of time by about 6%. Also, increasing the amount of nanoparticles of zinc oxide from about 0.013 to 0.1% by volume will increase the percentage of removal of sulphur per unit volume of time by about 10.85%. The experimental results show, using gas flow rates of 210 ml per minutes, and comparing the results of percent removal of sulphur per unit volume of time, it can be concluded that the increase of gas flow rate of 0.03 litters per minutes and the amount of nanoparticles of zinc oxide as much as 10. 85% by volume, the amount of sulphur removal per unit volume of time increases by about 21.76%, approximately.

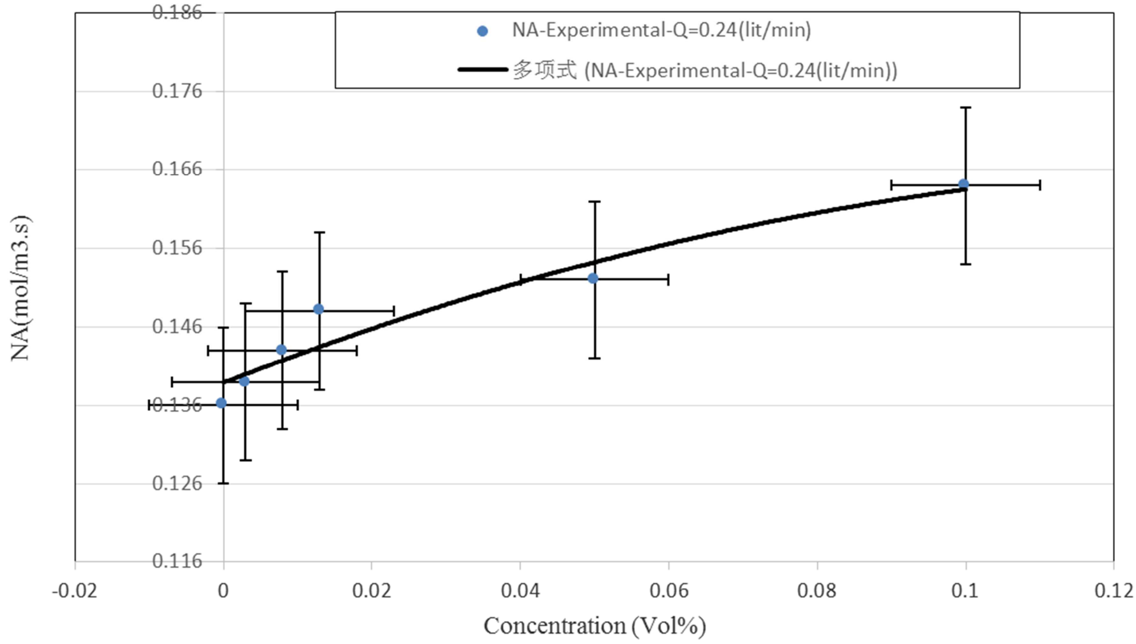

Figure 1. Mass transfer in terms of nano concentration in the column.

3.2. Effect of Temperature, Zinc Oxide and Magnetic Field

The operating temperature is another important parameter that affects the removal of sulphur in the absorption process. Based on the nature of the process, the operating temperature of the absorption process in the tower should be kept to a low level. The temperatures were 18.8, 23.4 and 32.2 degrees Celsius in the experiments. The obtained results show the changes in the percentage of removal of sulphur per unit volume of time with different amounts of nanoparticles of zinc oxide in a nano fluid with a magnetic field with a determined power and temperature. The empirical results show the increase in trend in the amount of sulphur removal per unit time with increasing nano concentration. The amount of sulphur removal per unit volume of time was from 167/0 to 182/0 mole/m^3 per second, from 172/0 to 194/0 mole/m^3 per second, and eventually from 173/0 to 2/0 mole/m^3 per second. The magnitude of the magnetic field changes with a voltage variation of 1.5 amps. In this study, the effect of the magnetic field on the absorption process is also considered. The graphs of magnetic field intensity changes are presented in this section.

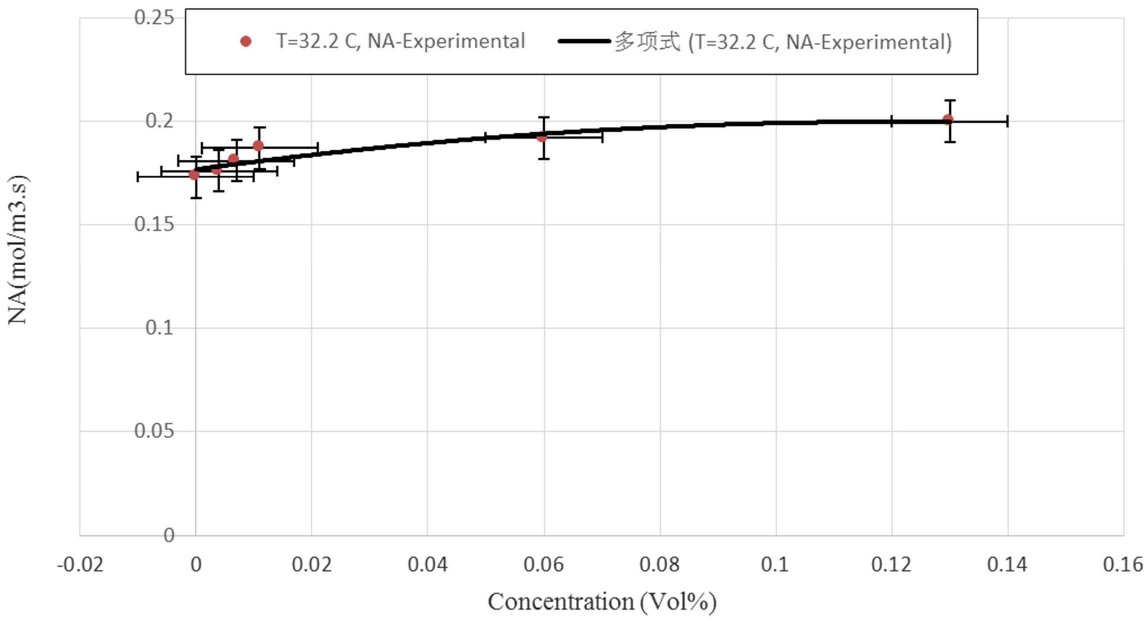

Figure 2. Mass transfer in terms of the Nano scale at 2.25 W and 32.2°C.

According to the Figure 2 and obtained experimental results, the effect of increasing the temperature from 18.8 °C to 23.4 °C is more pronounced than the effect of temperature change from 23.4 °C to 32.2 °C. Greater thermal energy is required to provide higher temperatures. Therefore, the optimum temperature at 23.4 °C and the percentage of sulphur removal per unit volume of time are also high enough at this temperature.

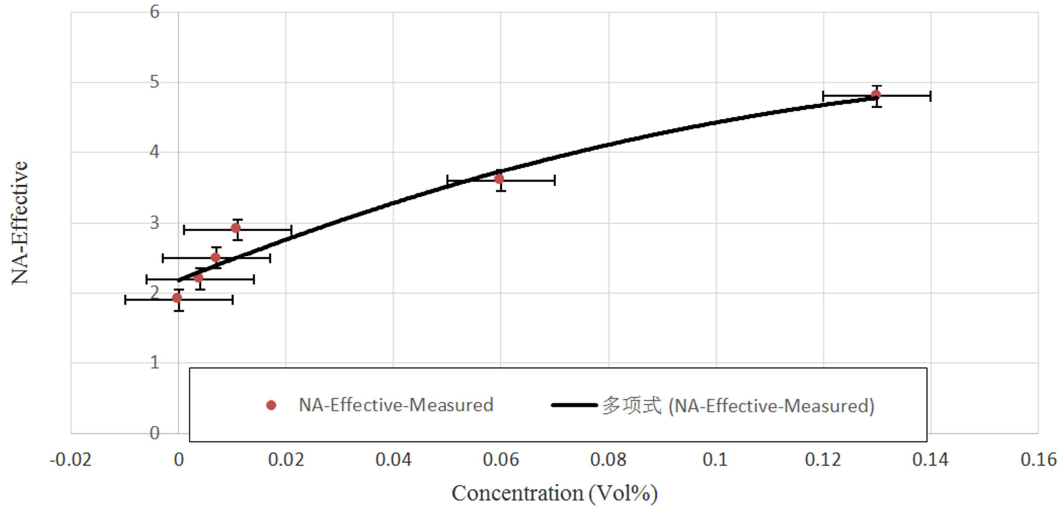

Figure 3. The percentage of removal of sulphur per unit volume of effective time based on the concentration of zinc oxide at 4.5 watts.

The effective mass flux as a dimensionless group is evaluated in this section. This factor is defined as a difference between the presence of magnetic field and simple filed. This definition can be a better representation of the effect of the magnetic field and the concentration of zinc oxide on absorption. As shown the Figure 3 and Figure 4 state the changes in the percentage of sulphur removal per unit volume of effective time in a magnetic field of 4.5 watts and 6.75 watts with an increase in the amount of zinc oxide from 0 to 0.13% vol. Theoretical and laboratory levels of sulphur removal per unit volume of effective time in the magnetic field are about 5.4. The increase in the percentage of removal of sulphur per unit volume of time in the magnetic field is 4.5 watts and 6.75 in the order of About 16.4% and 15.2%, respectively.

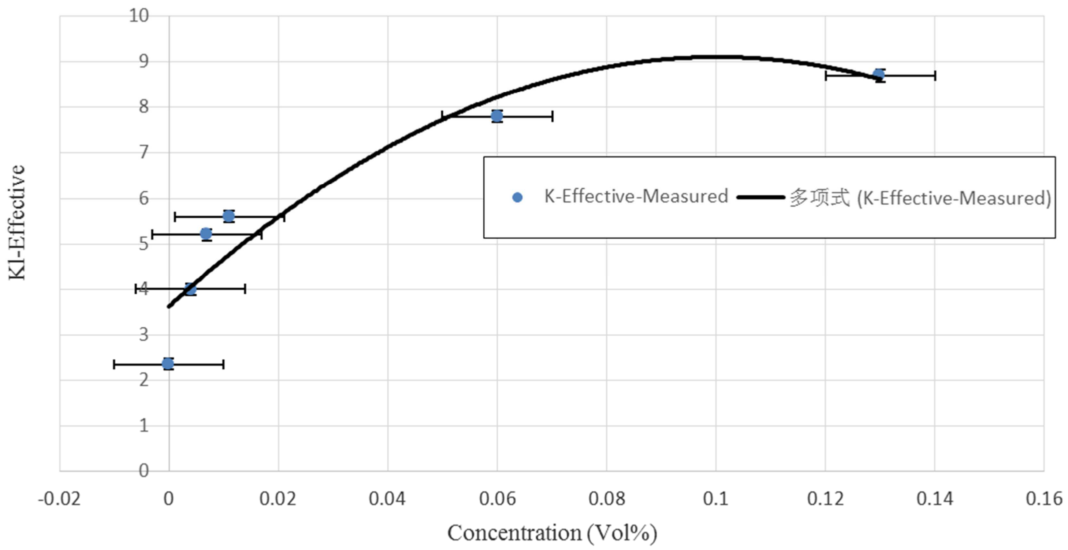

Figure 4. The effective NA level is based on the concentration of zinc oxide at 6.75 watts.

4. Conclusion

In this study, the effect of several variables such as magnetic field intensity, fluid bed temperature and concentration of zinc oxide nanoparticles dispersed in Nano-silver on the sweetening of sour gas in a reservoir containing three solid- liquid- gas phases were investigated. The process of adsorption of hydrogen sulphide on Nano-fluid was evaluated experimentally and theoretically. The experimental results were shown in the results and discussion section. Some important operational parameters such as gas flow rate, amount of nanoparticles of zinc oxide in nano-fluid were investigated in terms of volumetric percentages on the amount of adsorbed hydrogen sulphide. The results of this study indicate that the increase in the operating temperature increased the mass transfer coefficient and the mass transfer rate. According to the minimum energy required to maintain this temperature and the acceptable mass transfer rate at this temperature, the appropriate operating temperature is 23.4°C. Increasing the amount of zinc oxide nanoparticles increases the percentage of sulphur removal per unit volume of time in vitro and theory. Increasing the amount of nanoparticles of zinc oxide from 0 to about 0.013% by volume increases the percentage of removal of sulphur per unit volume of time by about 6%. Also, increasing the amount of nanoparticles of zinc oxide from about 0.013 to 0.1% by volume will increase the percentage of removal of sulphur per unit volume of time by about 10.85%. The obtained results show the changes in the percentage of removal of sulphur per unit volume of time with different amounts of nanoparticles of zinc oxide in a nano fluid with a magnetic field with a determined power and temperature. The empirical results show the increase in trend in the amount of sulphur removal per unit time with increasing nano concentration. The experimental results prove that the presence of magnetic field can improve the sweetening process, severely. This value for the determined operating conditions is about 17%.

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