Abstract of Dissertation

Title Innovative water scrubber packed with sponge carriers for biogas purification
(スポンジ担体を用いた新規スクラバーによるバイオガスの精製)

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To date, variety methods of enhancement of water scrubbing technology has been proposed to make the scrubbing system more versatile. Anyhow, most of the previous studied had primarily focus on the optimization of CH_4 concentration under high pressure condition due to the fact of water scarcity. Although, this considerably reduces the water used, yet distinctly increased the energy and maintenance cost for the water scrubbing operation (Eze and Agbo, 2010). Despite that, the scrubbing process also lead to the emission of dissolved gases likes CH_4, CO_2 and H_2S with effluents. The released of CH_4 and CO_2 to the atmosphere will subsequently contributed to the increase of global warming, whilst H_2S gas give the effect of toxic and corrosive (Petersson and Wellinger, 2009). Therefore, there is a need to redesign and optimization of the existing water scrubbing process for a more affordable and user-friendly system which can improve the quality of raw biogas and scrubbing effluent without harming the environment.The general objective of this thesis is to develop a biogas technology for CH_4 upgrading and its effluent treatment with an economic and environmentally benign approach. For this purpose**,** two different strategies are investigated:

a. Biogas purification at process level by imposing under atmospheric conditions in water scrubber reactor packed with sponge carrier.
b. End-of-pipe removal of dissolved CH_4, CO_2 and H_2S gas of scrubbing effluent by an integrated biological-physical process in single reactor.

To achieve above-mentioned objectives, this thesis was presented in 5 chapters:

- **Chapter 1** provides background information, research purpose and the outline of this thesis.
- **Chapter 2** is devoted to a literature review of each related topics in the introduction section, especially focuses on biogas upgradation and dissolved gases treatment.
- **Chapter 3** was devoted to fulfill the first and second objectives of strategy (a) by studying the influence of liquid to gas flow ratio, pH, temperature, HRT, and initial H_2S concentration on the performance of water scrubbing process by experiment and simulation works.
- **Chapter 4** was devoted to fulfill the first and second objectives of strategy (b) by utilizing a reactor builds with air supplied at upper and bottom for the treatment of biogas purification effluent through biological oxidation and physical stripping process
- **Chapter 5** summaries of the main finding obtained and recommendation for future study.

The experimental outcomes and conclusions drawback from this study are briefly described as follows:

Biogas purification performance of new water scrubber packed with sponge carrier

In **Chapter 3** the potential of a new water scrubber packed with sponge carrier for biogas purification was investigated under atmospheric condition and a mathematical model to describe the purification phenomena was constructed. During the study successful purification performance was demonstrated and a maximum average of 90-93% of output methane gas with untraceable output H_2S gas concentration were produced. Practically no influence of input H_2S concentration, HRT and pH (7 to 8) were observed whereas changed in temperature and Q_L/Q_G showing fluctuation of CH_4 contents. Through the develop simulation, the methods found an interesting finding that proper control of Q_L/Q_G is necessary in producing high methane concentration. Under high temperature condition, by using high scrubber column low Q_L/Q_G is enough to produce more than 90% of output methane. However, imposing with too low of Q_L/Q_G ratio condition, high purification performance is impossible to achieve although a very high column is installed. Here, the approaching method by installing framed sponge with proper controlled of Q_L/Q_G ratio compensated for the lack of pressurizing equipment under specified conditions.

Integrated biological-physical process for biogas purification effluent treatment

In **Chapter 4** a new post treatment method for the biogas purification effluent that is able to simultaneously remove the dissolved methane, hydrogen sulphide and carbon dioxide by biological oxidation and physical stripping process in a single reactor. A mathematical model was constructed, and simulations were conducted to explain on the effect of airflow rate supply on the biological and physical stripping process for high performance. The result demonstrated high performance with up to 98% of CH_4 was removed and effluent pH was successfully raised from 5.64 to 7.3. It was found that although physical stripping of carbon dioxide gas was conducted simultaneously in the reactor, the biological performance was maintained. This indicated that the integration of biological and physical process in a reactor is not only feasible but also providing with high treatment performance in removing dissolved gasses and regenerating the effluent water.