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Fischer Tropsch water composition study from distillation process in gas to liquid technology with ASPEN simulation

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ABSTRACT

Fischer-Tropsch is a polymerization reaction that produces a long chain of hydrocarbons such as linear paraffin, linear olefins, and water. Water is a by-product of Fischer Tropsch synthesis that contains impurities such as olefins and oxygen-containing compounds. Therefore, this study aims to analyze chemical oxygen demand (COD) level of Fischer Tropsch water from the distillation process by using Aspen simulation. Correspondingly, this study designs a Fischer Tropsch water distillation unit that can recover 1.2% of volatile organic compounds from the wastewater. In addition, this study has identified three (3) sections in the Fischer Tropsch water distillation unit which are distillation, recovery, and neutralization. Following this, a steady-state model is simulated through Aspen software with UNIQUAC-HOC as the thermodynamic model. The developed simulation model was found to be less than a 10% deviation as compared to the actual data from the natural gas processing plant located in Sarawak. Overall, the simulated distillation unit shows that 2100 tons of Fischer Tropsch water that can be treated at 120 °C and 2.21 bar per day. The overhead product is an enriched volatile organic compounds stream while the bottom product is an enriched water stream. For this study, the processed water quality from distillation column has been compared with both stripped water quality in natural gas processing and National Water Standard Quality. Consequently, the comparison shows that the chemical oxygen demand of processed water level is at 600 ppm after distillation which follows the stripped water quality in natural gas processing, however, requires post-water treatment before being discharge to the surface water sources.

1. Introduction

The conversion of natural gas into a valuable liquid form is referred as gas to liquid (GTL) technology. Natural gas is a clean and versatile fuel that can be converted into clean diesel, naphtha, kerosene, and light oils [1]. Similarly, gas to liquid products are produced by converting natural gas mainly methane into liquid fuel with four significant steps. The steps are (i) gas separation and purification, (ii) synthesis gas production, (iii) Fischer Tropsch synthesis, and (iv) cracking of long hydrocarbons into small chains as shown in Fig. 1 [1].

Likewise, gas to liquid technology also utilizes natural gas as a raw material in which natural gas is preheated and sent into an autothermal reactor for gasification processes. To illustrate, this process involves the reaction between oxygen and steam in producing synthesis gas [2]. Fischer Tropsch synthesis is a polymerization reaction where the products comprise of a long hydrocarbon chain such as linear paraffin and linear olefins [3]. The Fischer Tropsch products are formed by synthesizing a feedstock comprising carbon monoxide (CO) and hydrogen (H_2) as shown in Equation (1) [3].

$$nCO + (2n+1)H_2 \rightarrow C_nH_{2n+2} + nH_2O + Heat \quad (1)$$

The feedstock is also known as a synthesis gas that is formed by the reaction between methane and oxygen. Fischer Tropsch reaction products consist of carbon atoms molecules up to 100 in the presence of co-products such as processed water, unsaturated hydrocarbons, and oxygenates compounds. Conversely, wastewater containing organic solvents such as alcohol and halogenated solvents needs to be treated through distillation in order to remove the volatile polluting compounds [4]. The volatile organic compound (VOC) contributes significantly to the chemical oxygen demand (COD) of wastewater, namely known as VOC – COD effects. Thus, distillation has one significant advantage where the contaminating VOC is recovered and reused in the processing plant. As a result, there are two (2) products in Fischer Tropsch water distillation,

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