Control of a hydrolyzer in an oleochemical plant using neural network based controllers

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ABSTRACT

Hydrolyzer is a commonly found unit operation in the splitting of crude palm oil into fatty acids and glycerol in the oleochemical industry of Malaysia. The control of this hydrolyzer has to be done carefully since efficiency in the control of this unit will affect the further yield of the process. At present conventional controllers such as the PID controller have been used to control the unit especially during startup and shutdown of the plant and under presence of disturbances. However experience shows that these PID controllers cannot efficiently handle random disturbance entering the plant. In this study, neural network have been applied as an alternative to cope with the nonlinear dynamics of the hydrolyzer. A mathematical model had been developed and used to simulate the dynamic responses of the temperatures when the controllers were applied into the system. Two types of control strategies namely, direct inverse controller (DIC) and internal model controller (IMC) were implemented. In simulation with actual industrial data, within the control system. The controllers were evaluated on the ability to track set-point and the ability to control the temperature when disturbances and noise appeared in the system. Based on the results, IMC was found to perform very well in the temperature control of the hydrolyzer during set-point tracking and disturbance tests. The responses generated by the IMC was much more stable as compared to the conventional controllers and when noise disturbance was taken into consideration, the IMC also performs better than the DIC controller.

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1. Introduction

Oleochemicals refer to chemicals from natural oils and fats of both plant and animal origins. However, they also include those derivatives derived from the subsequent modification of carboxylic acid group of fatty acids by chemical or biological means, and other compounds obtained from further reactions of these derivatives. Prior to 1980, about 90% of the raw materials for oleochemical industry were tallow and coconut oil. However, since 1990, palm and palm kernel oils have become important raw materials complementing tallow and coconut oils due to the fact that fatty acids composition of palm and palm kernel oil are closely similar to tallow and coconut oil, respectively [1] and has found numerous applications in various food and non-food based areas in the world [2]. In fact production of palm oil and palm kernel oil has increased by about 300% in the last 15 years and Malaysia is at the moment the world’s biggest producer of them.

Fatty acids and glycerol are the major components of oleochemicals, and can be obtained through splitting of the crude palm oil. The whole process to produce these fatty acids and glycerol in a oleochemical process plant can be seen in Fig. 1. Before oil-splittiing, pre-treatment is necessary to remove impurities, which occur naturally in oil. After splitting, crude fatty acids will be purified through distillation or fractionation to contain the fraction that is required. Then fatty acid will be hydrogenated to convert unsaturated fatty acid to saturated ones. Glycerol obtained from oil-splitting usually dissolve in water which is known as sweet water [3]. Concentration of glycerol in sweet water is very low, thus further recovery is necessary to obtain high purity of glycerol. However the most important and crucial step in this whole process is the fat splitting step, which is done in the hydrolyzer or oil-splitting unit.

Oil-splitting or hydrolysis is the process of decomposing the oil into acids and glycerol by subjecting them in the presence of water to high temperature and pressure. This system involves a counter flow of oil and water (as reactants), where reaction and mass transfer occur at the same time. Fig. 2 gives an overall view to describe the hydrolyzer. Water is fed in excess from the top while tryglyceride is fed from the bottom of-the splitter. Fatty acids and glycerol are the reaction products. Fatty acids will flow upwards and discharge at the top at the splitter. Glycerol will dissolve in water and discharge as glycerol-water at the bottom of the splitter. Steam is injected in parallel and concurrently at the top and bottom sections of the column to maintain the high