Hybrid model of pH neutralization for a pilot plant

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Abstract. This paper proposes a hybrid model to identify the on-line pH characteristic of a neutralization plant. The hybrid model is the combination between neuro-fuzzy identification technique and first principle model. The neuro-fuzzy identification technique used training dataset to map the neutralization response curve in full ranges. The first principle model is based on material balances and chemical equilibrium equation. The objective of the proposed model is to extend the robustness effect for the on-line titration characteristic without having to re-design the model if the plant undergoes different conditions. In the experiment, the proposed model's dynamic response was compared with the on-line pH data. It showed the best fit for hybrid model with dynamic weight adjustment in nominal condition (RMSE = 0.1013) and in altered condition (RMSE = 0.5616) proved its capability in capturing the additional variations to a pH neutralization plant.

Keywords: ANFIS, pH neutralization, hybrid model

1. Introduction

The pH neutralization process is one of the fundamental parts of many industrial chemical processing. For example in an electrochemical process, heavy metals must be recovered (by reducing the solubility of the metals) from waste streams by controlling the pH value to prevent polluting the environment.

The pH neutralization shows strong nonlinear characteristic because of feed components. This is because of ion interactions in the mixing tank reactor. Theoretically, the nonlinear effects for this process come from negative logarithm of ionic Hydrogen. Where, process dynamic occurs when the Hydrogen ion increase or decrease during neutralization process and because of dynamic nonlinearity called the “S-shape” curve which consist of extreme sensitivity and insensitivity region.

Large time delay is another problem in pH neutralization modeling. This effect occurs when the mixing vessel for neutralization is too large. The reaction between acid and base will take some time before it reaches the desired state. Therefore, the time delay plays an important role for the model design to succeed. However, the proper selection of input-delay in the empirical model design can overcome this problem.

The pH neutralization characteristic response varies with the ionic strength in acid and base solution. Strong acid and strong base would give different characteristic compared with weak acid and weak base reaction. In practice, pH process is easily exposed to many variations since the compositions in the supply solution are not standard. Further, the deviation correlations between input-conditions and titration curve may afterward complicate the model development. For instance, in effluent wastewater treatment,