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Inferential Feedforward Control of a Distillation Column

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Abstract

An inferential feedforward control strategy is developed and applied to a simulated distillation column. In this control strategy, the effects of disturbances on the primary process variables (top and bottom compositions) are inferred from uncontrolled secondary process variables (tray temperatures) which can be easily measured. The proposed strategies are particularly useful when disturbances cannot be measured easily or economically. Robustness of the inferential feedforward controllers and the selection of appropriate secondary measurements are discussed. Nonlinear dynamic simulation results demonstrate the superior performance of this control strategy and verify the robustness analysis.

Keywords: Feedforward control, disturbance rejection, inferential control, distillation composition control.

1. Introduction

The primary function of a process control system is to maintain the controlled process variables at their desired values in the presence of disturbances. Process plants can have large time constants and long time delays. Substantial measurement delays in some process variables such as concentration often exist. The effects of disturbances may therefore not be satisfactorily rejected through feed back control only. A strategy widely used in process control is feedforward control (Shinskey, 1979) where disturbances are measured and anticipatory control actions are taken before the controlled variables are actually affected.

In many situations, however, some disturbances cannot be easily measured. Therefore it is not possible to apply direct feedforward control in connection with these disturbances. However, in most process plants there are usually some easily measured secondary process variables, which may or may not be controlled. The correlation between disturbances and the uncontrolled secondary process variables makes it possible to infer the effects of disturbances from the measurements of these uncontrolled variables. If the secondary process variables are controlled, then the changes in their associated manipulated variables can be used to infer the effects of disturbances. Based on these inferred disturbances, feedforward control can be implemented indirectly. Yu and co-workers (Yu, 1988; Shen and Yu, 1990; 1992) proposed an indirect feedforward control strategy where the effects of disturbances are inferred from changes in the uncontrolled secondary process variables. McAvoy *et al.* (1996) propose a nonlinear inferential cascade control strategy to consider the nonlinear aspects in many industrial processes. This paper presents an inferential feedforward control strategy for a distillation column. The effects of disturbances on the top and bottom product compositions are inferred from the measurements of tray temperatures. This approach shares some common ideas with the indirect feedforward control strategy of Yu and co-workers (Yu, 1988; Shen and Yu, 1990; 1992). However, the robustness issues, which are not addressed by them, are discussed here.

The paper is organised as follows. Section 2 presents the inferential feedforward control strategy and its robustness analysis. A procedure for secondary measurement selection taking into account of the robustness issues is also presented. Section 3 describes the applications of this control strategy to a comprehensive nonlinear simulator of a methanol-water separation column. The final section contains some concluding remarks.

2. Inferential feedforward control

2.1 Feedforward control

A feedforward control system is shown in Figure 1, where disturbances are measured and compensating control actions are taken through the feedforward controller. Deviations in the controlled variables can be calculated as

$$\Delta y = GF\Delta d + G_d\Delta d \qquad (1)$$

where G is the process transfer function model, G_d is the

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