A303 Controller Design for a Modified Fully Thermally Coupled Distillation Column

(Pusan Natl. U.) Hwang K. S., Kim M. H., Kim B. C. and O (Dong-A U.) Kim Y. H.*

1. Introduction

When the divided wall column (DWC)—a kind of the fully thermally coupled distillation column (FTCDC)—replaces the conventional distillation system, the existing columns are not utilized and a totally new column is built. Though the energy efficiency and operability of the DWC have been proved from the practical applications in many processes for long time, the replacement of the currently operating process with the DWC is not active due to the cost and difficulty of new column construction.

Another difficulty in the FTCDC implementation is that the specification control of the products in the FTCDC is more complex than that of conventional binary distillation columns, because the FTCDC composed of a prefractionator and a main column interlinked with two-way transfers produces three products in a column. While the control of overhead and bottom products of the FTCDC is similar to the binary column, the specification control of side draw is not simple. It has two impurities of the lightest and heaviest components, which means refining with the increased reflux flow or vapor boilup does not help to improve the specification of the side product. Generally the raised reflux flow and vapor boilup elevate the specification, but the effect of the increase is limited in the case of the FTCDC control.

In this study a modified FTCDC from the conventional distillation system is introduced, and its design procedure is explained. In addition, the control scheme of the modified FTCDC is proposed and examined in the regulation and set-point tracking of the specification of three products. In the selection of the manipulated variables, the step response of the specification is utilized to analyze the open-loop response of the column. Several indices of multi-variable controllability of the proposed control scheme are examined and compared with the cross-pairing scheme. The step changes of feed flow rate and feed composition are applied for the investigation of regulation performance, and those of the set points of product specification are used for the evaluation of the set-point tracking.

2. Control scheme

The difficult control of the FTCDC has been one of obstacles of its wide application. In the DWC configuration widely used in the practical applications the liquid split between the prefractionator and the middle section of main column is available, but the vapor split is difficult to manipulate owing to its vapor split mechanism, a simple separation of the bottom of the structured packing in the middle section of the DWC. In early studies, the draw rate of side product was employed as a manipulated variable with the cross pairing between the compositions of side and bottom products.

In the control of the modified FTCDC of this study, the vapor split between the prefractionator and main column were used as a manipulated variable different from the DWC control. Because the response delay in process control produces many difficulties in the control, the vapor flow was used as the manipulated variable. The manipulation of the side draw affects the mass balance among the process inputs and outputs, and therefore it can not be used for a long-term manipulated variable. The control performance of the proposed control scheme was examined with the inspection of dynamic response of the product specification when the set points of the product specification, feed flow rate and feed composition were altered.

3. Results and discussion

Though the MRI of the cross-pairing scheme predicts better performance than that of the proposed scheme, the elements of the RGA of the cross-pairing indicate poor performance from the scheme. The control performance of the proposed scheme was examined in the set-point tracking and regulatory control. The control performance of the proposed 3 x 3 structure, [L, V_3, V] for [x_D, x_S, x_B], in the set-point tracking of the product specification was satisfactory as predicted from the RGA analysis.

The evaluation of regulatory control was conducted with the changes of feed flow and feed component. When the feed flow rate is reduced by one percent, though some deviation was found in the specification of side product, the responses were close to the set points represented with the dashed lines. When the toluene composition in the feed is lowered by 5 percent, no significant variation of the product specification was observed with the load changes.

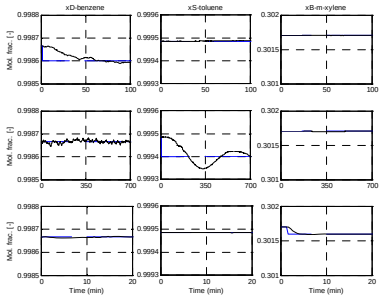

Figure 1. Responses of set-point tracking.

* yhkim@mail.donga.ac.kr