Systematic controlled variable selection for a reactor-separator-recycle process

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Abstract: A systematic plantwide control design procedure was proposed in (Skogestad, 2000). The main aim of this procedure is to design an optimal control structure for a complete chemical plant based on steady state economics. A very important step of Skogestad's procedure is the pairing of the unused degrees of freedom with self-optimizing controlled variables. The self-optimizing variables are defined as variables, that, when kept at constant setpoints, result in a near-optimal operation of the process despite the occurrence of disturbances. In this work we investigate the systematic selection of self-optimizing controlled variables, based on a quantitative local method named "Exact local method" (Halvorsen et al., 2003). This method can tackle the two main issues that arise in the selection of controlled variables problem: the disturbances and the measurement errors. Strictly speaking, however, these variables are only optimal under the assumption that the active set does not change. As a case study, a generic chemical plant consisting of a reactor, a separator and a recycle stream with purge, is considered. The specific process flow is selected mainly because it incorporates the basic structure of most of the chemical plants, and also because the controlled variables selection for this process has been studied previously in (Larsson et al., 2003) and (Wu and Yu, 1996). We assume that the plant operates at a given throughput mode and consider the process feed flow rate and the energy price as the two main disturbances. For various distinct regions with different sets of active constraints, identified in (Jacobsen and Skogestad, 2011), we select the self-optimizing controlled variables and evaluate the economic performance of the control structures against a simple strategy of keeping the unused degrees of freedom at their nominal optimal values. We find that the economic loss is significantly smaller for the cases where self-optimizing controlled variables are kept constant.

Keywords: Exact local method, self-optimizing control, control structure selection

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