Optimal Operation of a CO2 Capturing Plant for a Wide Range of Disturbances

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Combustion of the fossil fuels in power plants is one of the major sources of producing CO_2. Amine-based absorption/stripping CO_2 capturing processes are the dominant method in removing CO_2 content from the combustion flue gas streams. The stripping column uses a large fraction, about 15-30% of the net power generated in the power plant. Optimal operation of these processes is therefore very important. In particular, we study how to minimize the energy requirement during operation in the presence of unexpected disturbances while satisfying operational constraints.

In this study, the optimal operation of a post-combustion CO_2 capturing process is considered using the systematic plantwide procedure of Skogestad (2004) where the economical objective is to minimize sum of the energy costs and the penalty on the CO_2 released to the air.

The self-optimizing procedure is applied to select the best controlled variables (CVs) in different operational regions (in presence of large disturbances). These are the variables, which when they are kept constant in their optimal nominal setpoints, indirectly give operation close to the optimum. Operational regions are defined as the sets of optimally active constraints that are encountered as the disturbances (e.g., feed flue gas flowrate coming from the power plant) change over the expected operating window.

Dynamic simulation of the process is used to design the control layer and implement the final control structures for different regions. In the dynamic mode, first “stabilizing” CVs are identified and their control loops are closed to avoid instability or drift in the process when disturbances occur. In the supervisory control layer, one may use decentralized (PID controllers) or multivariable control (MPC). To analyze the feasibility of decentralized control, we use the relative gain array (RGA) as a tool to select pairings of the self-optimizing CVs with the manipulated variables. The RGA analysis gives some surprising insights into the dynamic behaviour of this process.

The performance of different decentralized control configurations and MPC (model predictive control) are compared. Finally, we propose a simple control structure which handles the disturbances close to optimal in all operational regions.

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