Optimal Operation of an Evaporation Process

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Abstract: This contribution deals with the optimum operation of an industrial evaporation process. The process is composed of a set of multiple effect evaporators processing a solution and aiming at removing a certain amount of water from it. The first effect receives a certain amount of fresh steam and the last effect is connected to a condenser system to remove lower pressure steam. The solution flow circulates in counter-current, being partly recirculated. The process can be operated manipulating the different control loops, in particular the set point of the temperature controller of the solution at the hottest point, which acts on the fresh steam flow, the plant load and the recirculating solution flow.

A Real Time Optimization, RTO, system has been designed with the purpose of computing the values of the variables that constitute its degrees of freedom and provide minimum specific steam consumption, satisfying at the same time all operational constraints. The system contains a reduced order first principles model of the process, a steady state detector, a data reconciliation system to continuously update the model and use coherent plant information, and a process optimizer that computes the optimum operating point at given time intervals.

Nevertheless, besides these short term decisions, a realistic operation of the process must consider the fouling that takes place in the evaporators as a function of the current decisions, which reduces the heat transfer coefficient and the process efficiency, forcing periodic stops for cleaning with the corresponding associated costs. This phenomenon develops in a scale of weeks so that a two-time scale problem must be formulated and solved jointly, including the planning of the cleanings over a certain time horizon. In addition, uncertainties originated in disturbances and model inaccuracies must be taken into account explicitly to achieve a realistic economic optimum, which leads to the use of two-stage stochastic optimization formulations.

The paper formulates and solves the problem as a large scale optimization. In order to achieve efficient solutions, an optimization environment that includes automatic differentiation, interior point methods and stochastic optimization has been used. The paper provides and analyses results obtained.

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