Optimum Operation of a Beer Filtration Process

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Abstract: This contribution deals with the optimum operation of a beer filtration process. The process includes a row beer tank and a pump that feeds a set of membrane filters. The pump creates a difference in pressure between both sides of the membranes (TMP) so that one fraction of the beer, the permeate, flows through the membrane, and is sent later to another section for bottling, while the remain flow, the retentate, is recycled back to the feeding tank. Both flows can be regulated manipulating the pump speed and a valve respectively.

During the operation of the membranes different types of beer impurities are present. Some of them build a cake layer inside the membrane tubes while others deposit in the pores obstructing them. As a result, the resistance of the membrane to the beer flow increases, and, in order to maintain the flow of permeate, the TMP has to be increased continuously. At a certain value of the TMP, a backflush cleaning is required, which restores only partially the state of the membrane. After several cycles, when the elapsed time between backflushes is shorter than a certain value, a deeper chemical cleaning is necessary, which reestablish its functionality but damage the membrane, shortening its operation life.

Being membranes expensive, optimal economic operation can be defined in terms of minimizing the number of chemical cleanings, as well as the use of energy, when processing a certain amount of beer in a given time. The main degrees of freedom in the operation are the values of the permeate flow set point, maximum TMP required for activating the backflushes and minimum elapsed time required for chemical cleaning. The problem is hybrid in nature, with discontinuities created by the cleanings.

The corresponding optimization problem is formulated in the framework of predictive control but integrating the economic operation as target of the controller. A simplified model of the process is used in the MPC while the process is represented by a full distributed non-linear model. The paper formulates two problems: one of on-line state and model parameters estimation of the reduced model and another one of optimal operation. Instead of using binary variables for representing the discontinuities, the problem employs a sequential approach, embedding them in the dynamic simulation of the process model combined with a control parameterization that allows computing the solution in terms of the continuous variables that represent its degrees of freedom. Results of the optimal operation are presented.

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