Improved dissolved oxygen control in fermentations

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Dissolved oxygen tension, DOT, is relevant for aerobic fermentations and is as such a candidate as controlled variable, since it is vital to ensure aerobic conditions in the biological system [1]. Standard manipulated variables in a fermentation tank with the capability of controlling the DOT include agitator speed, aeration rate, feed flow rate and head space pressure [2] [3] [4]. During fermentation process development there is a need to ensure appropriate tuning of the controllers. This is challenging in an industrial environment, where the same equipment is sometimes used for different hosts or processes, running under a variety of conditions. Appropriate tuning changes both during and between batches, as a result of the non-steady state batch process, with evolving rheology and mass transfer conditions. As opposed to having several controller settings to each individual situation, advanced control strategies could be used to eliminate the requirement of strain or production type specific controller settings.

In this work, an advanced PID control strategy is developed which is capable of controlling the DOT to a satisfactory level for fermentations of various metabolic and rheological properties. Provided with a dynamic model of the fermentation process, off-line development was made possible [2]. Through sensitivity analysis, model improvement and closed-loop simulation, process understanding is obtained for use in the controller development. This leads to the development of a gain scheduling strategy and a number of programmed adaption strategies using for example, on-line rheological indications. Based on process models the controller candidates are tested in an off-line benchmarking scheme. The controllers are benchmarked quantitatively determining the integral absolute error, IAE, of various controller tests, and qualitatively analysing the DOT response.

The top candidate controller is challenged in the pilot plant at Novozymes A/S, where it is tested on fermentations of three different strains representing the ranges in rheological and metabolic properties of the fermentations at Novozymes A/S. For comparison of controller performance fermentations of each strain is also carried out with their current individual controllers.

References

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