APPLICATION OF ALTERNATIVE FERMENTER DESIGN

IN

WHEY-ETHANOL PRODUCTION

(A Preliminary study)

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To

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ABSTRACT

The performance of a crossflow-microfiltration recycle reactor for whey-ethanol production was studied. Experiments using the yeast strain *Kluyveromyces marxianus* Y-113, an industrial whey-ethanol strain, and reconstituted acid whey permeate powder were carried out. Unsteady state experiments (i.e. with 100% cell recycle) were conducted at 46-137 g/l feed lactose concentration and dilution rates of 0.44-1.3 hr^{-1}. These experiments were used to estimate the maximum specific growth rate (μ_m), biomass substrate yield coefficient (Y_{xs}), product substrate yield coefficient (Y_{ps}). A mathematical model for biomass, lactose and ethanol concentration prediction was also developed. The model was based on Monid kinetics incorporating the concepts of a significant biomass volume fraction and single product inhibition. Two unsteady state experiments were conducted at 53.4-55.7 g/l lactose and dilution rate of 0.88-0.95 hr^{-1} to check fermentation model accuracy. Two steady state runs at 64-110 g/l lactose, dilution rates of 0.34-0.43 hr^{-1} were established for comparison with the unsteady state runs and to observe the effect of operation under stable conditions with the cell concentration regulated at 10 g/l..

Productivity increases of up to 13 times over the commercial batch fermentation process using the same organism was obtained. The highest productivity obtained was 13.7 g/l.hr. when the biomass was allowed to accumulate to 29.6 g/l, but lactose utilization (46%) and ethanol concentration (10.5 g/l) were low. In general, lower values of substrate utilization and ethanol concentration were noted at high dilution rates. At high feed lactose concentrations, lower lactose utilization was obtained. It was also noted that the growth rate was not significantly affected by substrate concentration and dilution rate. The product substrate coefficient (Y_{ps}) was affected by dilution rate but independent of lactose concentration. Increasing dilution rate also decreased the biomass yield coefficient (Y_{xs}) and the product substrate yield coefficient (Y_{ps}). Further experiments are needed to better understand the effects of these parameters on yield coefficients. Steady state runs showed close agreement to the corresponding unsteady state experiments.

Major problem of the fermenter operation was insufficient membrane flux which resulted in short fermentation runs at some condition. To solve this

problem, a dual membrane configuration coupled with a permeate back flushing mechanism should be introduced.

The mathematical model developed was adequate, but not optimal, an uncertainties of ± 30% and ± 20% in prediction of lactose and biomass concentrations were noted. While this was acceptable in the context of preliminary economic analysis and process optimization, to further improve the model accuracy, a relationship between the various yield coefficients and operating conditions has to be determined. Better estimation of the maximum specific growth rate (μ_m) and incorporating a function to describe the variation of specific growth rate (μ) with biomass and ethanol concentrations is needed. More accurate estimation of the biomass substrate yield coefficient (Y_{xs}) is also necessary for further model refinement.

In conclusion, the crossflow-mircofiltration recycle fermenter has demonstrated potential application in whey-ethanol production with much improved productivity over current commercial and batch systems. Further studies are needed to determine its performance as compared to other intensive fermenter designs. The mathematical model developed also provides sufficient accuracy for preliminary process economic analysis and for process optimization study.

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