Energy Integration of a Sugarcane Biorefinery through Multiperiod Mixed Integer Nonlinear Programming

Cássia OLIVEIRA[1], Leandro PAVÃO[2], Mauro RAVAGNANI[2], Antonio CRUZ[1], Caliane COSTA[2]

[1] Federal University of São Carlos - UFSCar, Brazil
[2] State University of Maringá - UEM, Brazil

Energy integration in a sugarcane biorefinery allows reducing the steam consumption in the plant and, consequently, providing more bagasse to the second generation ethanol production. However, variations in the prices of ethanol and electricity influence in 2G ethanol and surplus electricity production. These variations in the process imply in different utilities demand. The HEN (Heat Exchanger Network) synthetized should be able to meet the different process conditions.

Collaborations in this regard include methodologies for design of flexible heat exchanger networks, which allow fluctuations in some parameters process, such as flow and temperatures. Among the approaches used for this problem, a common practice is the heat exchanger network for multiperiod operations, a particular case of flexible networks, which can operate in different established conditions. In this study, a multiperiod approach was used for the HEN synthesis. The periods differ in the bagasse fractions deviated to second generation ethanol and electricity production. A virtual biorefinery developed in the EMSO simulator (Environment for Modeling, Simulation, and Optimization) was used, which comprises 1G/2G anhydrous ethanol and electricity production process. To reduce the complexity of HEN synthesis for all periods, a MINLP (Mixed Integer Nonlinear Programming) model was solved for each period, separately. Later, the timesharing strategy of Jiang and Chang (2013) was used for the automatic integration of heat exchanger networks obtained in each period. For problem solving of MINLP problem, a free program was developed in C ++ language using Particle Swarm Optimization algorithm.

Period 1 represents the simulation of 1G ethanol and electricity production process and Periods 2 and 3 represent the simulation of 1G/2G ethanol and electricity production process with different fractions of bagasse. Therefore, the number of streams involved in energy integration differs among periods and, consequently, the number of variables. Period 1 has 672 variables and Periods 2 and 3 have 1080 variables. The results demonstrated a reduction in TAC (Total Annualized Cost) of HEN proposed in this work compared to the process without energy integration. This reduction in TAC, in particular in utilities demand, allows less consumption of bagasse in the cogeneration system, and then the surplus bagasse can be made available for 2G ethanol production. Thus, the energy integration in biorefinery enables to increase ethanol production, minimize costs and reduce the use of environmental resources.

References

Jiang, D., C.T. Chang, A new approach to generate flexible multiperiod heat exchanger network designs with timesharing mechanisms. Industrial & Engineering Chemistry Research, 2013. 52: p. 3794-3804.

ISBN: 978-84-697-8629-1