(340b) Dynamic Operability Analysis of a Natural Gas Combined Cycle Power Plant Using a Novel Branch and Bound Method

Conference: AIChE Annual Meeting

Year: 2020

Proceeding: 2020 Virtual AIChE Annual Meeting

Group: Computing and Systems Technology Division

Session: Interactive Session: Systems and Process Control

Time: Friday, November 20, 2020 - 8:00am-9:00am

Authors:

Dinh, S. - Presenter, Illinois institute of technology
Lima, F. V., West Virginia University

The optimal design and the control policies for chemical systems have complex impacts on each other [1]. A different design results in a system with different reachable setpoints and dynamic behaviors. In recent years, operability approaches have been developed to simultaneously optimize a process design (physical dimensions, material properties, etc.) while considering the controllerâ€™s capability. Dynamic operability studies extended the steady-state input-output mapping to a dynamic mapping to evaluate the operability index during process operation [2] and the transient time to reach a new steady state [3]. In this presentation, a dynamic operability mapping is developed to find a controllable design region, which will help to determine optimal control laws under stochastic disturbances within this region.

Under the influence of a stochastic disturbance, the process achievable output set (AOS) is shifted from its nominal value by the amount corresponding to the projection of the probability density function of the random variable associated with the disturbance after mapping it through the disturbance model. If the intersection of all the AOSs at different realizations of the disturbance is non-empty, the design is controllable, and the variance of the outputs can be quantified by the hyper-volume of the dynamic AOS when the process outputs converge to a time-invariant set. However, evaluating the dynamic AOS of a high-dimensional system by sampling techniques is computationally expensive and requires a large number of function evaluations. A novel branch and bound estimation of the dynamic AOS is developed in this work based on the fact that the gradient of the operability mapping function at each closure point of the AOS is singular and there exists a convex cone that only intersects with the dynamic AOS at one point which also corresponds to a closure point of the AOS.

The proposed dynamic operability framework is applied to a load-following natural gas combined cycle (NGCC) power plant. The framework aims to find a controllable design that can achieve the desired set of net load power generation when the heating value of natural gas and the ambient conditions are characterized by random variables. Results of the framework application to the NGCC system will be discussed for different disturbance realizations.

References:

[1] Flores-Tlacuahuac, A., & Grossmann, I. E. (2011). Simultaneous cyclic scheduling and control of tubular reactors: Parallel production lines. Industrial & Engineering Chemistry Research, 50(13), 8086-8096.

[2] Gazzaneo, V., Carrasco, J. C., Vinson, D. R., & Lima, F. V. (2020). Process operability algorithms: past, present, and future developments. Industrial & Engineering Chemistry Research, 59(6), 2457-2470.

[3] Bunin, G. A., Lima, F. V., Georgakis, C., & Hunt, C. M. (2010). Model predictive control and dynamic operability studies in a stirred tank: Rapid temperature cycling for crystallization. Chemical Engineering Communications, 197(5), 733-752.

Topics: Process Automation & Control | Natural Gas

LinkedIn **Twitter** **Facebook**

YouTube **Flickr** **Slide Share**

About
Join AIChE
Global
Ethical Guidelines
Press
Privacy & Security
Code of Ethics
Sitemap