Optimal Maintenance Scheduling of a Gas Engine Power Plant using Generalized Disjunctive Programming

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A new continuous-time model for long-term scheduling of a gas engine power plant with parallel units is presented. Gas engines are shut down according to a regular maintenance plan that limits the number of hours spent online. To minimize salary expenditure with skilled labor, a single maintenance team is considered which is unavailable during certain periods of time. Other challenging constraints involve constant minimum and variable maximum power demands. The objective is to maximize the revenue from electricity sales assuming seasonal variations in electricity pricing by reducing idle times and shutdowns in high-tariff periods. By first developing a generalized disjunctive programming model and then applying both big-M and hull reformulation techniques, we reduce the burden of finding the appropriate set of mixed-integer linear constraints. Through the solution of a real-life problem, we show that the proposed formulations are very efficient computationally, while gaining valuable insights about the system. © 2014 American Institute of Chemical Engineers *AIChE J*, 60: 2083–2097, 2014

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Introduction

Power systems are becoming increasingly important to chemical engineering. In the context of process design and operation, recent works have been looking into systems subject to: (1) varying power demand[1–3]; (2) fluctuating electricity pricing.[4–10] Concerning the latter, different scheduling models have been proposed to optimize cement,[4] air separation,[5] steel,[6–9] and combined heat and power plants,[10] and important economic benefits have been reported in cases of low capacity utilization. In this work, we study the opportunities arising from seasonal variations in electricity pricing when considering the long-term maintenance scheduling of a power plant providing electricity to a chemical complex.

Industrial sites require regular maintenance to ensure reliability of their equipment and avoid emergency shutdowns. The main concerns of maintenance scheduling are to guarantee feasible material and utility balances while minimizing cost of labor.[11] As in-house skilled labor is limited and external labor is expensive, the maintenance of plants is scheduled so as to make effective use of in-house labor.

The maintenance scheduling of generators in power systems is one of the most significant problems in power systems operation and management.[12] To avoid premature aging and failure of generators leading to unplanned and costly power outages, it is important to carry out preventive maintenance at regular intervals.[13] The maintenance schedule affects many short- and long-term planning functions. For example, unit commitment, fuel scheduling, reliability calculations, and production cost all have a maintenance schedule as input. Therefore, a suboptimal schedule can affect each of these functions adversely.[14]

In centralized power systems, the maintenance scheduling of generator units is usually performed by the system operator and imposed to power plants,[12] but this is no longer valid in currently restructured electric energy systems.[15] The conventional approach for maintenance scheduling now involves interaction between the independent system operator (ISO) and the generation companies (GENCOs). In this process, the objective of the GENCOs is to maximize their annual benefits, favoring unit maintenance in low price weeks.[15] In contrast, the ISO will also try to maximize the reliability of the power grid, seeking a maintenance plan with similar reliability throughout the weeks of the year and preferring maintenance in low demand weeks. Hence, the ISO may return some maintenance requests for modification. To achieve a maintenance plan that meets the target of both producers and operators, Conejo et al.[15] proposed a coordinating mechanism based on incentives/disincentives, where all producers

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