Natural Gas Reduction in Industrial Waste Incineration by Optimized Short-term Scheduling

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Waste production is a major issue in all branches of the chemical industry. Bulk chemicals have a quite low waste to product ratio, but they are produced in huge quantities, pharmaceuticals and fine chemicals are in contrast produced in low quantities, but they have a large waste to product ratio (Poliakoff et al., 2002). In some countries, such as Switzerland, up to 70 % of the chemical waste is incinerated (BAFU, 2012). Major chemical industrial sites have own in-house incineration units which guarantee an independent waste management. On the one hand, the heat released in the incineration process is generally used for steam production. In order to keep the incineration at steady state, it is necessary a minimum energy input into the system. Hence, in case that the waste does not provide enough energy, additional natural gas is required. On the other hand, the optimal functionality of the incineration treatment and its well thought-out planning and scheduling are of utmost importance to avoid constraining unnecessarily the daily production (Wassick, 2009). However, most decisions in practice are still made on a purely empirical basis.

In order to improve the operation of waste incineration plants, (Anderson et al., 2005) applied a multi-objective evolutionary algorithm. This strategy provided the operators with the ability to adapt some selected parameters of the incineration units to improve the overall treatment performance based on a given input and set of constraints. Recently, Wassick (2009) has presented the benefits of using systematic modeling and optimization in the waste management and plant integration in the Dow Company. Over one year the optimized scheduling of the presented model was compared with the actual schedule of the normal work process. Results indicate that optimal scheduling tools provide schedules with lower costs.

This work aims to provide to waste management operators with a detailed short-term optimized schedule for liquid waste incineration. The optimization objective is to reduce the overall consumption of natural gas through adequate mixing and scheduling of waste streams with different energy content, thus avoiding situations with excess and shortage of energy.

Additionally holdups in the production caused by bottlenecks in the waste treatment units have to be avoided and all legal and technical constraints have to be respected.

The waste management and incineration system considered in this work consists of several storage tanks, a complex piping network, tank wagons for the waste transport, unloading pumps and firing lances of the incineration units. A mixed-integer linear programming (MILP) formulation is introduced to approach the short-term planning and scheduling of liquid waste transfer from different production sites to the incineration units and its disposal. The model is composed of two main parts: (i) waste transfer and mixing issues, (ii) the incineration process itself with its associated energy calculations and constraints. The scheduling horizon was set in the range of one week discretized in uniform time intervals.

The developed optimization tools have been tested and validated in a chemical plant in Switzerland. It could be shown, that, compared to the current performance of waste incineration, the optimized schedule would have reduced the overall natural gas consumption, while respecting all system and regulatory constraints and guaranteeing the provision of enough energy for a continuous and proper incineration.

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