

Water Treatment Process Design Problem

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Overview

Water is one of the most common components found in process industries. It is actively present in many different tasks. For example, as steam or cooling water, as an intermediate extracting fluid, or as a solvent. As a result of these operations a significant amount of contaminated wastewater is usually produced, and the problem of how to treat it before releasing it to the environment to satisfy environmental regulations arises.

Traditionally, a centralized facility has been used to treat the wastewater streams coming from different parts of the plant. The usual procedure consists in mixing these streams together and feed it to the facility. One drawback of this approach is that water is not reused in order to reduce the consumption of freshwater. Moreover, this design requires that a large flow of water be treated leading to a substantial investment a operating expenses.

The recent approach has been to consider distributed systems that reuse the water and reduce the load for the treatment. The optimal design of these systems is not trivial as they involve complex splitting and blending operations.

In this work we focus on the treatment section of process water plants. We present two alternative formulations to find the optimal set of technologies to remove contaminants: a) Flow based formulation b) Concentration based formulation. The key difference between both formulations is in the way in which each stream is defined. In the Flow based formulation, each stream is characterized by a set of individual component flows, whereas in the Concentration based formulation each stream is characterized by a total flow and a set of concentrations. Although this appears to be a subtle difference we will explain why these two formulations may lead to different performances when they are solved.

The structure of this problem is particularly suitable to be represented as a Generalized Disjunctive Program, which can be reformulated as a non-convex MINLP. The source of non-convexities is given by a set of bilinear terms and concave functions.