

Water Treatment Process Design Problem

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Problem Statement

In the Water Treatment Network Design Problem, we are given a set of contaminated water streams i , $i \in I$, for which the composition of contaminants j , $j \in J$, and molar flows are perfectly defined. The goal of this problem is to find a set of treatment units k , $k \in K$, with known treating performances and interconnections which will minimize the cost of the network while satisfying maximum concentrations of contaminants in the outlet stream. (A general scheme of the system is shown in Fig. 1). Fig 2 shows the network for a system with three streams and three treatment units.

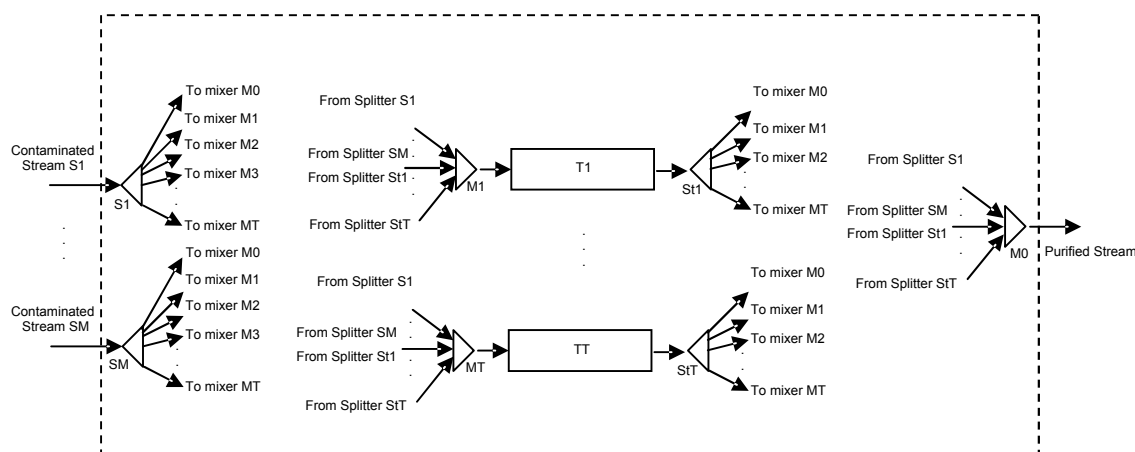


Fig. 1 Superstructure for a Water Treatment Network Design problem

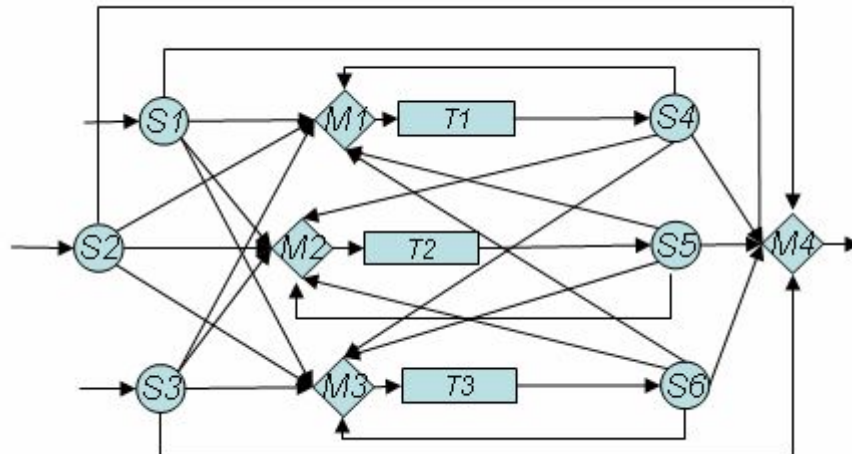


Fig. 2

The general model description can be summarized as follows:

Min Cost of Treatment Units

s.t.

Physical Constraints:

- (a) Mass balance around each splitter
- (b) Mass balance around each mixer
- (c) Mass balance around each treatment unit

Performance Constraints:

- (d) Contaminant composition of the purified stream less or equal than a given limit for each contaminant.

Logic Constraints:

- (e) Treatment units not chosen have their inlet flow set to zero
- (f) Every treatment unit chosen must have a minimum flow

We assume that the performance of the treatment units only depends on the total flow entering the unit and its composition. Moreover, the flow of contaminants leaving the unit is a linear function of the inlet flow of contaminants. Let inf_{jk} be the flow of contaminant j entering the treatment unit k and let C_{jk} be the performance coefficient

associated to the treatment unit k and contaminant j , then the flow of contaminant j leaving the treatment unit k , $outf_{jk}$, is given by:

$$outf_{jk} = (1-C_{jk}) inf_{jk}$$

We also assume that the cost of each unit k , CTU_k , can be represented as the sum of an investment cost, $INVC_k$, which is proportional respect the total flow to some exponent α between 0.5 and 1 and an operating cost, OPC_k , which is proportional to the flow.

For example, the cost of the treatment unit k , treating the total flow inf_k is given by:

$$CTU_k = INVC_k + OPC_k$$

where

$$INVC_k = \theta_k inf_k^\alpha + \gamma_k$$

$$OPC_k = \beta_k inf_k$$

And β_k , γ_k , θ_k are the cost coefficients for unit k .

We further assume that each treatment unit k requires a minimum flow to work L_k