Clean Techn Environ Policy (2013) 15:473–487
DOI 10.1007/s10098-013-0609-3

ORIGINAL PAPER

Optimization of water network integrated with process models

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Received: 26 November 2012 / Accepted: 13 March 2013 / Published online: 31 March 2013
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Abstract In this paper, a novel approach for the synthesis of water network incorporated with process models is introduced. The process models are utilized to relate the variables (i.e., flow rate and concentration) of process output (typically defined as internal water source) with those of process input (i.e., water sink). A generalized water network superstructure is developed to embed all possible process units and all the connections among resources, interceptors, process units, and wastes. The problem is formulated as four optimization problems (minimum freshwater flow rate, intercepted flow rate, intercepted mass load, and number of connections), and the four models are solved in sequence to locate the targets. A literature case is used to validate the proposed approach. Moreover, a sour water network of a practical refinery plant is presented to illustrate the applicability and effectiveness of the proposed approach.

Keywords Water minimization · Optimization · Mathematical programing · Process model · Sour water network

List of symbols

Sets and indices

NFS	Set of fresh sources
NPU	Set of process units
NIU	Set of interceptor units
NCOMP	Set of components
s	Index for fresh source
u	Index for process unit
i	Index for interceptor unit
c	Index for component
λ	Slack factor

Parameters

$x\mathrm{FS}_{s,c}$	Concentration of component c in fresh source s (ppm)
$x\mathrm{FU}_{u,c}^{\mathrm{in,max}}$	Maximum inlet concentration of component c for process unit u (ppm)
$x\mathrm{FU}_{u,c}^{\mathrm{out,max}}$	Maximum outlet concentration of component c for process unit u (ppm)
$\mathrm{RR}_{i,c}$	Removal ratio for component c for interceptor unit i
$x\mathrm{FI}_{i,c}^{\mathrm{in,LB}}$	Lower bound for inlet concentration of component c for interceptor unit i (ppm)
$x\mathrm{FI}_{i,c}^{\mathrm{in,UB}}$	Upper bound for inlet concentration of component c for interceptor unit i (ppm)
$x\mathrm{FE}_{c}^{\mathrm{UB}}$	Upper bound for the concentration of component c for environment (ppm)
$\mathrm{FS}^{\mathrm{min}}$	Minimum flow rate for the freshwater sources (t/h)
$\mathrm{FI}^{\mathrm{min}}$	Minimum flow rate for the interception units (t/h)
$\mathrm{MFI}^{\mathrm{min}}$	Minimum interception mass load for the interceptors (kg/h)
$\Delta\mathrm{FU}_{u}$	Delta flow rate for process unit u (t/h)

Continuous variables

FS_{s}	Flow rate allocated from freshwater source s (t/h)
$\mathrm{FSU}_{s,u}$	Flow rate from freshwater source s to process unit u (t/h)

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