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Synthesis of an integrated water and membrane network with multiple electrodialysis regenerators

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2016
http://hdl.handle.net/10539/21102

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Abstract

The increasing cost of freshwater and wastewater treatment coupled with stringent environmental regulations has pushed process industries towards sustainable engineering, emphasising the need for water minimisation. This can be achieved through the implementation of process integration strategies such as water recycle, reuse, regeneration-recycle and regeneration-reuse between water sources, water sinks and regenerators. This concept is referred to as water allocation planning (WAP). This work addresses the WAP problem through the application of process integration and its enabling tools. A comprehensive mathematical formulation comprising of a detailed electrodialysis model that is linked to a water network model is proposed. Regeneration technologies, particularly membranes, are highly energy intensive, and hence despite being desirable should not be applied at the expense of energy. In this regard, the model developed is for the simultaneous optimisation of water and energy. The water and energy consumption terms are translated into monetary terms and the objective set to minimise the total annualised cost of the system. To demonstrate the proposed approach, the model is applied to a pulp and paper plant case study. The optimisation problem, presented as a mixed integer nonlinear programming (MINLP) problem, is solved in GAMS/DICOPT. The results indicate a potential of 12% savings in freshwater intake, 16% reduction in wastewater generated and a 14% savings in the total annualised cost for the entire network.