Preface

Ali Elkamel

Department of Chemical Engineering,
University of Waterloo,
200 University Avenue West,
Waterloo, ON, N2L 3G1, Canada
E-mail: aelkamel@cape.uwaterloo.ca

Biographical notes: Ali Elkamel is an Associate Professor of Chemical Engineering at the University of Waterloo. Prior to joining the University of Waterloo, he served at Purdue University, Procter and Gamble, Kuwait University, and the University of Wisconsin. His research has focused on the applications of systems engineering and optimisation techniques to pollution problems and sustainable development.

In the context of current developments and state-of-the-art of related industrial practices and academic research, Pollution Prevention, with its underpinning conventional philosophy of source reduction via process optimisation, can be broadly and comprehensively defined as practices that reduce or eliminate the creation of pollutants and wastes, at the source. This is accomplished via a four-pronged approach of increased efficiency in the utilisation of raw materials, energy, water, or other resources; substitution of hazardous substances with less harmful alternatives; elimination of toxic substances from production/manufacturing processes, and protection of natural resources by means of conservation efforts.

In the USA, as recently as 15 years ago, the practice of environmental management focused almost exclusively on the paradigm of 'end-of-pipe' treatment comprising control and treatment of pollution. It was only in the late 1980s that recognition was given to the preventive approach, giving rise to the whole notion of Pollution Prevention. Indeed, a search on the database Engineering Village 2/Compendex for the term 'pollution prevention', dating back since the year 1985 until the present, returns approximately 1300 records, with 480 or so appearing in the last five years, a clear indication of the strong growth of the field, surpassing even the results of a quick comparison with a search result for the term 'membrane separation' (which is arguably an active and prominent research area in the chemical engineering domain).

This special issue highlights a number of innovative contributions from leaders in the process systems engineering community who are actively working on pollution prevention practices and applications. We begin with the work by Almutlaq and El-Halwagi that proposes a rigorous pinch-analysis-based algebraic targeting approach for material recycle/reuse strategy. The ultimate objective of resource conservation is accomplished through minimisation of fresh resource usage, maximum recycle/reuse of process resources, and minimum discharge of wastes.

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The next paper by Singh, Li, Lou, Hopper, Golwala, Ghumare and Kelly studies the viability of the pollution prevention approach of emissions reduction through flare minimisation. The proposed approach has been applied to an ethylene plant, with the analytical aid of dynamic process simulation.

Bagajewicz and co-workers, Janjira and Magaraphan, extend their series of work on financial risk management to environmental risk by employing an analogous representation via a cumulative probability distribution of emissions. Both types of risk are accounted for simultaneously in a process design framework as applied to the catalytic reforming process in a petroleum refinery with consideration for carbon dioxide and benzene emissions.

The next contribution by Hamad, Al-Fadala and Warsame tackles the problem of waste and wastewater minimisation in liquefied natural gas plants by primarily employing the thermal pinch analysis method. Combining this method with graphical tools and linear programming technique, the authors attempt to identify energy integration options and impurities composition under different plausible operating scenarios.

In a departure from pinch analysis-based approach, Xu and Diwekar propose a new genetic algorithm for the multiobjective optimisation approach under uncertainty for the integrated design of solvent selection and recycling of acetic acid recovery from its aqueous solution. The work, with consideration for environmental impact, produces superior results to the simulated-annealing-based SA-Constraint method and demonstrates the significance of accounting for uncertainty in the optimal design.

Manan, Tan, Foo and Tea then introduce water cascade analysis, another pinch-analysis-based numerical technique, in identifying potential reduction in fresh water consumption and wastewater generation and for the subsequent retrofit of the associated water distribution network. The method has been successfully applied to a paper mill plant with reported annual savings.

The paper by Thurston and de la Torre explores a different application of pollution prevention practice with a model that addresses the extended producer responsibility legislation issue. This is executed by examining the impact of leasing arrangement programs on cost, reliability, and environmental aspects, in determining the optimal combination of new, recycled (and reused), and remanufactured components in personal computers.

Next, Park, Kim, Ko, Moon and Yeo introduce an algorithm known as Goal Constrained Programming (GCP) for the multiobjective optimisation of scheduling of paper cutting. The proposed algorithm is found to be particularly suitable for problems in which each of the multiple objective functions has a different degree of priority in determination of the optimal combination of cutting patterns that satisfy both economic and environmental targets.

The following paper by Malcolm, Zhang, and Linninger offers a systematic methodology comprising pollution abatement technological models that are capable of assessing the feasibility of waste management options with their associated cost and expected emissions. The framework could potentially aid regulators in formulating environmental policies that do not unnecessarily burden manufacturers' financial standing.

The paper by Gabbar and Suzuki describes an integrated computer-aided design with a pollution control framework that is capable of evaluating and controlling possible pollution at source level (in future actual operation) during the conceptual process design stage itself. The methodology employs hierarchical modelling and simulation that utilises process variables and performance indexes of pollution within each model building block.

The following work by Alva-Argaez, Kokossis and Smith extends the water pinch analysis method by employing mathematical programming techniques to develop a design methodology based on Mixed-Integer Non-Linear Programming (MINLP) formulation of a superstructure model. The solution strategy of the mixed-integer program employs a decomposition scheme that utilises barrier and penalty-based methods. The developed tool is mainly intended for industrial water-using systems with application to multi-contaminant systems.

Zhou and Manousiouthakis then describe the application of the decomposition-based, generic process network representation known as Infinite Dimensional State-Space (IDEAS) to homogeneous and isothermal reactor network synthesis problems with an underlying goal of reduction of byproduct formation. The undertaken work produces encouraging results that suggest the possibility of exact quantification of the fundamental tradeoffs between desirable and undesirable product generation.

Aydogan, Orcun, and Pekny study the effects of different waste recovery systems, which include physiochemical- and bioregenerative-based technologies, on the overall waste generation rates for an Advanced Life Support System (ALSS), touted as possibly the ultimate pollution prevention practice with zero waste generation. In this endeavour, the ALSS, which was used on a space exploration to Mars, is intended for utilisation on Earth-based applications.

Meanwhile, at a more down-to-Earth level, Ba-Shammakh, Elkamel, Douglas and Croiset present an optimal mixed-integer non-linear programming model of cost-effective strategies for mitigating carbon dioxide emissions in a network of power plants. The resulting optimal strategies consist of fuel balancing, fuel switching, and technologies with increased-thermal-efficiency.

Finally, the paper by Lovelady, El-Halwagi and Krishnagopalan offers a model for reduced water usage and discharge in pulp and paper plants. This is achieved via the implementation of optimal cost-effective allocation, recycle, and separation of aqueous streams, by employing mass integration strategies that comprises process simulation and targeting techniques.

I wish you a fulfilling journey in savouring the breadth of the intellectual offering that this special issue offers.