

Editorial

Special Issue on “Energy Conservation and Emission Reduction in Process Industry”

Yi Man ^{1,2,*} , Zhiqiang Sun ³  and Sheng Yang ³ 

¹ State Key Laboratory of Pulp & Paper Engineering, South China University of Technology, Guangzhou 510006, China

² Guangdong Artificial Intelligence and Digital Economy Laboratory (Guangzhou) (Pazhou Lab), Guangzhou 510330, China

³ School of Energy Science and Engineering, Central South University, Changsha 410083, China; zqsun@csu.edu.cn (Z.S.); ceshyang@csu.edu.cn (S.Y.)

* Correspondence: manyi@scut.edu.cn

The process industry is an important pillar industry for national economic and social development and an important support force for sustained economic growth. At the same time, it is a highly energy-consuming and high-emissions industry. In the past decade, the production process, equipment, and automation levels of process industries have been substantially improved, but their development is still constrained by problems such as resource scarcity, high energy consumption, and serious environmental pollution.

Energy-saving and emissions reduction are the focus of the process industry, guiding it towards sustainable development. For example, simulation models of production processes are being developed to assess the energy-saving potential and provide guidance for optimizing production operations to achieve energy savings and emission reductions. However, current research is insufficient to achieve these goals.

This Special Issue “Energy Conservation and Emission Reduction in Process Industry” aims to summarise the latest advances in the theory and application of energy-saving and emission reduction in the process industry to address the long-term challenges of high energy consumption and pollution and to promote the sustainable development of the process industry. In the following pages, you will find selected contributions on topics such as modelling and optimisation, environmental protection, and some review papers for industrial energy saving and emission reduction.

Research Article

Modelling and Optimisation

This section is divided into three main categories: machine-learning-based modelling, mechanistic-method-based modelling, and optimization-algorithm-based modelling.

On the topic of machine-learning-based modelling, Xu et al. [1] proposed a graphite purity identification method using a multi-model weighted fusion mechanism. A two-channel convolutional neural network was constructed to extract the depth features of the graphite images on a self-built, small sample dataset, extended offline and enhanced online. After weighted fusion of the two features, a Softmax classifier was used for classification. The experimental results show that the recognition accuracy after weighted fusion is better than that of the single network, reaching 97.94%. Gao et al. [2] proposed an energy management model based on the Deep Deterministic Policy Gradient (DDPG) method, the greedy dynamic programming algorithm, and the genetic algorithm (GA). The simulation results showed that compared with the current forms of energy, the three energy management methods reduced the cost of capacity and operating of the energy storage system by 18.9%, 36.1%, and 35.9%, respectively. Zhang et al. [3] proposed a power consumption model and the steam consumption model based on linear regression, an artificial neural network and the extreme gradient boosting tree. The result indicated that the power consumption model



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and steam consumption model based on the extreme gradient boosting tree are better than the models based on linear regression and artificial neural networks.

In the mechanistic-method-based modelling part, Chen et al. [4] proposed a mathematical model for rapid estimation of water evaporation heat in the paper drying process. During modelling, the drying curve is selected as the model input variables, and then evaporation heat (ΔH) can be calculated. Compared with the traditional method based on sorption isothermals, the new model based on the drying curve has some advantages in measurement speed and easy access to basic data. Finally, the paper verifies the reliability of the model from two application scenarios of the laboratory and production line. Yu et al. [5] proposed an improved heat transfer model based on an AVL-BOOST environment to improve the efficiency of the diesel engine and reduce emissions. In addition, a five-component biodiesel skeletal mechanism containing 475 reactions and 134 species was developed to simulate the fuel spray process and combustion process. Finally, the propulsion and load characteristics of a diesel engine fuelled with biodiesel fuel were investigated by the improved heat transfer model in terms of power, brake-specific fuel consumption (BSFC), soot, and NO_x emissions. The result showed that the errors between the experiment and simulation were less than 2%. Xiao et al. [6] proposed a computational fluid dynamics (CFD) decompression model based on the non-equilibrium phase transition and the Span–Wagner equation of state (EoS) to study the effects of the actual flowing state within the pipeline on the transient behaviour of liquid CO_2 decompression. Then, the CFD model was verified by comparing the simulated results to test data of a large-scale “shock tube” with an inner diameter of 146.36 mm. The results showed that the evaporation coefficient had a significant impact on the transition behaviour of CO_2 decompression, while the condensation coefficient made no difference.

In the optimization-algorithm-based modelling part, Chen et al. [7] proposed an optimization model for minimizing steam consumption was constructed. Compared with before optimization, the steam consumption of the optimized bleaching system reduced by 19.48% (0.5014 t/ad) at a loss of 0.11% brightness (0.1 ISO%) and 5.17% viscosity (33 mL/g). The cost of bleaching pulp has decreased by 1.62% (3.19 USD/ad) after optimization. The verification experiments showed that all the pulp quality indices can meet the requirements of bleached pulp. Zeng et al. [8] proposed an energy-efficiency scheduling model. The model was solved by proposing a novel IMOEA/DTL method. The experiment made a comparison between the proposed method and an MOEA/D-MR-based model, an NSGA-II-based model, and a SPEA2-based model. The experiment results demonstrate that the proposed method performs better than NSGA-II and SPEA2 in terms of the C-metric and the HV-metric. Moreover, the proposed method has been proven to have an energy-saving ratio of 2.6% through a real scheduling problem. Tao et al. [9] modelled the complex team accident management process using basic cognitive units to lay the groundwork for a new HRA methodology based on this cognitive process. At the same time, this study modelled staff behaviours in the main control room based on an SOP. Based on these two models, a cognitive-behavioural model was established for the team in the main control room of the nuclear power plant, which facilitates the optimization of a corresponding Human Reliability Analysis model.

Environmental Protection

This section can be divided into two categories: experimental analysis and macro-analysis.

In the experimental analysis part, Li et al. [10] proposed the calculation model of the amount of sludge to be cleared to improve the unit water quality and the amount of carbon dioxide released by clearing the silt. They proposed countermeasures to improve the water quality of Baiyangdian and increase the carbon sink capacity. Yang et al. [11] studied the factors affecting the accuracy of the soil calibration model through an indoor calibration test, and soil samples were prepared to verify the accuracy of the soil calibration model. The test results showed that the dry density range, water content range, and sample quantity of 13 samples of soil had a significant influence on the correlation coefficient (R^2) of the equation of the soil calibration model. To restore the ecological environment

in Xiangtan Manganese Mine, in 2015, Lin et al. [12] proposed the ecological restoration test of heavy metal polluted wetlands in the mining area. The N.L. Nemerow (pollution index) method was used to evaluate the heavy metal pollution of soil from a single-factor pollution index and a comprehensive pollution index. The results are consistent with those of the isotopic research of Sutkowska, Vladislav Chrastný, Vaněk, Aleš, and Rafael Baieta. Deng et al. [13] proposed a high-efficiency and stability microsphere (PVA)-immobilized *Bacillus velezensis* cell system to remove the chemical oxygen demand (COD) based on simultaneous adsorption and biodegradation (SAB) for the treatment of slaughter wastewater. The removal CODMn rates of microsphere (PVA) immobilized cells were 16.99%. These findings revealed that the PVA-bacteria system was a simple, green, and inexpensive process, as well as a promising method. Liu et al. [14] achieved the genome-wide identification of Cd-responsive conserved and novel miRNAs and their target genes in *Brassica juncea* via transcriptomic and sRNA-sequencing technology. These findings may deepen our understanding of the regulatory relationship between miRNA and transcripts in *Brassica juncea* in response to Cd stress, and provide further insight into the molecular mechanisms of Cd stress in plants. Wang et al. [15] investigated the effects of the N2 temperature, injection pressure and cycle number on the permeability of naturally fractured coking coal. A testing system for HTN2 injections was developed. The research results are helpful for rapidly extracting the methane and guaranteeing mine safety.

In the macro-analysis part, Zhu et al. [16] proposed a regulated intermediary model based on social exchange theory and the individual-environment matching theory. The authors investigated the enterprise's GHRM, personal green behaviour, relational psychological contract, environmental knowledge and green values. This study explains the relationship between GHRM and employees' green behaviour and provides an important basis for enterprises to implement GHRM practice and promote employees' green behaviour. Meng et al. [17] studied the impact of FDI on technological innovation in China's industrial sectors from the perspective of technology transactions from 2001 to 2019 and analysed whether the intensity of environmental regulation can promote the relationship. Results indicate that FDI promotes technological innovation through technology transactions. The authors also conducted regional heterogeneity analysis, and the results showed that in the eastern and western regions of China, FDI can stimulate technological innovation within regional industrial sectors through technology trading. Ding et al. [18] developed a sustainability analysis model based on an intergenerational externalities influence and examined the influence of the shift in comprehensive production cost burden through the whole supply chain, which aims at the sustainable development of the exploitation process of rare metal minerals. The results indicated that in a vertically linked industrial chain, the upstream and downstream structure of the supply chain, and the type of production cost are the factors that determine sustainable development.

Reviews

Liu et al. [19] summarized the arrangement of heating surface and temperature regulation method of existing double-reheat boilers in China, including a brief history of the double-reheat boiler, the scheme for heating surface arrangement, and methods for regulating steam temperature. This work will help to set a benchmark for the development of double-reheat boilers and the future 700 °C power generation unit in the world. Li et al. [20] summarized the previous studies related to three important aspects of temperature control in proton exchange membrane fuel cells to better guide thermal management of the proton exchange membrane fuel cell (PEMFC), including research on temperature characteristics, and temperature control based on battery material structure, temperature control based on cooling medium and cold start.

This Special Issue covers a broad range of topics that all aim to contribute to energy conservation and emission reduction in the process industry. For this to be achieved, the well-being of green sustainability in the process industry must be provided through sustainable action in terms of energy, resources, environment, and society.

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