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Cheng Tung Chong, Jo-Han Ng, Mohd Shiraz Aris, Guo Ren Mong, Norshakina Shahril, Sing Tung Ting, Meor Faisal Zulkifli. *Impact of gas composition variations on flame blowout and spectroscopic characteristics of lean premixed swirl flames*. Pages 1-13.

The injection of gases from different oil and gas fields and external sources such as liquefied natural gas increases operational risks for the relevant gas turbine power plant operators. In practice, the absence of interchangeability specifications in the gas supply network code has caused combustion blowout, wear and tear to occur due to combustion dynamics and diluent effects. Understanding the effects of diluents on natural gas combustion is essential to ensure the safe operation of existing facilities. The present work investigates the flame stability and spectroscopic characteristics of diluents-containing natural gas by using a swirl flame burner. Stable and continuous swirl flames were successfully established using different types of gas compositions, including those diluted with nitrogen and carbon dioxide. Diluting the modelled natural gas with CO2 and N2 results in higher blowout limit as compared to the baseline pure methane case. Preheating the burner and mixtures can extend the flame blowout limits, although the effect of CO2 on flame blowout is more pronounced than that of N2 due to its higher heat capacity. This work shows the effects of non-reactive diluents on gas turbine flame can be significant, particularly at high-level dilutions. Mitigation measures such as gas composition and flame spectroscopy monitoring can be deployed to ensure safe operation of the system. By using the statistical analysis technique of linear regression, the proportions of all the fuel mixture components of CH4, C2H6, CO2 and N2, alongside temperature were found to be significant factors in determining flame blowout limits. The developed predictor equations for OH intensity and lean blowout equivalence ratios show the predictive capability of >89% at 90–95% confidence level.

- **Keywords:** Natural gas; Diluent effects; Gas turbine; Blowout limit; Emissions spectroscopy

Muhammad Athar, Azmi Mohd Shariff, Azizul Buang, Salman Nazir, Heri Hermansyah, Tan Lian See. *Process equipment common attributes for inherently safer process design at preliminary design stage*. Pages 14-29.

Hazards associated with chemical processes can lead to accidents and require therefore proper management. An inherent safety strategy is a proactive approach to serve this purpose, one capable of minimizing hazards whilst offering sustainable process design.

Current inherent safety techniques are limited to comparing process routes and selecting safer one using the process parameters, whereas process equipment characteristics are rarely scrutinized. Therefore, this paper consolidates a new technique that integrates the mutually shared attributes of process equipment, in order to offer inherently safer process design at the preliminary design stage. Inherent safety assessment for process equipment (ISAPE) consists of an indexing procedure, followed by risk assessment. The indexing procedure can highlight the critical process equipment, which can be further studied through risk assessment. When the risk is beyond acceptable threshold and must be minimized, inherent safety concepts are implemented, leading towards inherently safer process design. The complete ISAPE technique is exhibited through the case study of the acetone production process. In this case study, various ISD options have been applied to the critical process equipment, identified through the proposed indexing; the options have then been compared to select the best one. The method is easy to use, and as such, it is suitable to be put into practice by design engineers at the preliminary design stage.

- **Keywords:** Indexing; Inherent safety; Inventory; Plant layout; Preliminary design engineering; Sustainable process design

Su Shiung Lam, Yiu Fai Tsang, Peter Nai Yuh Yek, Rock Keey Liew, Mohammad Shahril Osman, Wanxi Peng, Wak Ha Lee, Young-Kwon Park. *Co-processing of oil palm waste and waste oil via microwave co-torrefaction: A waste reduction approach for producing solid fuel product with improved properties*. Pages 30-35.

Microwave co-torrefaction (MCT) was performed on empty fruit bunch (the most abundant waste from oil palm industry) mixed with waste oil (used engine oil, used cooking oil) to simultaneously utilize these waste materials to produce better quality solid fuel product. The effect of temperature and types of waste oil on the product yield and fuel properties (high heating value (HHV), energy yield, and fuel ratio) were investigated. MCT provided a rapid heating (50–65°C/min) and a shorter process time of 5–8min than that shown by conventional torrefaction performed using furnace (> 30min). The rapid heating could be attributed to the use of a cubical microwave cavity with helical lift for 2-dimensional movement (rotational and translational motion) that allows uniform distribution of microwave radiation for heating and torrefaction. The empty fruit bunch torrefied with used engine oil at 250°C showed maximum energy yield of 100wt% and produced solid fuel product with high mass yield (85.5wt%), fuel ratio (1.8), carbon content (68.3wt%) and fixed carbon content (62wt%). Solid fuel product of high higher heating value (28.0MJ/kg) was produced from microwave co-torrefaction of empty fruit bunch with used engine oil at 300°C. Our results demonstrate that microwave-co-torrefaction represents a promising waste reduction approach to convert empty fruit bunch mixed with waste oil to produce solid fuel with improved properties.

- **Keywords:** Microwave; Torrefaction; Oil palm waste; Empty fruit bunch; Waste oil; Fuel

Zain Anwar, Atif Mustafa, Muhammad Ali. *Appraisal of process safety management practices in refining sector of Pakistan*. Pages 36-40.

Globally industries have successfully implemented Process Safety Management (PSM) systems which have enormously reduced incident magnitude, their dreadful repercussions, and have proven organisational stability thereby maximizing profit margins. Due to limited data access, lack of incident and near-miss reporting & recording trend, lack of understanding and implementation of process safety management, petroleum refining sector as one of the most prone-to-incident industries globally was selected as a base case to evaluate process safety management practices in Pakistan.

Various process and safety veterans were interviewed to figure out the present status of PSM systems in downstream (refining) sector and identify the gaps. Local regulations were reviewed to gauge their extent for process safety coverage in comparison to international process safety management regulations. Pertinent international publications and Center for Chemical Process Safety (CCPS) books were also reviewed to gain valuable insights of PSM in highly hazardous processes. Interviewing process and safety veterans and reviewing local regulations surfaced several gaps and provided areas of improvement in order to setup a healthy process safety management framework for hazardous petroleum refineries. This includes, absence of local PSM regulations, lack of PSM awareness, inadequate leadership commitment, lack of implementation of a dedicated PSM system, ineffective near-miss and incident reporting and database maintaining policy. Outcomes of this study are not merely limited to the refining sector of Pakistan but provide an opportunity for other sectors as well to implement PSM in an effective manner.

- **Keywords:** Process safety management; Refining sector; OSHA PSM elements; Accident; Incident

Jiawen Cai, Shengqiang Yang, Xincheng Hu, Wanxin Song, Yawei Song, Qin Xu, Shuai Zhang. *Risk assessment of dynamic disasters induced by gas injection displacement in coal seams*. Pages 41-49.

Gas injection displacement technology not only helps to increase gas production, but also serves to store greenhouse gases by reducing CO2 emissions. However, coal seam dynamic disasters caused by gas (CO2) injection displacement are rarely reported. In order to explore the change in coal seam outburst risk after gas injection, the indexes (ΔP) of initial velocity of gas diffusion and the isothermal adsorption curves of coal with different metamorphic degrees were experimentally measured under different concentration ratios of CO2/CH4 mixed gas, and the experimental process of gas injection displacement and the change in pore structure were also investigated. The experiment results indicate that the ΔP of CO2 is nearly three times of that of CH4. Therefore, the accuracy of safety situation judgment of a coal seam would be reduced if outburst risk of the coal seam is only assessed through the ΔP in the pure CH4 environment. The results of isothermal adsorption experiment show that the gas adsorption capacity of three kinds of coal increases with the rise of the CO2 concentration in the mixed gas. The results of gas injection displacement experiment reveal that CO2 plays a significant role in replacing CH4, but a large amount of CO2 has been adsorbed into the coal seam before CH4 can be completely desorbed, which in turn raises outburst risk of the coal seam. After the displacement, the internal pore structures of the three kinds of coal samples become tinier and tinier. Finally, a new comprehensive index K′=αBET×ΔP/f was established to assess the risk of dynamic disasters in a coal seam. Compared with the single index ΔP, the new comprehensive index K′ can more accurately grasp the possibility of outburst danger in a coal seam subjected to gas injection displacement.

- **Keywords:** Gas injection displacement; Dynamic disaster; Initial diffusion velocity; Pore structure; Risk assessment

Filippo Ciarapica, Maurizio Bevilacqua, Sara Antomarioni. *An approach based on association rules and social network analysis for managing environmental risk: A case study from a process industry*. Pages 50-64.

One of the most important challenges of high-risk industries regards environmental risk management. In all sectors characterized by high-risk processes, failure can lead to catastrophic environmental events, so it is necessary to have a model capable of extracting useful information from the data collected and able to provide company managers with decision-making tools. In this work, a framework has been developed to

manage environmental risk in a process industry. In order to analyse adverse environmental events, data provided by different sources and geographically dispersed repositories have been considered. A conceptual model, based on Association Rules (AR), has been developed to investigate the network of influences among data collected. Moreover, a Social Network Analysis has been used to represent the association rules, providing a complete overview of the factors' interaction and to identify communities of nodes in order to define local and global patterns and locate influential entities. To test the proposed approach and assess its impact on environmental management strategies, a medium-sized refinery case study has been analysed. The big data analytics approach proposed in this work, taking into consideration a wide set of objective and predictive variables, allowed the refinery managers to show new cause–effect correlations in refinery processes regarding adverse environmental event typology, immediate and root causes, refinery plant area involved in the adverse event, risk index and corrective actions.

- **Keywords:** Environmental management system; Environmental risk management; Business intelligence; Big data analytics; Association rules; Social network analysis

Esrafil Asgari, Ali Esrafili, Ahmad Jonidi Jafari, Roshanak Rezaei Kalantary, Heshmatollah Nourmoradi, Mahdi Farzadkia. *The comparison of ZnO/polyaniline nanocomposite under UV and visible radiations for decomposition of metronidazole: Degradation rate, mechanism and mineralization*. Pages 65-76.

ZnO/polyaniline (ZnO/PANI) nanocomposite was produced through aniline in-situ chemical polymerization method on ZnO nanostructure. Different techniques including FT-IR, FE-SEM, EDX, DRS and TGA were employed to identify the composition and structure of the nanocomposites. The results confirmed the good quality of produced ZnO/PANI nanocomposite so that, it could be activated under UV and visible radiations. Photocatalytic activity of the nanocomposites for the degradation of metronidazole (MNZ) under UV and visible radiations as a function of time, MNZ concentration, catalyst dose, solution pH and catalyst stability was evaluated for several stages of the process. The maximum MNZ degradation (97%) under UV and visible radiations was happened over 120 and 150min, respectively and 1.0mgL−1 ZnO/PANI nanocomposite, 10mgL−1 MNZ concentration at pH 7.0. In the optimal condition, kinetic studies, COD, TOC, AOS, reusability test and predicted degradation mechanism were considered in the present study. The photocatalytic activity of ZnO/PANI nanocomposite was higher than ZnO under UV and visible radiations. The constant degradation rate of MNZ by ZnO/PANI nanocomposite was 2.53×10−2min−1, which was almost 63 times higher than ZnO photocatalysts. Besides, it was confirmed the important role of hydroxyl radicals (OH) and superoxide anion radical (O2−) in MNZ degradation. The photocatalytic performance under UV and visible radiations was associated with the significant absorption of UV and visible light and reduction of charge carrier recombination. With regard to the findings, it can be concluded that ZnO/PANI nanocomposite is a auspicious procedure for the removal of MNZ under UV and visible radiations.

- **Keywords:** ZnO nanoparticle; Polyaniline; Photocatalytic decomposition; Antibiotic; Metronidazole; UV and visible radiations

Fernando Antonio da Silva Fernandes, Sabrina Arcaro, Erwin Francisco Tochtrop Junior, Juan Carlos Valdés Serra, Carlos Pérez Bergmann. *Glass foams produced from soda-lime glass waste and rice husk ash applied as partial substitutes for concrete aggregates*. Pages 77-84.

Concrete is one of the most widely consumed materials in the world. It is composed mainly of natural aggregates - 70–80% of its volume. Extraction of natural aggregates for concrete production harms the environment, and has decreased over the past years. The use of recycled aggregates that can replace natural aggregates in concrete and meet the specifications of structural projects can be an economical and sustainable solution for the construction industry. This study investigated the effects of partial replacement of natural aggregates (pebbles) with glass foam (10–30 %wt), produced with soda-lime glass wastes, rice husk ash and calcium carbonate, on the uniaxial compression strength (3, 7, 28, 56, and 90 days) and consistency (Slump test) of structural concrete. Results show that the larger the size and concentration of the recycled aggregates, the lower the mechanical compressive strength of concrete. Hence, the highest compressive strength at all ages was shown by the material with 4.8mm glass foams and 10% addition - 38MPa after 90 days. Furthermore, partial replacement positively favors the slump of concrete (>90mm), enabling its commercialization and workability for pumping from mixer trucks.

- **Keywords:** Concrete; Recycled aggregate concrete; Glass foam; Environment; Compressive strength; Slump test

Xin Li, Xiao Yang, Shuai Wang, Jingwei Yang, Longlong Wang, Zhaoyou Zhu, Peizhe Cui, Yinglong Wang, Jun Gao. *Separation of ternary mixture with double azeotropic system by a pressure-swing batch distillation integrated with quasi-continuous process*. Pages 85-94.

Two pressure-swing batch distillation processes, which are double-column batch stripper process and its integration with quasi-continuous process named triple-column process, were designed and investigated to separate the tetrahydrofuran/methanol/water ternary system. There are two azeotropes in the system and previous studies about batch distillation to separate such mixtures are insufficient. Based on the residue curve maps, the feasibility of the processes was analyzed. Control structures were explored to implement efficient separation and ensure the safety and stability of the process. The minimum total annual cost was used to optimize the processes. The double-column batch stripper process can separate the tetrahydrofuran and water well but the methanol purity is only 99.4 mol%. To improve the separation effect, a third column was integrated in the batch distillation process to separate the methanol/water mixture directly. The new triple-column process has the characteristics of batch distillation and continuous distillation. The results show that the minimum TAC of double-column batch stripper process is 147,815 $/y which is a little lower than that of triple-column process by only 3.2%. The final compositions of tetrahydrofuran and water are same in the two processes, which are 99.9 mol% for water and 99.85 mol% for tetrahydrofuran, but the methanol purity is different. The methanol is 99.4 mol% in the double-column process while 99.9 mol% in the triple-column process. The improved methanol purity reflects the high separation efficiency and it is beneficial for the environmental protection.

- **Keywords:** Batch distillation; Environmental protection; Process design; Control structure; Process optimization

M. Yitbarek, K. Abdeta, A. Beyene, H. Astatkie, D. Dadi, G. Desalew, B. Van der Bruggen. *Experimental evaluation of sorptive removal of fluoride from drinking water using natural and brewery waste diatomite*. Pages 95-106.

This paper focuses on introducing low-cost water treatment options by using waste products from the beer industry, thereby contributing to cleaner production. To this purpose, sorptive removal of fluoride from drinking water using locally available natural grade diatomite (NGD) and brewery waste diatomite (BWD) was studied in a batch

adsorption system. The equilibrium was achieved within an adsorption time of 60 min for NGD and 30 min for BWD at the optimum pH of 5 and adsorbent dose of 60 g/L. The equilibrium data were best fitted to the Freundlich isotherm (R2 = 0.979 and 0.995) for NGD and BWD, respectively. The adsorption capacity (qmax) calculated from the Langmuir isotherm value obtained for NGD and BWD was 0.917 mg/g and 0.617 mg/g, respectively. The adsorption kinetics data for both adsorbents followed the pseudo-second-order model (R2 = 0.734 and 0.947 for NGD and BWD, respectively). The influence of other anions on fluoride removal process has a slight influence, following the order PO43− > HCO3− > CO32− > SO42− > NO3− > Cl- for both adsorbents. The materials can be used on a system level for real water sample of low fluoride concentration (≤ 5 mg/L) and could be regenerated. Though BWD is considered as a waste for the brewery, it is used as a useful material for removal of fluoride. This application can be a stepping stone for providing a solution for safe management of industrial waste while providing a resource for water treatment on a system level.

- **Keywords:** Batch adsorption; Brewery waste diatomite; Defluoridation; Natural grade diatomite; Water treatment

Sharmin Sultana, Bjørn Sørskot Andersen, Stein Haugen. *Identifying safety indicators for safety performance measurement using a system engineering approach*. Pages 107-120.

The paper presents a method for the development of safety indicators for a process industry application based on a system engineering perspective. Traditional approaches use probabilistic risk assessment or linear accident models which assume that accidents are linear chains of events and do not consider complex systemic factors and interactions. After BP's Texas City refinery incident, the investigation committee reported that BP had a false sense of safety performance due to providing more focus on managing personal safety rather than process safety. System engineering concepts may help the process industry to operate their activities without any severe accidents by establishing a better safety management system. This paper adopts the STAMP (System-Theoretic Accident Model and Processes) accident causation model to identify system specific indicators and also describes the proposed method with the help of a simple process industry application which is an LNG ship to ship transfer process. It compares the developed method with other methods for practical case applications. The first step of the present method is to establish the safety control structure, then safety performance indicators are identified. Further work is necessary to investigate to what degree these STAMP based indicators are complementary to indicators developed by other methods.

- **Keywords:** Safety; Risk; Performance; Indicator; STAMP; System

Jihao Shi, Xinhong Li, Faisal Khan, Yuanjiang Chang, Yuan Zhu, Guoming Chen. *Artificial bee colony Based Bayesian Regularization Artificial Neural Network approach to model transient flammable cloud dispersion in congested area*. Pages 121-127.

Recently, the Bayesian Regularization Artificial Neural Network (BRANN) approach has been used for flammable cloud estimation in a congested offshore setting. These authors observed that BRANN exhibits lower accuracy under specific release and dispersion scenarios. To improve BRANN's accuracy and robustness, the authors have proposed the integration of the Artificial Bee Colony (ABC) algorithm with the BRANN approach. The new ABC-BRANN approach is tested for a wide range of scenarios. The performance of ABC-BRANN approach is compared with the Particle Swarm Optimization (PSO)-BRANN and BRANN approach. The results demonstrate the proposed ABC-BRANN approach is more accurate and robust. It provides an effective alternative for transient dispersion study in congested areas such as an offshore platform.

- **Keywords:** Transient dispersion; Bayesian Regularization Artificial Neural Network; Particle Swarm Optimization; Artificial Bee Colony; Time-series forecasting

Ken-Lin Chang, Tsai-Chieh Teng, Cheng-Kuei Fu, Chun-Hung Liu. *Improving biodegradation of Bisphenol A by immobilization and inducer*. Pages 128-134.

Loss in activity remains key challenges for the potential use of laccase in industrial and environmental biotechnology. Enzyme immobilization is an exciting alternative for improving the stability and reusability of enzymatic processes. In this study, the laccase enzyme was successfully immobilized onto SiO2 supports through covalent binding. The stability and durability during the reuse of immobilized laccase were superior to free laccase. After 30 reaction cycles of continuous use, the relative activity was above 80%. In addition, immobilized laccase was able to degrade Bisphenol A (BPA) more effectively than free laccase, especially in the presence of TX-100. The BPA was completely degraded within an incubation time of 5h. The results suggest that immobilization is feasible for improving the stability and reusability of laccase for many applications.

- **Keywords:** Laccase; Stability; Immobilization; Bisphenol A

Mohamed E. Zayed, Jun Zhao, Ammar H. Elsheikh, Yanping Du, Farid A. Hammad, Ling Ma, A.E. Kabeel, S. Sadek. *Performance augmentation of flat plate solar water collector using phase change materials and nanocomposite phase change materials: A review*. Pages 135-157.

Harvesting solar energy through usage of flat plate solar water collector (FPSWCs) has been widely used in different domestic, agricultural, and industrial applications. Phase change materials (PCMs), due to their unique thermo-physical properties, have been exploited in different designs of solar collectors to maximize the useful heat gained by collectors. Moreover, adding nanoparticles to PCMs to produce nanocomposite (NC) PCMs with superior thermo-physical properties added new advantages to the applications of these materials in solar collector applications. This literature review focuses on the different developments of these materials and their implementation with flat plate solar water collectors. Furthermore, the effect of adding different types of nanoparticles, including: metal, metal oxides, carbon nanoparticles, a high thermal conductivity skeleton graphite, and metal foams, on the heat transfer behavior and thermal conductivity of PCMs are also reviewed and analyzed. The reviewed results indicated that a significant improvement in the thermal conductivity of PCMs has been obtained using carbon-based nanoparticles, specifically graphite and graphene nano-platelets compared to metal and metal oxides nanoparticles at different nanoparticle concentrations. It is also revealed that, the integration of the PCMs in FPSWCs leads to a satisfactory storage capacity and could provide hot water temperature for a longer time. Moreover, it is recommended that the use of NCPCMs may be considered as an effective tool to improve the efficiency of the FPSWC. However, further optimization studies are needed to explore the impact of different factors such as nanoparticle type, nanoparticle weight fraction, nanoparticle size, and PCM type on the collector performance. A noteworthy observations, important proportionalities, and future trends are also discussed.

- **Keywords:** Flat plate collector; Thermal conductivity; Phase change materials; Nanocomposite phase change materials

Jie Cao, Linchao Dai, Haitao Sun, Bo Wang, Bo Zhao, Xuelin Yang, Xusheng Zhao, Ping Guo. *Experimental study of the impact of gas adsorption on coal and gas outburst dynamic effects*. Pages 158-166.

Coal and gas outburst is one of major dynamic disasters that have affected safety production in coal mines for many years, in which gas is an important factor that influence its intensity. To analyze the role of gas, especially the role of gas adsorption, in the dynamics of coal and gas outbursts, a self-developed experimental device for the measurement of the dynamic effects of coal and gas outburst was used to perform outburst experiments under different adsorption gas conditions. The device has a simulated roadway sub-system with a length of up to 50 m, which can collect and monitor the typical dynamic effect appearance characteristics such as the shock wave propagation and the pulverized coal distribution of the outburst. Based on the energy theory, we quantitatively discuss the effect of gas adsorption on the outburst. After the outburst occurred, the air in the roadway around the outburst port was disturbed by the shock wave, and the gas pressure rose and then fell within a very short period of time. The adsorption properties of the coal determined the intensity of coal and gas outbursts. The amount of outburst pulverized coal in the CO2 test condition was 3 times larger than that in the air test condition. Additionally, the particle size distribution of the coal samples did not change markedly during the test, indicating that the impact of the crushing effect on the pulverized coal was not significant during the outburst process under the action of gas only. The coal-gas transport energy was 3–5 orders of magnitude greater than the coal crushing energy and the remaining kinetic energy of the gas. It was verified that the role of gas in the outburst process principally related to throwing and carrying the broken coal in the roadway. The energy involved in the outburst process for the CO2 condition was approximately 5.8 times larger than the energy involved in the outburst process for the air condition, which was mainly due to the different adsorbed gas internal energies. The adsorption characteristic is one of key factors affecting the outburst energy and strength. These research results can provide guidance for perfecting coal and gas outburst mechanisms and developing outburst disaster early warning technologies.

- **Keywords:** Coal and gas outburst; Adsorbed gas; Physical test; Two-phase flow of coal and gas; Energy

M.J. Fernández-Rodríguez, D. de la Lama-Calvente, A. Jiménez-Rodríguez, R. Borja, B. Rincón-Llorente. *Influence of the cell wall of Chlamydomonas reinhardtii on anaerobic digestion yield and on its anaerobic co-digestion with a carbon-rich substrate*. Pages 167-175.

The aim of this study was to investigate the influence of the cell wall of the microalga Chlamydomonas reinhardtii (C. reinhardtii) on its anaerobic digestion (AD) by comparing the AD of C. reinhardtii 6145 and of its mutant without cell wall C. reinhardtii cw15, assessing simultaneously the influence of the cell wall on anaerobic co-digestion of these strains with a carbon-rich substrate, olive mill solid waste (OMSW). The OMSW is the main by-product from two-phase olive oil manufacturing process. Biochemical methane potential (BMP) tests of the sole substrates and different mixtures (OMSW-microalgae) (85%-15%, 75%-25%, 50%-50%) were carried out. The results showed that the cell wall was not hindrance and became an advantage by releasing intracellular biomass to be degraded slowly. The influence of the substrate composition in the mixtures of OMSW and Chlamydomonas reinhardtii (6145 and cw15) was assessed through the calculation of performance and kinetic parameters by using the Transference Function model. The mixture 50% OMSW-50% C. reinhardtii 6145 allowed the highest methane yield (542±4mL CH4/g VS) and also resulted in one of the highest maximum methane production rates, Rmax (129±3mL CH4/(g VS·d).

- **Keywords:** Microalgae; Cell wall; Olive mill solid waste; Anaerobic co-digestion; Kinetics

Qing Guo, Wanxing Ren, Jintuo Zhu, Jingtai Shi. *Study on the composition and structure of foamed gel for fire prevention and extinguishing in coal mines*. Pages 176-183.

The spontaneous combustion of coal in coal mine gob remains a serious threat to workers' safety, and the present work examined the use of foamed gel to prevent coal ignition. A foamed gel is a polymeric substance consisting of foam agent, gelling agent, cross-linker and water. Gelation time, foaming multiple and water loss are key factors to evaluate the fire suppression properties of these materials. The experiments in this study demonstrated that the optimum volume fractions of the foaming, gelling and cross-linking agents were 0.5%, 2%, and 1% respectively. The average gelation time of the foamed gel was 174s, the foaming multiple was 5.4, and the water loss of the foamed gel over 10min was 11%, which was significantly less than the value of 91% for pure foam. 3D-X ray experiments showed that foamed gel has similar structure as pure foam, and gel skeleton could maintain the intact of foamed gel, enhance the stability, and increase heat capacity. Compared to pure foam, the foamed gel examined in this study exhibits superior fire prevention performance.

- **Keywords:** Foamed gel; Coal ignition; Gelling

Ruipeng Tong, Mengzhao Cheng, Xiaoyi Yang, Yunyun Yang, Meng Shi. *Exposure levels and health damage assessment of dust in a coal mine of Shanxi Province, China*. Pages 184-192.

The concentrations, health risks and quantitative probabilistic health effects for dust at four workplaces from a coal mine in Shanxi were discussed. A total of 582 dust samples from 21 types of works in various workplaces were collected and analyzed, and their mean concentration ranged from 1.29 to 19.38 mg/m3. The probabilistic health damages assessment for coal miners caused by dust were conducted by Monte Carlo simulations and the United States Environmental Protection Agency (USEPA) inhalation risk model. The roadheader drivers and drillers in driving place suffered the greatest health risks with the average value of 5.60×10-6 and 5.55×10-6, respectively. The health risks in other workplaces are relatively lower and in the sequence of coal place, transshipment point, and shotcreting point. The health damages for coal miner at various workplaces followed a lognormal distribution, the disability-adjusted life year (DALY) ranked in the following sequence: driving face (1.76±0.14a) > coal face (1.63±0.06a) > transshipment point (1.24±0.11a) > shotcreting point (0.97±0.07a). Sensitivity analyses indicate that exposure duration (ED) have the greatest impact on the dust health damages, followed by exposure time (ET), inhalation rate (IR) and dust concentration (C). These results provide basic information for dust pollution control and health management in coal mines.

- **Keywords:** Coal mine; Dust; Health risk; Disability-adjusted life year; Monte Carlo method

Petr Trávníček, Luboš Kotek, Petr Junga, Tomáš Koutný, Jana Novotná, Tomáš Vítěz. *Prevention of accidents to storage tanks for liquid products used in agriculture*. Pages 193-202.

The storage of liquid substances like livestock slurry, liquid fertilizer, digested material and many others is an integral part of farms. The storage is realized in tanks with a volume of several cubic meters up to several thousand cubic meters. Various materials such as steel, reinforced concrete, plastics and combinations of these materials are used to construct such containers, less often wood or composite materials. Compared to the chemical industry, the stored substances are not toxic to the human body, and in the event of accidents, only minimal damage to human health is usually caused.

Hazardousness of stored substances consist of harmfulness to the environment, mainly due to the high concentration of these substances. In particular, water resources are threatened, both surface water and underground drinking water sources. In general, agriculture is often overlooked sectors. Despite that it is a crucial sector for human existence. As is the case with the safety of operation of technological equipment. In the field of chemical industry hundreds of publications have been written on this subject; in the field of agriculture, these publications are rather an exception. Employees working in the chemical industry are regularly trained to deal with emergencies, with employees in the agricultural sector this is an exception. It is clear from various reports that the accident is not avoided even in this sector. The authors collected a total of 241 records of accidents resulting in leakage of stored material from the tanks. Relative number of accidents causes by human error is 17%, organizational causes 20.7%, external causes 20.7%, and other causes 14.1%. Unknown causes were found in 27.4%. The data were statistically processed and selected emergency scenarios was described in more detail. The output of the work is recommendations for the safe operation of storage tanks.

- **Keywords:** Environment; Accident; Europe; Agriculture; Statistical analysis

Debapriya Sarkar, Kriti Gupta, Kasturi Poddar, Rimi Biswas, Angana Sarkar. *Direct conversion of fruit waste to ethanol using marine bacterial strain Citrobacter sp. E4*. Pages 203-210.

Ethanol tolerant strains were isolated from the marine waters of Digha and Shankarpur of West Bengal, India and screened for ethanol production using several domestic wastes including, paper, kitchen, garden, and fruit wastes. Strain E4 was found to be the most efficient in ethanol production through fermentation of kitchen and fruit waste. Phylogenetic analysis of the 16S rRNA gene of strain E4 showed its closeness to Citrobacter sp. Production of 2.96g/l of ethanol was obtained using fruit waste using High-Performance Liquid Chromatography (HPLC) analysis. The yield of ethanol production was obtained as 0.13g of ethanol/g of reducing sugar present in fruit waste. Although after optimization of fermentation condition, the yield was improved to 0.30 in batch scale. The production was optimized using Central Composite Design. The production was scaled up to 4l culture volume in the stirred tank bioreactor. Finally, a distillation of fermentation broth resulted in 16.10ml of product with a yield of 0.30g of ethanol from 1g of fruit waste. Thus the isolated marine strain Citrobacter sp. E4 could be potentially used for ethanol production from fruit wastes without any pretreatment in a cost-effective and eco-friendly way.

- **Keywords:** Waste; Ethanol; Fermentation; Marine bacteria; Optimization; Scale-up

Seyyedeh Cobra Azimi, Farhad Shirini, Alireza Pendashteh. *Evaluation of COD and turbidity removal from woodchips wastewater using biologically sequenced batch reactor*. Pages 211-227.

The wood industry consumes a lot of water. Due to the reduction of water resources in the world, the treatment of this contaminated water is very essential. In this study, the removal efficiencies of the chemical oxygen demand (COD) and turbidity from woodchips wastewater with the use of a sequencing batch reactor (SBR) were studied at a bench scale. Woodchips wastewater samples were collected with a COD of 1300 mg L−1 and a turbidity of 93 NTU. The optimization of the SBR process was investigated by response surface methodology (RSM) based on a central composite design (CCD). A quadratic polynomial model was fit to the data with R2 of 0.9919 for COD reduction, R2 of 0.9910 for turbidity removal, and R2 of 0.9945 for sludge volume Index (SVI), respectively. The effect of three parameters, including initial COD, mixed liquor suspended solids (MLSS), and Hydraulic retention time (HRT) on the COD reduction and turbidity removal were evaluated. The initial COD (A), MLSS (B), cycle time (C), AB, AC, BC, A2, B2, and C2

were considered as the affective parameters in the COD reduction. Initial COD (A), MLSS (B), A2, B2, C2, AC, and BC were observed as the remarkable model terms on the turbidity removal. Also, initial COD (A), MLSS (B), cycle time (C), B2, C2, and BC were the significant model factors in SVI index. At optimal conditions, involving an initial COD of 1000 mg L−1, an organic loading rate (OLR) of 0.450 kg COD/m3d, MLSS of 3000 mg L−1, and cycle time of 24 h, we observed 94.6% of COD reduction, 98.5% turbidity removal, and 79 mL g−1 SVI. The results also showed that the kinetic of COD reduction and turbidity removal could be represented by the pseudo-second-order model.

- **Keywords:** Woodchips wastewater; Chemical oxygen demand; Turbidity

R. Fazai, M. Mansouri, K. Abodayeh, H. Nounou, M. Nounou. *Online reduced kernel PLS combined with GLRT for fault detection in chemical systems*. Pages 228-243.

In this paper, an improved fault detection method is proposed based on kernel partial least squares (KPLS) model and generalized likelihood ratio test (GLRT) detection chart in order to enhance the monitoring abilities of nonlinear chemical processes. To deal with both high computational cost for large data set and time-varying dynamics of industrial processes, the proposed method is used to select a reduced set of kernel functions to build the KPLS model and applies it for online fault detection based on GLRT chart. Comparing with the conventional KPLS technique, the proposed method has the advantages of improving the computation efficiency by decreasing the dimension of kernel matrix. The developed online reduced KPLS-based GLRT (OR-GLRT) could improve the fault detection efficiency since it is able to track the time-varying characteristics of the processes. The fault detection performance of the developed OR-GLRT method is evaluated using a Tennessee Eastman process. The simulation results show that the proposed method outperforms the conventional GLRT technique.

- **Keywords:** Fault detection; Dynamic process; Chemical processes; Kernel PLS (KPLS); Generalized likelihood ratio test (GLRT); Online reduced GLRT (OR-GLRT)

Paweł Górnaś, Magdalena Rudzińska, Anna Grygier, Qian Ying, Inga Mišina, Elise Urvaka, Dainis Rungis. *Sustainable valorization of oak acorns as a potential source of oil rich in bioactive compounds*. Pages 244-250.

The acorns (fruits) of the oak species Quercus rubra L. and Quercus robur L., grown over the world mainly in forests and parks, are usually not collected or utilised, therefore represent a potentially cheap/free source of plant material with potential applications in the processing industry. In the present study, oil recovery and composition from acorns collected from Q. rubra (n=6) and Q. robur (n=7) individuals was evaluated. Oil yields from Q. robur and Q. rubra acorns ranged from 3.1 to 6.3% and 20.1–24.0%, respectively. In the oils of both species C18:1 (28.4–65.7%), C18:2 (24.1–48.0%) and C16:0 (7.5–17.9%) were the main fatty acids with some differences in proportions between species. On average, β-sitosterol constituted 64.3% and 68.1% of total sterol concentration, which amounted to 244.9 and 271.4mg/100g oil in Q. robur and Q. rubra, respectively. Q. rubra acorn oil was rich in β-tocopherol (93%), while Q. robur in γ-tocopherol (96%). A nearly six-fold higher level of total tocopherol content was recorded for Q. robur relative to Q. rubra. Principal component analysis of chemical composition data confirmed their ability to distinguish between Q. robur and Q. rubra samples. The unique and high concentration of lipophilic compounds in both species, and the availability (cheap/free) of acorns, make oak fruits an interesting source of plant material for industrial applications.

- **Keywords:** Oak acorns; Quercus robur L.; Quercus rubra L.; Fatty acids; Tocopherols; Phytosterols; PCA

A. Gil, J.A. Siles, M. Toledo, M.A. Martín. *Effect of microwave pretreatment on centrifuged and floated sewage sludge derived from wastewater treatment plants*. Pages 251-258.

As a result of the growing number of wastewater treatment plants (WWTP), increasing quantities of sewage sludge are being produced. Biological treatments are usually the most frequent method used to treat this type of waste. However, due its poor biodegradability, a previous treatment is required to enhance this sludge. In this study, the application of a microwave pretreatment was evaluated at different power ratings (400 and 700W) for a specific applied energy ranging from 0 to 30,000J/g TS. The pretreatment was applied to floated sludge and centrifuged sludge from a WWTP. The effect of the variables power and specific energy differed depending on the type of sludge. Organic matter solubilization was evaluated in both sludges based on the CODs/TVS ratio (soluble chemical oxygen demand/total volatile solids). The results showed a 43% and 66% increase in solubility for the floated sludge at 400 and 700W, respectively, and a 162% and 187% increase for the centrifuged sludge at 700 and 400W, respectively. The increase in organic and nitrogenous matter during pretreatment had a positive effect on the aerobic biodegradability of the floated sludge and biodegradation kinetics, as the specific oxygen uptake rate (SOUR) increased up to 8.5 times for a specific energy of 15,000J/g TS. Independently of the moisture content, the floated sludge showed the best results above 10,000J/g TS. No significant differences were observed between the applied powers in terms of organic matter solubilization.

- **Keywords:** Pretreatment; Microwave; Sewage sludge; Solubilization; Organic matter; Nutrients

Til Baalisampang, Rouzbeh Abbassi, Vikram Garaniya, Faisal Khan, Mohammad Dadashzadeh. *Modelling an integrated impact of fire, explosion and combustion products during transitional events caused by an accidental release of LNG*. Pages 259-272.

In a complex processing facility, there is likelihood of occurrence of cascading scenarios, i.e. hydrocarbon release, fire, explosion and dispersion of combustion products. The consequence of such scenarios, when combined, can be more severe than their individual impact. Hence, actual impact can be only represented by integration of above mentioned events. A novel methodology is proposed to model an evolving accident scenario during an incidental release of LNG in a complex processing facility. The methodology is applied to a case study considering transitional scenarios namely spill, pool formation and evaporation of LNG, dispersion of natural gas, and the consequent fire, explosion and dispersion of combustion products using Computational Fluid Dynamics (CFD). Probit functions are employed to analyze individual impacts and a ranking method is used to combine various impacts to identify risk during the transitional events. The results confirmed that in a large and complex facility, an LNG fire can transit to a vapor cloud explosion if the necessary conditions are met, i.e. the flammable range, ignition source with enough energy and congestion/confinement level. Therefore, the integrated consequences are more severe than those associated with the individual ones, and need to be properly assessed. This study would provide an insight for an effective analysis of potential consequences of an LNG spill in any LNG processing facility and it can be useful for the safety measured design of process facilities.

- **Keywords:** LNG spill; Accident transition; Integrated consequence; CFD

Rafael Amaya-Gómez, Mauricio Sánchez-Silva, Felipe Muñoz. *Integrity assessment of corroded pipelines using dynamic segmentation and clustering*. Pages 284-294.

Corrosion defects impact the resistance of hydrocarbon pipelines by increasing the risk of failure and the resulting Loss of Containment (LOC). Different approaches have been proposed to estimate this risk of failure based on empirical approaches (e.g., API 579-1/ASME FFS-1, ASME B318S or API1160), and other focus on probabilistic evaluations. Nevertheless, few works are dealing with spatial variability of corrosion defects and how segmentation (required for reliability evaluation) may affect intervention decisions. In this paper, information obtained from In-Line Inspections (ILI) is used to build a corrosion degradation model under a pressure-stress failure criterion, which is used in turn, to develop a dynamic segmentation strategy. This strategy aims at identifying optimal intervention times and Locations. Results show that existing reliability evaluations using static segmentations are suboptimal and may hide critical zones. This result is illustrated by a real case study in which corrosion evolution is better estimated, and the problems associated with conventional static segmentation are stressed.

- **Keywords:** Corrosion; Dynamic segmentation; Pipeline integrity; In-Line Inspections; Clustering

Xingwei Zhen, Jan Erik Vinnem, Sturle Næss. *Building safety in the offshore petroleum industry: Development of risk-based major hazard risk indicators at a national level*. Pages 295-306.

There has been an important controversy over whether the series of major accidents at Chinese Bohai Bay in 2011, i.e. the Penglai 19-3 and Suizhong 36-1 oil spills, are a sign of systematic safety problems in the Chinese offshore petroleum industry or a casual result of fortuities. It is hard to obtain the answer unless the national risk level of the offshore petroleum industry is monitored and measured. This paper describes an effort to propose and discuss an analytical approach for the development of major hazard risk indicators that can be used for monitoring, measuring and predicting national risk levels in the offshore petroleum industry. This study focuses on major hazards on offshore installations, hence personal safety hazards that affect individuals are not covered. Firstly, a risk-based approach for developing major hazard risk indicators on offshore installations is developed. Both leading and lagging major hazard risk indicators on offshore installations are suggested. After that, the proposed analytical approach is tested by the risk assessment results of the Norwegian Continental Shelf (NCS) in the latest ten years (2007–2017). This is followed by a discussion on suitability and challenges of the proposed risk-based approach. It has been demonstrated that the results of this study can provide a realistic and jointly agreed major hazard risk picture in the offshore petroleum industry.

- **Keywords:** Major hazard; Risk indicator; Offshore petroleum industry; Risk assessment; Barriers; Precursor events

Kyle Akio A. Tiangco, Mark Daniel G. de Luna, Anabella C. Vilando, Ming-Chun Lu. *Removal and recovery of calcium from aqueous solutions by fluidized-bed homogeneous crystallization.* Pages 307-315.

Water hardness removal is an important step in wastewater treatment as it can precipitate out on pipes and interfere with day-to-day chemicals such as soap and detergent. Fluidized-bed homogeneous crystallization (FBHC) process on water hardness removal is of significant interest as it can give removal rates that meet effluent standards while simultaneously produce a pure, reusable source of calcium. The highest % Calcium removal (% Caremoval) was 99.8% with 98.9% Crystallization Ratio (% CR) at 300mgL−1 influent [Ca2+] concentration, pH of 10.6, and molar ratio (MR) of 1.0 with effluent pH of 10.2±0.05. The addition of ions resulted to a finer crystal with an average diameter of 0.149, 0.297 and 0.297mm for [F-], [NO3-], and [SO42-] ions respectively. The presence of ions inhibits the formation of larger crystals. X-ray diffraction (XRD) peaks showed that the recovered crystals were comparable with the reference standard

characteristic peak of calcite. Scanning electron microscope (SEM) micrograph showed the agglutination of nuclei forming larger crystals with an average size of 0.5mm.

- **Keywords:** Box-behnken design (BBD); Calcium; Carbonate; Fluidized-bed homogeneous crystallization (FBHC); Nucleation; Crystallization

Pengfei Wang, Yijie Shi, Lianyang Zhang, Yongjun Li. *Effect of structural parameters on atomization characteristics and dust reduction performance of internal-mixing air-assisted atomizer nozzle*. Pages 316-328.

As a air-liquid two-phase flow nozzle, the internal-mixing air-assisted atomizer nozzle has been widely used in the field of spray technology for dust reduction. Structural parameters are important factors to influence the atomization characteristics and dust-reducing performance of the atomizing nozzle. However, the mechanism of the influences of the structural parameters is not clear. In this study, the customized experimental spraying platform for dust control was used to study the atomization characteristics and dust reduction performance of the nozzles under different structural parameters. Based on the experimental results, when the parameters such as water pressure and air pressure were constant, the dust reduction efficiency for both the total dust and the respiratory dust first increased then decreased with the increase of the diameter of the water-injection hole in the liquid cap and the number of air-injections holes. The dust reduction efficiency was optimal when the diameter of the water-injection hole in the liquid cap was 1.5mm and the number of air-injections holes was 4. As the diameter of the air cap outlet increased, the dust reduction efficiency for both the total dust and the respiratory dust was improved; however, the improvement was limited. Based on the comprehensive consideration of the factors including the dust reduction efficiency of the nozzle, the water flow rate, and the air flow rate, the diameter of the air cap outlet should be in the range of 2.0˜3.0mm. When an internal mixing air atomizing nozzle was used for dust reduction in industrial production sites, it is recommended have the diameter of the water-injection hole to be 1.5mm, the number of air-injection holes to be 4, and the diameter of the air cap outlet to be 2.0˜3.0mm. Under these recommended structural parameters, the dust reduction performance of the nozzle is good while the water consumption and air consumption remain relatively low.

- **Keywords:** Internal-mixing air-assisted atomizer nozzle; Structural parameters; Atomization characteristics; Dust reduction performance; Droplets; Dust

Peng Zhang, Shaobo Liu, Xiaofei Tan, Yunguo Liu, Guangming Zeng, Zhihong Yin, Shujing Ye, Zhiwei Zeng. *Microwave-assisted chemical modification method for surface regulation of biochar and its application for estrogen removal*. Pages 329-341.

Estrogenic hormones have become an emerging and serious concern in the recent years, owing to their adverse effects on ecosystems and human health. It is necessary to explore green, effective and sustainable technologies to remove these contaminants. Biochar derived from biomass residue has been recognized as an effective adsorbent for removing pollutants from aqueous solutions. Objective of this study was to investigate the influence of microwave-assisted chemical modification method on the property of biochar and evaluate its application for 17β-estradiol (E2) removal. Biochar derived from rice husk biomass waste were modified by acid (sulfuric acid and phosphoric acid), alkali (sodium hydroxide and sodium bicarbonate) and oxidizing agent (hydrogen peroxide), respectively. Various characterization techniques and adsorption experiments were carried out to investigate the property and the adsorption performance of biochar. The results showed that alkali modified biochar have higher adsorption capacity for E2 than other modified biochar. And the maximum adsorption capacity was 44.9mg/g obtained

from the Langmuir model at 298K, which can be attributed to its higher surface area and superior hydrophobic property. This study not only provides useful information for E2 removal from aquatic environment, but also gives insight into the reuse of biomass waste.

- **Keywords:** Biochar; Rice husk biomass; Estrogens; Modification; Adsorption

Girish Gupta, Sushil K. Kansal. *Novel 3-D flower like Bi3O4Cl/BiOCl p-n heterojunction nanocomposite for the degradation of levofloxacin drug in aqueous phase*. Pages 342-352.

The present work represents synthesis of a novel Bi3O4Cl/BiOCl heterostructure using precipitation method and detailed characterization of the composite using FT-IR, XRD, FESEM, TEM, BET and EDX techniques. The photocatalytic activity of as-prepared Bi3O4Cl/BiOCl heterostructure was evaluated under visible light and the degradation of levofloxacin drug was studied for a reaction time of 180min. Under the optimized conditions of catalyst dose 1g/L, 11pH, and drug concentration of 10mg/L, the prepared heterostructure showed high activity i.e. 87% reduction of the drug as compared to bare BiOCl (32%) and BiOBr (57%) catalysts. This enhancement in photocatalytic activity was due to the effective separation of charge carriers at the heterojunction interface. Additionally, the antibacterial activity of the prepared Bi3O4Cl/BiOCl catalyst was evaluated for levofloxacin against Escherichia coli (Gram-negative bacteria) showing zero inhibition. Mineralization studies using TOC analysis was also performed showing 55% mineralization of the drug under optimized conditions. These finding suggest that Bi3O4Cl/BiOCl composite catalyst was found to be a promising heterogeneous catalyst for drug degradation studies.

- **Keywords:** Nanocomposite; Bismuth oxychloride; Precipitation method; Photocatalysis; Levofloxacin; Mechanism

Xiaoxi Gong, Weijun Tian, Liang Wang, Jie Bai, Kaili Qiao, Jing Zhao. *Biological regeneration of brewery spent diatomite and its reuse in basic dye and chromium (III) ions removal*. Pages 353-361.

Laboratory bioregeneration tests for brewery spent diatomite with the ammonifying bacteria Lysinibacillus fusiformis were conducted. After a 14-day incubation, 51% of the proteins accumulated in spent diatomite were degraded. Scanning electron microscopy (SEM), Fourier transform infrared spectrometry (FTIR) and Brunauer–Emmett–Teller (BET) analysis showed that the surface performance and pore structure of spent diatomite after bioregeneration were improved markedly. Adsorption experiments for methylene blue (MB) and Cr(III) of diatomite regenerated via the biological method showed that the removal degrees of MB and Cr(III) reached 95.5% and 71.7%, respectively, which were significantly higher than those obtained with the thermal regeneration method. These results illustrated that the biological method was better able to improve the adsorption ability of spent diatomite. Investigations on adsorption mechanisms confirmed that physical adsorption related to the porous structure of diatomite influenced both MB and Cr(III) adsorption. In addition, the hydroxyl group on the diatomite surface were critical for MB adsorption, and chemical adsorption associated with the ion exchange process might be an important sorption mechanism of Cr(III).

- **Keywords:** Brewery spent diatomite; Biological regeneration; Adsorption; Methylene blue; Cr(III)

Bo Zhang, Chengjun Liu, Zhuangzhuang Liu, Zhanqi Li, Maofa Jiang. *Remediation of the vanadium slag processing residue and recovery of the valuable elements*. Pages 362-371.

The vanadium slag processing residue (VSPR), which is a metallurgical waste produced during the vanadium extraction process from the vanadium titano-magnetite, exhibits potential environmental risk due to the toxicity of chromium in this residue. To remediate the VSPR and recover the valuable elements including iron, chromium, vanadium and titanium, a novel process, i.e., "carbothermic reduction"-"magnetic separation"-"sulfuric acid leaching"-"solvent extraction", is proposed in this work. The transfer of iron, chromium, vanadium and titanium in the novel process was theoretically and experimentally analyzed. The results demonstrate that the iron oxide can be selectively reduced via the carbothermic reduction. To minimize the loss of chromium, vanadium, and titanium in the magnetic separation, the reduction temperature is suggested to be below 1100°C to inhibit the reduction of the chromium, vanadium, and titanium oxides in the spinel of (Fe,Mn)x(V,Cr,Ti)3-xO4. Iron was concentrated in the magnetic phase while chromium, vanadium and titanium were concentrated in the non-magnetic phase after carbothermic reduction and magnetic separation. With perchloric acid as oxidizer, the spinel of (Fe,Mn)x(V,Cr,Ti)3-xO4 in the non-magnetic phase was decomposed through sulfuric acid leaching at 160°C without the generation of hexavalent chromium, and the metal elements were effectively leached. The toxicity test shows that the leaching residue is harmless. Finally, iron, titanium, vanadium, chromium could be preliminarily separated via the solvent extraction by employing D2EHPA as the extraction agent.

- **Keywords:** Vanadium slag; Chromium; Remediation; Carbothermic reduction; Sulfuric acid leaching

Aya Tolba, Mohamed Gar Alalm, Mohamed Elsamadony, Alsayed Mostafa, Hafez Afify, Dionysios D. *Dionysiou. Modeling and optimization of heterogeneous Fenton-like and photo-Fenton processes using reusable Fe3O4-MWCNTs*. Pages 273-283.

In this work, iron (II, III) oxide (Fe3O4) was synthesized and incorporated onto multi-walled carbon nanotubes (MWCNTs) to prepare Fe3O4-MWCNTs composite in a quest for evaluating its performance and reusability in both Fenton-like and photo-Fenton processes. The characterization of Fe3O4-MWCNTs by X-ray diffraction (XRD), transmission electron microscopy (TEM), Fourier-transform infrared (FTIR) spectroscopy, and energy dispersive X-ray (EDX) spectroscopy showed that the prepared catalyst can behave as a composite. Methylene blue (MB) was used as a substrate for evaluation of Fenton-like and photo-Fenton processes. The reusability of the catalyst and the influence of operation parameters such as pH, H2O2 dosage, and catalyst loading were investigated. Complete degradation of MB was attained by Fe3O4-MWCNTs in the aforementioned processes, whereas the removal efficiency of MB by using bare MWCNTs under the same conditions was 52%, which suggests that the generated oxidant species due to the reactions between H2O2 and leached iron contribute to the degradation of MB. A degradation pathway was proposed based on the oxidation intermediates that have been detected by mass spectrometry. The reusability of Fe3O4-MWCNTs has been examined in four consecutive cycles. The final removal of MB in the fourth cycle was 94%. The optimization of MB removal was investigated by response surface methodology (RSM) based on central composite design (CCD). Moreover, an artificial neural network (ANN) of type feed-forward back propagation was employed to model the influence of operating conditions. The ANN model revealed a high correlation in the prediction of the removal efficiency (R2=0.9934).

- **Keywords:** AOPs; Dyes; Fenton; Methylene blue; MWCNTs; Wastewater

J.M. Bonilla, A. Àgueda, M.A. Muñoz, J.A. Vílchez, E. Planas. *Thermal radiation model for dynamic fireballs with shadowing*. Pages 372-384.

This paper presents a new methodology for determining the thermal radiation of dynamic fireballs considering the presence of obstructions (i.e. safety barrier, topographic

elevation). The specific type of obstruction considered is a flat wall. The key feature of the methodology is that, due to the presence of a barrier, the dynamic fireball evolves through different stages of relative visibility (i.e. null, partial or complete) during its transitional regime. A set of equations defining the boundaries of each region has been developed, which are required to calculate the configuration factor for each transient position of the fireball. According to the relative visibility, analytical or numerical methods must be used to determine the configuration factor between the fireball and the receiver. This methodology aims to achieve a more realistic modeling of the fireball elevation mechanism, enabling safety engineers to better estimate the fraction of thermal radiation received in common scenarios in the process industry and to improve the design of safety barriers to minimise the impact of radiation on vulnerable elements or critical infrastructures. The study is of particular interest for land use planning and plant location.

- **Keywords:** Configuration factor; Sphere; Safety barrier; Shadow effect