Process Safety and Environmental Protection

rok 2008, ročník 86

Číslo 5 (September 2008)

Krzysztof Warmuzinski. *Harnessing methane emissions from coal mining*. Pages 315-320.

Abstract: Methane emissions associated with coal-mine ventilation pose a tremendous environmental problem and lead to inadvertent loss of a valuable energy source. The proportion of methane released through underground ventilation is as high as 70% of all the coal-related emissions. Additionally, the CH_4 Global Warming Potential is 21 (for a timescale of 100 years), compared with 1 for carbon dioxide. If the heat of combustion of the methane could be usefully employed, this would bring a twofold benefit of avoiding both CH_4 release and CO_2 emission from the production and use of the fuel thereby displaced. The projects carried out in the Institute of Chemical Engineering, Polish Academy of Sciences explored three major routes for utilizing ventilation air methane (VAM): (1) using VAM as combustion air in conventional boilers, (2) oxidizing VAM in reverse-flow reactors (either catalytic or non-catalytic) to produce heat, (3) enriching VAM (via pressure-swing adsorption or membrane separation) to concentration levels suitable for subsequent use (in, say, reverse-flow reactors). The investigations have now been focused upon homogeneous combustion of VAM in reverse-flow reactors.

- **Keywords:** Ventilation air methane; Combustion air; Reverse-flow reactors; Pressure-swing adsorption; Membrane separation

Gernot Gwehenberger, Michael Narodoslawsky. *Sustainable processes : the challenge of the 21st century for chemical engineering*. Pages 321-327.

Abstract: The 21st century inherits stark challenges for human society: environmental degradation, global warming and shrinking fossil resources. All these problems are paired with a dramatic growth of the economy in China and India, home to 2.3 billion people. We need to make more from less and we need to do this while reducing our impact on nature by the order of magnitudes. This challenge is particularly tough for chemical engineering. This sector is on the one hand responsible for providing most of the products of daily consumption, the base for modern agriculture as well as energy carriers for power generation, transport, heating and cooling. On the other hand chemical engineering has a considerable impact on the environment, via its resource consumption,

its emissions and the impact of its products. Chemical engineering will have to explore new ways in order to stay ahead of these challenges. The paper discusses some of the aspects of the changes that process engineering will face in the 21st century as it will widen its raw material base to include more renewable resources and simultaneously reduce its environmental impact. As a result, the structure of process industry will be transformed dramatically. Existing design principles and methods will also be challenged and adapted to the new challenges of sustainable development. Given the strong impact that the challenge of sustainable development will pose to process technology engineering education will have to change accordingly. For the first time in decades, process engineers will again be faced with developing new processes rather than process optimization. They will need to understand how to integrate processes into the ecosphere, how to set up raw material logistics and will have to deal with stake holders outside industry. The process concept will become more encompassing and include the life cycle of products. All these new skills must be taught to students today to make them fit for their carrier in the 21st century.

- **Keywords:** Sustainable processes; Renewable resources; Process synthesis; Process evaluation

Ana Carvalho, Rafiqul Gani, Henrique Matos. *Design of sustainable chemical processes : systematic retrofit analysis generation and evaluation of alternatives*. Pages 328-346.

Abstract: The objective of this paper is to present a generic and systematic methodology for identifying the feasible retrofit design alternatives of any chemical process. The methodology determines a set of mass and energy indicators from steady-state process data, establishes the operational and design targets, and through a sensitivity-based analysis, identifies the design alternatives that can match a set of design targets. The significance of this indicator-based method is that it is able to identify alternatives, where one or more performance criteria (factors) move in the same direction thereby eliminating the need to identify trade-off-based solutions. These indicators are also able to reduce (where feasible) a set of safety indicators. An indicator sensitivity analysis algorithm has been added to the methodology to define design targets and to generate sustainable process alternatives. A computer-aided tool has been developed to facilitate the calculations needed for the application of the methodology. The application of the indicator-based methodology and the developed software are highlighted through a process flowsheet for the production of vinyl chlorine monomer (VCM).

- **Keywords:** Process design; Sustainability metrics; Mass and energy indicators; Safety index;Indicator sensitivity algorithm

Prachi Singh, Geert F. Versteeg. *Structure and activity relationships for CO_2 regeneration from aqueous amine-based absorbents*. Pages 347-359.

Abstract: A study to determine the relationships between structure and activity of various amine-based CO_2 solvents was performed. The desorption of CO_2 from saturated solvents at 80 °C and atmospheric pressure was measured to assess the initial desorption rate and desorption capacities at pseudo-equilibrium. Evaluation of the desorption capacity at lower temperature, 80 °C, will give a better understanding for more energy efficient and lower circulation rate absorbent for CO_2 absorption process. Results showed that an increase in chain length between the amine and different functional groups in the solvent structure up to four carbon, results in an increase in initial desorption rate and also an increase in the desorption capacity at pseudo-equilibrium was observed for most solvents. Steric hindrance effect was noticed when a side chain with an alkyl group was present at α-carbon position to amine group in the

structure. Increase in the number of the amine group in solvent structure, results in higher desorption capacity up to 75% of CO_2 is desorbed. Aromatic amines substituted with an amine group by a side chain at the cyclic ring shows an increase in desorption capacity at pseudo-equilibrium compare to other group substitution.

- **Keywords:** Desorption; CO_2; Amine; Acid gases; Regeneration; Absorbent

M.A. Papalexandrou, P.A. Pilavachi, A.I. Chatzimouratidis. *Evaluation of liquid bio-fuels using the Analytic Hierarchy Process*. Pages 360-374.

Abstract: Biomass-derived liquid bio-fuels are being promoted as a major feasible fuel alternative in the European Union, in order to reduce Europe's transport dependency on crude oil. In particular, liquid bio-fuels if used in internal combustion engines can substitute a considerable amount of conventional fuels. These bio-fuels include conventional bio-ethanol and bio-diesel, which are derived from agricultural crops as well as second-generation bio-ethanol and synthetic diesel derived from lignocellulosic biomass. There are numerous pathways dealing with the production and use of liquid bio-fuels, depending on biomass feedstock, production technology, by-product usage and final bio-fuel consumption in vehicle power trains. In order to examine this complete chain of bio-fuel production and use, an evaluation study was carried out. This study used data from the *Well to Wheels* analysis *of future automotive fuels and power trains in the European context* (WTW report). Bio-fuels are assessed using the Analytic Hierarchy Process, which comprises of a synthesis of evaluation criteria and a sensitivity analysis. The criteria that were analyzed throughout the complete bio-fuel chain are bio-fuel substitution cost over conventional fuels, potential of substitution, total cycle GHG emissions and total cycle energy consumed.

- **Keywords:** Liquid bio-fuel evaluation; Well to Wheels pathways; Analytic Hierarchy Process

A.P. Reyes-Córdoba, P.N. Sharratt, J.A. Arizmendi-Sánchez. *Contribution of knowledge management for the implementation of waste minimisation measures into process industries*. Pages 375-388.

Abstract: Successful and widespread implementation of existing methodologies for waste minimisation has failed to provide significant benefits for industrial applications. One of the main reasons for this is the lack of a comprehensive approach that integrates and guides the application of the proper tool depending on the case. Existing methodologies have been developed for particular stages in the process of life cycle and they require a different information which may not be available and could result too costly to obtain. The aim of this work is to present the theoretical framework of a tool that integrates these methodologies and provides criteria to select the appropriate structure for the case at hand. The proposed tool is an ontology-based approach for the structured organisation of information aiming to identify waste minimisation opportunities.

- **Keywords:** Waste minimisation; Information; Knowledge; Ontology

Li-Bing Chu, Xin-Hui Xing, An-Feng Yu, Xu-Lin Sun, Benjamin Jurcik. *Enhanced treatment of practical textile wastewater by microbubble ozonation*. Pages 389-393.

Abstract: In this paper, microbubble technology was employed to increase the mass transfer rate of ozone and enhance the ozone oxidation of practical textile wastewater. Experiments were performed using a microbubble generator and a bubble contactor, which is commonly used in ozonation system, for comparison. The microbubble generator

produced a milky and high intensity microbubble solution, which could reach a higher oxygen transfer rate at a lower input gas flow rate. A volumetric oxygen transfer rate (VOTR) of 0.086–0.413 kg/m^3 h and a total mass transfer coefficient of 0.1072–0.4859 min^{-1} were obtained at airflow rates of 0.02–1.5 dm^3/min. During the ozonation of practical textile wastewater by using the microbubble system, the input ozone could be almost completely utilized, and the rate of decolorization and organic reduction were much faster than those of the bubble contactor. For the practical textile wastewater tested, the time required for 80% removal of color was about 140 and 280 min by ozone microbubble and conventional bubbles, respectively. The chemical oxygen demand (COD) removal efficiency in the microbubble system was higher by 20%. The results revealed that in addition to the enhancement of the mass transfer of ozone, microbubbles could improve the oxidation of actual textile wastewater.

- **Keywords:** Ozonation; Microbubble; Mass transfer; Practical textile wastewater