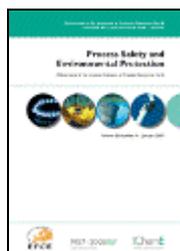


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Isaac Kweku Adu, Hirokazu Sugiyama, Ulrich Fischer and Konrad Hungerbühler. *Comparison of methods for assessing environmental, health and safety (EHS) hazards in early phases of chemical process design. Pages 77-93.*

This paper compares, qualitatively and quantitatively, some simple environmental, health and safety (EHS) assessment methods that are used in the early phases of chemical process design. The qualitative work summarises the methods into a set of categories, the parameters needed within each category and how each method uses the different parameters to calculate the assessment score. The quantitative part involves the comparison of the methods based on the original process mass calculations, applied to six alternative routes of methyl methacrylate (MMA) production. The results demonstrate that generally, the higher the number of reaction steps, the higher the probability of the process being more hazardous. The more toxic substances a process has, the higher its environmental impact. The use of the reaction mass in the original form defined in each method significantly affected the evaluation results. The use of a unit mass instead gave the same rank pattern of the routes to all the health and safety methods. These unit-mass-based results were further analysed into the level of categories, e.g. fire/explosion, within each EHS aspect, where methods use either different parameters and/or different mathematical formulations or the same parameters and formulations. Surprisingly, in many cases even the results for methods with different parameters and/or formulations agreed rather well. In summary, there is no unique merit of one method over the other in any of the environmental, health and safety aspects. The appropriate simplicity of a method according to early design phase where it can be applied is the only merit that separates the methods.

- **Keywords:** Environment; Health; Safety; Hazard assessment; Early design phase; Methyl methacrylate (MMA)

Jaime Sales, Fesil Mushtaq, Michalis Christou and Rosa Nomen. *Application of the HarsMeth methodology as a tool for analysing the chemical accidents reported to the MARS database. Pages 95-102.*

This paper presents a comparative analysis between the causes that lead to accidents in the chemical industries, and the issues covered by the hazard assessment methodology HarsMeth. The objective of the report is to identify possible synergies between lessons learned from accident analyses and the requirements that an efficient hazard assessment tool must meet to be reliable.

The analysis has been performed on a selection of accidents involving chemical reactivity that have been reported to the MARS database. The main causes have been identified and linked to the different topics included in HarsMeth, referring to specific management or technical issues, in an attempt to identify what areas of a chemical process are more critical as potential causes of accidents.

- **Keywords:** Accident analysis; Chemical reactivity; Hazard assessment methodologies; Lessons learned

R.M. Darbra, M. Demichela and S. Murè. *Preliminary risk assessment of ecotoxic substances accidental releases in major risk installations through fuzzy logic. Pages 103-111.*

In the present work a fuzzy logic model to preliminary assess the risk of accidental releases of ecotoxic substances in hazard plants has been developed. The methodology is based in three steps, the characterization of the hazardousness of the substance, the delimitation of the soil and groundwater vulnerability and the identification of the protective and preventive measures of the plant. The tool has been tested with a set of storage yards of ecotoxic substances, mainly oil, in the Regione Piemonte area (Italy). The results obtained are in good agreement with the real situation of the surveyed storage yards. Thus, by using this methodology it is possible to preliminary assess the risk from uncertain data.

- **Keywords:** Preliminary risk assessment; Fuzzy logic; Ecotoxic substances

Chan T. Leong and Azmi Mohd Shariff. *Inherent safety index module (ISIM) to assess inherent safety level during preliminary design stage. Pages 113-119.*

One of the acceptable methods to quantify the level of inherent safety is based on the inherent safety index. This paper reviews presently available techniques for quantification of inherent safety level in a design and addresses the shortcoming of current techniques by proposing direct integration of process design simulator with inherent safety index. This integrated index is known as inherent safety index module (ISIM) and it is one of the modules developed in a newly proposed framework to determine inherent safety level in the preliminary design stage. This framework is an enhancement of the framework developed earlier by Mohd Shariff et al. [Mohd Shariff, A., Rusli, R., Chan, T.L., Radhakrishnan, V.R. and Buang, A., 2006, Inherent safety tool for explosion consequences study, J Loss Prev Process Ind, 19: 409–418]. This new framework allows process information from process design simulator to be extracted and analyzed for the determination of inherent safety level (ISL), consequences and probability of unwanted incidences. The availability of such information at earlier stage of design will help process designers to obtain ISL that will assist them in producing safer designs by the application of inherent safety principles in a more efficient and cost effective manner. This paper also discusses the overall concept of the proposed framework to produce an inherent safety tool. A case study is provided to illustrate the benefit of having inherent safety index known to process designers during preliminary design stage. With the right information, modification to process conditions can be carried out and this is likely to produce a safer process plant.

- **Keywords:** Inherent safety; Risk; Consequences; Safety index; Preliminary design

Enrique González Ferradás, Fernando Díaz Alonso, Marta Doval Miñarro, Agustín Miñana Aznar, José Ruiz Gimeno and Juan Francisco Sánchez Pérez. *Consequence analysis by means of characteristic curves to determine the damage to humans from bursting spherical vessels. Pages 121-129.*

This paper aims at presenting a methodology to perform consequence analysis produced by pressure waves from spherical vessel burst. To carry out this operation characteristic curves are used. These characteristic curves for spherical vessel burst were presented in a previous paper [González Ferradás, E., Diaz Alonso, F., Sanchez Perez, J.F., Miñana Aznar, A., Ruiz Gimeno, J. and Martinez Alonso, J., 2006. Characteristic overpressure–impulse–distance curves for vessel burst, *Process Safety Progress*, 25(3): 250–254]. They allow the overpressure and impulse to be determined at each distance from the vessel. When combined with damage criteria (such as those shown by the PROBIT equations), the characteristic curves allow consequence analysis for this kind of explosions to be carried out, as the damage is shown in the same diagram as the overpressure, impulse and distance. In this paper the main PROBIT equations to evaluate damage to humans from pressure waves (which include eardrum rupture, death due to skull fracture, death due to whole body impact and lung damage) are evaluated and the most suitable PROBIT equations are selected. Diagrams are presented and equations are also developed for using this methodology in a computer program or spread sheet calculations.

- **Keywords:** Vessel burst; Tank rupture; Sphere explosion; Consequence analysis; Damage

Frédéric Paviet, Olivier Bals and Gérard Antonini. *The effects of diffusional resistance on wood char gasification. Pages 131-140.*

The steam gasification kinetics of wood char is studied. First, the kinetic expression of wood char gasification is derived (kinetically controlled). The modelling, uses the random pore model, has been experimentally validated. The char gasification study is performed in a tubular kiln, at various temperatures (850 °C, 900 °C, 950 °C and 1000 °C) and vapour pressures (0.2 bar, 0.5 bar and 0.7 bar). The steam gasification kinetics parameters (activation energy...), together with the physical properties of the char (porosity, specific surface...) are experimentally determined. By performing experiments with different particle sizes, steam flow rates and initial sample weights, the experimental conditions which permit the minimization of the steam penetration limitation, are found. Secondly, a 1D isothermal and non-equimolar reaction-diffusion model is developed in order to assess the diffusional effects taking place during steam gasification in a fixed bed. The model takes into account local chemical reaction rate and effective transport properties dependant on time and position within the char bed. Inter particle diffusion and structural changes of the char bed during the gasification are taken into account. The model shows a good agreement with the experimental results, obtained at various bed heights, and point out the relevant role played by diffusional effects within a fixed bed reactor. Finally, the kinetic results are used to estimate, in a down draft gasifier, the total carbon yield conversion as a function of both the mass fraction of stagnant zones within the bed char and of the characteristic length of these stagnant zones.

- **Keywords:** Steam gasification; Wood char; Kinetics; Diffusion

Muddassir Nazir, Faisal Khan, Paul Amyotte and Rehan Sadiq. *Multimedia fate of oil spills in a marine environment : an integrated modelling approach.* Pages 141-148.

A fugacity-based methodology is presented to predict the fate of spilled oil in the marine environment. In the proposed methodology, oil weathering processes are coupled with a level IV (dynamic) fugacity-based model. A two-compartment system, comprised of water and sediment, is used to explore the fate of oil in a marine environment. During a spill, oil is entrained into the water column due to natural dispersion, which is considered as the primary input source to the water compartment. The direct input to the sediment compartment is assumed negligible. However, the water column acts as a source to the sediment compartment. Unlike the conventional multimedia modelling approach, the impact area is not predefined. Instead, the oil slick spreading process determines the contaminated area growth. Naphthalene is used as a representative oil compound (an indicator) to demonstrate the application of the methodology. The current study suggests that the water compartment response to the chemical input is faster than the sediment compartment. The major fate processes identified are advection in water and volume growth in the sediment.

- **Keywords:** Oil spill modelling; Oil weathering; Dynamic multimedia model; Fugacity-based model