Safety through the prism of Industry 4.0: Augmentation of past approaches

Spyridon Damilos, Stratos Saliakas, Adamantia Kostapanou, Panagiotis Kolozis, Vanessa Lislevand, and Elias P. Koumoulos*

Innovation in Research & Engineering Solutions (IRES), 1000 Brussels, Belgium

E-mail contact: *epk@innovation-res.eu*

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Abstract:

Risk assessment comprises the hazard identification, assessment of related risks and evaluation of current and recommended control systems, to ensure people's safety in the workplace and minimise any harmful effects on human health. There are several process hazard analysis (PHA) methods depending on process development status (i.e., conceptual stage, under development, operational unit or system), the criteria and scope of the assessment (e.g., human safety-oriented assessment, analysis of process failures, etc.), as well as the scoring systems and the different parameters and factors, such as likelihood of failure, detectability, effectiveness or controls or any other risk control measure[1].

Process hazard analysis techniques such as failure mode and effect analysis (FMEA) summarise the identified failure modes, the likelihood of events, consequences resulting in physical and human health hazards and exposure to airborne pollutants, and controls providing a risk priority number (RPN) to prioritise mitigating action. At the same time, new systems and technologies of Industry 4.0 are gaining increasing attention as risk and safety management tools[2]. The use of artificial intelligence (AI) and machine learning (ML) tools, and cloud computing offer real-time monitoring and analysis of preventing actions, as they are able to exploit non-linear correlations between the targeted stressors and other environmental or process parameters. Industry 4.0 offers a novel approach by conjugating the use of AI/ML analytics for risk assessment of innovative processes and the production of advanced materials. Especially within the framework of advanced materials, such as high-entropy alloys (HEA) which are gaining increasing attention due to their significant mechanical, thermal, and physical properties, the manufacturing protocols are not standardised or established or are currently on a low TRL level.

Therefore, the study explores the steps for the development of augmented PHA methodologies where the previous risk assessments of various processes can be used as training instances for the AI/ML models. The resulting algorithms can subsequently support the selection of additional controls and designing the manufacturing process at early or conceptual stages taking into account the safety dimensions mitigating the associated risks. This methodology can benefit both the safety practitioners and the manufacturers, providing a cost-effective and in-depth analysis of potential risks and use of appropriate hazard controls ensuring a safe-by-design approach.

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