Using System Dynamics In Integration With Pha Methodology For Process Hazards Analysis In Production Systems

By

Ahmed Abdelwahed Khamis

A thesis submitted in partial fulfillment
Of
The requirements for his degree of

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In

INDUSTRIAL ENGINEERING
(PRODUCTION ENGINEERING)

Department of Industrial Engineering
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ABSTRACT

System safety is a key element for the continuity and sustainability of the performance of systems. System safety ensures that processes are free from hazards that lead to the failure of tools and equipment and threaten the safety and health of workers. System safety is a methodology used to analyze potential failure in administrative and technical systems, which controls potential hazards and prevents accidents. The application of system safety methodologies is based on the use of traditional methods of hazards analysis, which include what-if analysis, hazards, and operability study (HAZOP), failure modes and effect analysis (FMEA), and fault tree analysis (FTA), and bowtie analysis (BTA). The widespread use of these traditional methods has emerged in various applications such as industry, health, and oil and gas. However, many shortcomings have emerged as a result of the inability of these methodologies to analyze hazards in complex systems as well as their inability to study hazards arising from interactions between systems components. Also, traditional hazard analysis methods lack the capability to make quantitative analysis to help the decision-makers and safety practitioners to make informed decisions. Recently, there is limited use of modern methods in hazards analysis such as system theoretic process analysis (STPA), and system dynamics (SD) to overcome the shortcomings of traditional methods. Also, there is no clear framework explaining how to apply these modern methodologies in hazard analysis. The application of these modern approaches showed a significant improvement in the detection of hazards in complex systems, which result from the interactions between the components of the systems and their interactions, which may create new, more severe, and undetectable hazards using traditional methods.

This study presented a new hazard analysis methodology based on the integration of traditional hazard analysis methods and modern hazard analysis methodologies using system dynamics. The proposed methodology depends on using the traditional hazards analysis method (Bowtie analysis). in addition to using The Systems-Theoretic Process Analysis (STPA) to discover and analyze the system loss scenarios. the discovered loss scenarios will be simulated using system dynamics simulations. This study focuses on the implementation of modern hazard analysis methodology which enhancing using of STPA and system dynamics for hazard analysis in complex systems. Also, this thesis aims to study the effectiveness of using traditional hazards analysis in analyzing complex system hazards. The implementation of the proposed methodology showed that it is possible to identify, analyze and simulate accidents that may be caused by hazards related to complex operations, and to suggest an appropriate control measure to mitigate these hazards to prevent accidents. The application of the proposed methodology showed effectiveness in integrating the use of traditional methods and improved methods in hazard analysis, where traditional methods are used in the general understanding of system hazards without addressing the hazards resulting from interactions between system components. In addition, the use of STPA methodology has been used to discover the hazards resulting from interactions between the components of the system, which could not be detected using traditional methods. In addition, simulating these hazardous situations using system dynamics contributed to clarifying the response of system elements during emergencies and the impact of the interactions detected using STPA on increasing the hazards of the operations. This thesis contributes to providing a framework for safety practitioners to implement the dynamic hazards analysis method in process hazard analysis in complex systems. In addition, this thesis greatly contributes to increasing the use of STPA and system dynamics simulation in the analysis of

complex systems hazards, which will provide a robust approach to control system hazards that enhance the provision of system safety.