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Integration of interlock system analysis with automated HAZOP analysis

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Abstract

The paper details the integration of a method for the analysis of interlock systems with a software support system for HAZOP analysis.

The proposed software aims to enhance the potential of HAZOP in terms of depth and efficiency of the analysis. This enhancement is reached through the continuation of the hazard and operability analysis, limited to a group of events which may hold high risks for the plant and/or surrounding environment.

The analysis technique of the emergency interlock systems and other plant protection measures proposed by the Center for Chemical Process Safety (CCPS) of the American Institution of Chemical Engineers (AIChE) has been assumed as a starting point.

The system carries out interactively HAZOP analysis of a plant and identifies the presence of possible interlock actions through the analysis of the plant P & I diagram and then visualises the individual interlock systems starting the design phase in which it is possible to analyse and change interactively the single interlocks systems, in order to obtain the required reliability.

Keywords: HAZOP; Interlock systems; Support system

1. Introduction

The HAZOP analysis [1] examines the most significant deviations of the main variables of the pieces of equipment, which make up a chemical plant, and provides the necessary information for directing other subsequent risk analysis techniques.

During the last years, research has been conducted into the ways of using computer systems to facilitate, where possible, the work of the analysts and at the same time prevent errors when applying the technique itself [2–7]. Our previous work [8,9] has also addressed the issue of automating the HAZOP analysis for continuous, semi-continuous and batch chemical plants.

Introducing an analysis method of interlock systems within a HAZOP study could improve this qualitative risk analysis tool, providing a quantitative evaluation element, that allows to intervene directly, modifying the protection devices that were found inadequate.

Designing the interlock system of a chemical plant is actually closely linked to the events which each single interlock action should avoid. Providing methods of equipment protection requires specific information regarding the events under analysis, the dynamics of the process in relation to their occurrence and the relevance of their frequency and consequences.

It is clear therefore that HAZOP analysis is the ideal starting point in choosing the protection equipment for a chemical plant, yet it must be integrated with quantitative information to evaluate the risk connected with hazard events, whether the protection system is present or not.

This might take place through a software support system, which allows the protection system to be designed in an interactive manner, based on the HAZOP analysis results.

Through the analysis of risks, using one or more specific techniques, potentially dangerous events are identified, which are then characterized in terms of magnitude and frequency.

For the events identified, the analyst proceeds to define mitigation interventions, taking into account the degree of risk associated. This includes the choice of alternative basic control objectives and configurations, quantification of the remaining risk, and provision of physical protection systems most appropriate for the single pieces of equipment.

The need for installing and defining an interlock system is based on various factors. These factors include the comparison with measures chosen in designing similar plants, the company objectives and rules regarding safety

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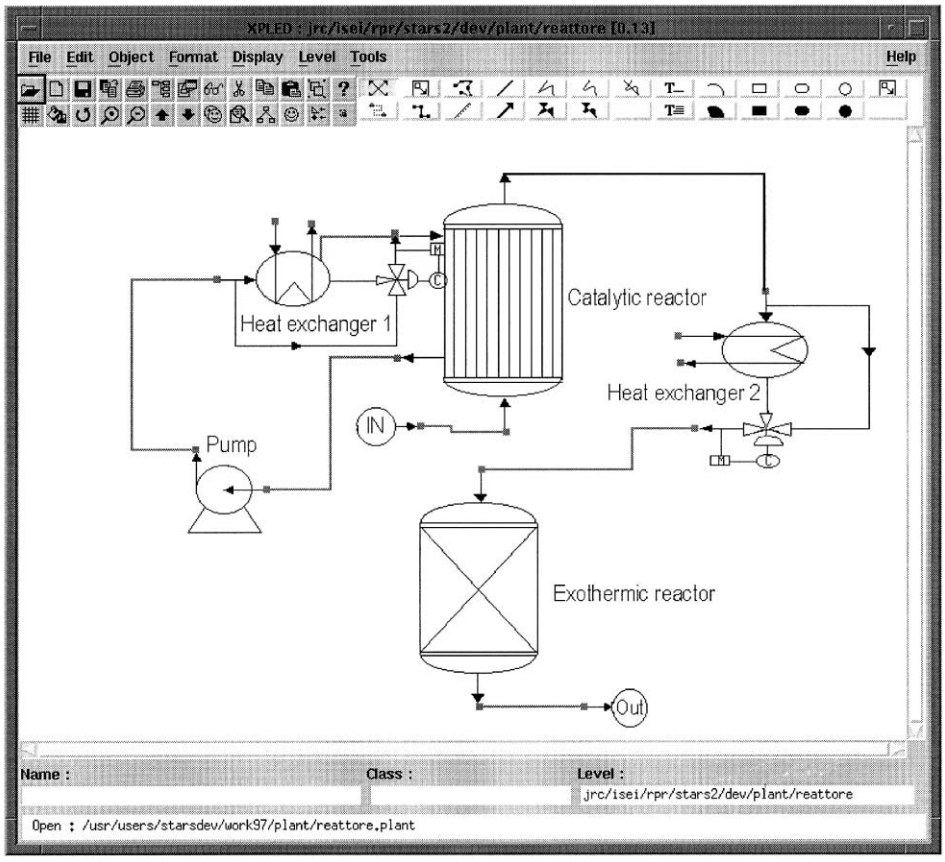

Fig. 1. Plant editor window.

management, the experience of the design team and analysis and quantification of the remaining risk.

A number of methods for the determination of safety integrity levels are reported in IEC 61508 document [10]. Within the scope of the present work, for the integration of the analysis of interlock systems with HAZOP analysis in a single interactive support system, the method suggested [11] by the Center for Chemical Process Safety (CCPS) of American Institution of Chemical Engineers (AIChE) has been chosen for the analysis of emergency interlock systems and other protection measures. For HAZOP analysis the HAST system, that enables an interactive application of the method, has been chosen.

2. HAST

HAST [8] is a support system which allows the safety analyst to carry out the HAZOP analysis of a plant in an interactive mode, based on a graphic description of the plant as shown by the example in Fig. 1.

This is designed by a specific plant editor which uses graphic objects corresponding to the single units of the plant, present in a software library provided in the system but which may be integrated, if necessary, with other graphical objects. These may be designed using a specific component editor.

Specific elements are associated with each graphical object, in different forms — tables, rules, etc. — which make up the whole model of the single component. The library of component models defines the fundamental knowledge base necessary to carry out a HAZOP analysis. A taxonomy editor enables the properties and characteristics of the components to be defined, grouping them in classes, allowing the properties to be transferred from more general classes to more specific ones.

The most important part of a component model used by HAST consists of a collection of mini trees, which may be considered as cause trees and consequence trees, with each one corresponding to a deviation of one of the variables, normally considered in the HAZOP analysis.

The qualitative models of the equipment unit are similar to those developed by Lees and Kelly [12] to analyse and simulate the propagation of faults in chemical process plants. The qualitative models of equipment units used in HAST have been developed with the aim of being used for an automatic HAZOP analysis. Different types of qualitative models of chemical units, referred to as ‘cause models’, ’HAZOP models’ and ’consequence models’, have been set up for the specific objectives of