Computer-aided HAZOP of batch processes

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Abstract
HAZOP studies are widely used for identifying hazard and operability problems during plant design. However, HAZOP studies are time consuming, labour intensive and expensive. Therefore, major research projects have been carried out to develop tools to automate the HAZOP technique. Some advances have been made in the area of automated hazard identification of continuous plants by considering the causes and consequences of deviations from steady state. The computing technique used is generally based on signed-directed graph. However, this technique is inappropriate for batch processes. A batch plant moves through a number of stages during normal operation and signed-directed graphs do not record state information as they only show how process variables influence each other.

Some work on computer-aided batch HAZOP has been done using Petri nets, which represent state information explicitly. Therefore, a Petri net is able to show how a plant changes from one state to another after a transition has taken place, i.e. after an operation has been carried out. However, given a plant description and a set of operating instructions, the construction of a Petri net for analysis can be very time consuming.

This paper describes the results of a research project that considers novel computing techniques for supporting batch HAZOP. An object-oriented approach is used to represent plant components. Each component inherits the properties from its class definition. Furthermore, the class definition also includes the operations that objects of that class can carry out. Each operation includes the pre-conditions that must be true before that operation could be carried out and also the after-effect of the operation. For example, a tank can be filled from a source. The pre-condition of the operation fill is that there must be a flow path from the source to the tank and that the flow path is not blocked in any way, e.g. any valve between the source and the tank must be open. The after-effect is that the tank is filled to the required level and the material in the source is reduced by the same amount.

Given a plant description and a set of operating instructions, a qualitative simulation of the plant going through the state changes is generated. Thus the effect of following a sequence of operating instructions can be analysed. Each batch HAZOP guideword is applied by introducing a particular error into the operating instructions and the consequence is determined by running the qualitative simulation. For example, consequence of missing out an instruction or carrying out an instruction in the wrong order can be easily assessed. Details of the prototype system will be described and examples will be used to illustrate the results.

Keywords: Batch HAZOP, qualitative simulation