SIIC079

DYNAMIC RISK ANALYSIS OF CHEMICAL REACTOR USING DYNAMIC BOW-TIE APPROACH

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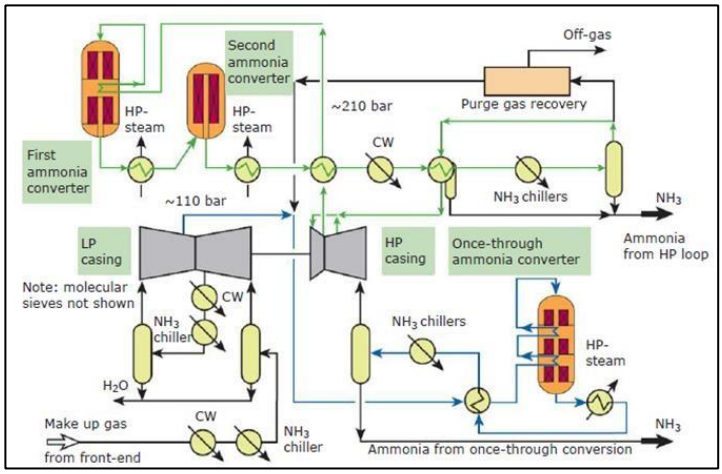
Abstract:
Chemical reactors have been designed accordingly to the complexity of a chemical plant to support the demand of the production. Thus, a risk analysis and assessment are necessary to estimate the probability of accident to occur. A bow-tie (BT) model is used in many risks analysis studies as it covers the accident estimation including the causes and consequences. However, bow-tie model has a static characteristic hence, limiting its application in real time monitoring and risk updating. Thus, a combination of BT model and Bayesian network (BN) is focused for constructing a dynamic risk analysis of chemical reactor using dynamic bow-tie approach. This study was conducted to develop dynamic bow-tie approach for dynamic risk analysis of chemical reactor by using Bayesian approach for three-bed ammonia reactor based on Uhde process dual-pressure ammonia synthesis and to compare the risk analysis method between the conventional risk analysis and the dynamic risk analysis. In this study, HAZOP was used for identifying hazard revolving around the chemical reactor. BT approach constructed the causes and consequences modelling of the reactor and BN was used for risks updating of the dynamic risk analysis through real time failure rate data. Thus, potential accident probabilities and associated risks were updated and used for risks assessment. The results of the study showed that the most likely causes of rapid increase of pressure in reactor were due to human failure, process control failure and heat exchanger failure which led to rapid increase of reactor temperature. Once the reactor overpressure occurred, it would most likely to result in reactor shutdown and the worst-case scenario resulted in reactor ruptured which could lead to explosion. Thus, priority would be given to the most probable root events and main contribution factors, which have been identified in the study, in order to reduce the occurrence probability of the worst consequences. The dynamic bow-tie approach results were compared with the event tree analysis result of the study. The results showed that the dynamic bow-tie approach could predict the failure probability of the reactor while, ETA could not predict the occurrence of the events more accurately.

***Keywords*:**
Dynamic risks analysis, Bow-tie approach, Bayesian network, Chemical reactor.

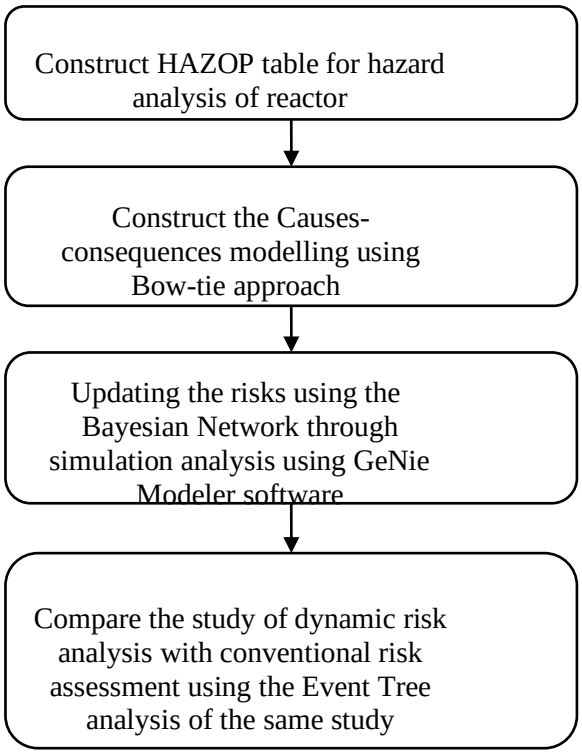
Objectives:

- To develop dynamic bow-tie approach for dynamic risk analysis of chemical reactor by using Bayesian approach for Uhde process dual-pressure ammonia synthesis based on SAFCO IV ammonia plant in Al-Jubail, Saudi Arabia,
- To compare the risk analysis method between the conventional risk analysis and the dynamic risk analysis.

Methodology:

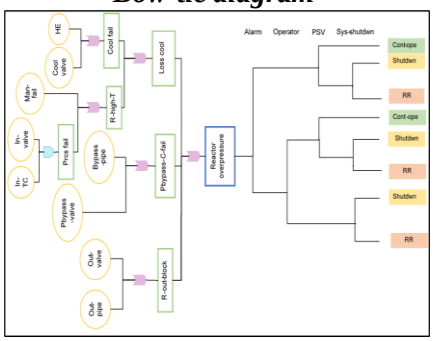


The PFD of the three-bed ammonia reactor from the Uhde process dual-pressure ammonia synthesis based on SAFCO IV ammonia plant in Al-Jubail, Saudi Arabia



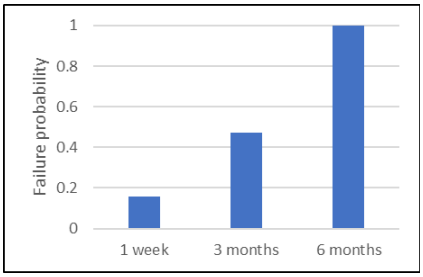
Results:

Bow-tie diagram

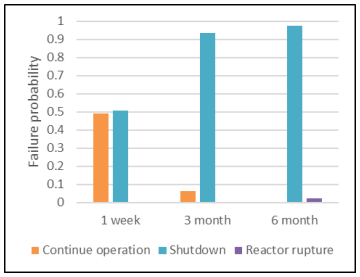


Bayesian network of reactor overpressure with three-time slices

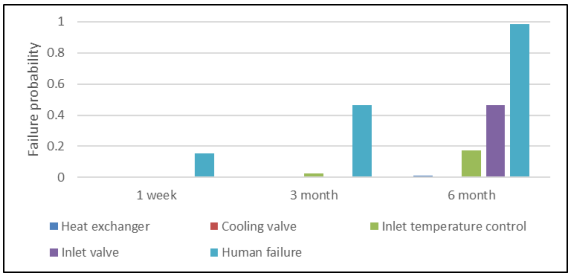
Reactor overpressure of ammonia reactor for three time-slices



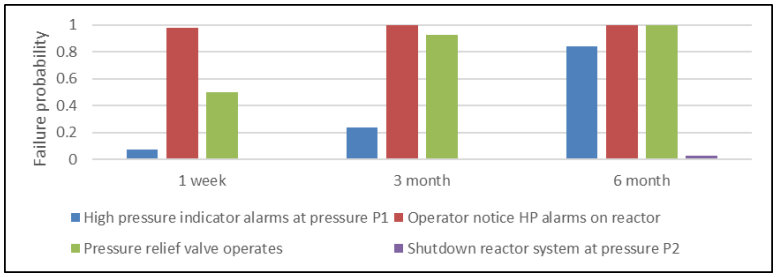
The consequences of the reactor overpressure with three time-slices



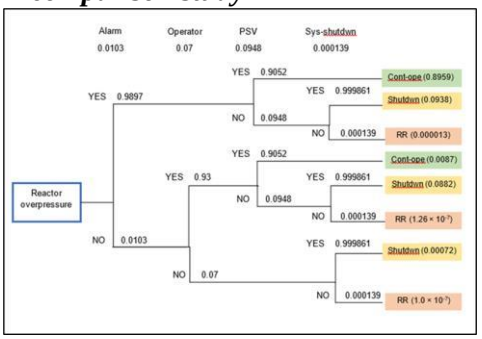
Failure probability graph of the loss of cooling for three time-slices



Failure probability graph of the safety barriers for three time-slices



Conventional risk analysis of reactor overpressure of the ammonia reactor for comparison study



Conclusion:

In conclusion, the study for developing dynamic bow-tie approach for dynamic risk analysis of chemical reactor by using Bayesian approach have been a success. From the results obtained, the probability of the top event which is the reactor overpressure, primary events, intermediate events, safety barriers and the consequences increases as the time interval increasing. The dynamic bow-tie approach could overcome the limitation of the bow-tie itself which is its static nature. It also provides advantages for the developing of the real-time assessment tool due to its ability to update the probability value in which its combining bow-tie analysis for causeconsequences modelling and Bayesian network for risk updating. Thus, it could prevent severe consequences from happening due to early detection of the causes which is the primary events.