UNIVERSITI TEKNOLOGI MARA

QUANTITATIVE RISK AND ECONOMIC LOSS RISK ASSESSMENT FOR PRESSURE VARIATION ON METHANOL PRODUCTION

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of the requirements for the degree of
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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

Methanol production using carbon dioxide as raw material has been identified as one of the potential routes to reduce carbon dioxide emission using the carbon capture utilization strategy. Researches using high pressure of 442 bar and high temperature of 280^{o}C on lab-scale experiment successfully produce 3 times more methanol compared to conventional, with 90% carbon dioxide conversion. However, there is a lack of comprehensive quantitative studies on safety and risk for high-pressure upscale methanol production. In this study, data from researchers using a conventional reactor operating at a pressure condition of 76.4 bar and temperature 288^{o}C are used to simulate the Reference Plant. Meanwhile, data of high-pressure conditions between 76.4 bar to 500 bar with the similar operating temperature of Reference Plant on the lab-scale experiment are used as the basis to develop methanol modification process plants, simulated using HYSYS software. Therefore, this study highlights a comprehensive quantitative safety analysis for pressure variation, which is Quantitative Risk Assessment (QRA) as this method calculate the consequence of a hazardous substance on surrounding people, count the frequencies of incidents scenario per year and quantify the risk by combining the consequence and frequencies analysis. A plant location in Manjung, Perak has been identified and the plant layout has been designed according to its guidelines, while the hazardous incident scenario has been determined. Operating pressure, mass and volume of the chemical were extracted from the simulation using HYSYS, while weather data such as wind speed, air temperature and humidity were collected at the location mentioned. All the input data, including chemical properties, atmospheric data, operating pressure, mass and volume of chemical, and hole's leakage size was then simulated in ALOHA and MARPLOT software to determine distance and number of fatalities. A prediction model of QRA using Artificial Intelligence, Artificial Neural network (ANN) and Adaptive Neuro-Fuzzy Inference System (ANFIS) tools are then performed to simplified prediction of the consequence method from QRA, which has 26 inputs. Selected data for ANN and ANFIS prediction methods are reduced to 6 inputs only, which are pressure, mass, volume, leakage size, wind speed and wind direction, computed in MATLAB software using ANN and ANFIS toolbox to predict distance and percentage area affected in red zone area. Finally, the economic loss risk study was performed using the cost of fatalities and injuries, damage equipment cost, business disruption cost and emergency cost to assess how risk reduction measurement can be quantify economically after doing QRA. Plant 10 which operates at 500 bar has the highest reduction of individual risk with 64%, while, all modification plants manage to reduce societal risk by lowering the F-N curve diagram into borderline of the broadly acceptable region and Plant 1 operates at 76.4 bar has the highest reduction fatalities risk for about 89%. Evaluation for 12 scenarios resulting the best prediction method is ANFIS using triangular membership function which attains percentage error between 0.02% to 4.22%. The results of the economic loss risk assessment showed that all modification plants have improved the safety of the Reference Plant, by the range between 59% to 89%.

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