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Dynamic Modelling Approach to Identifying Critical Operating Conditions in Ammonia Synthesis

Valiyeva K.[1], Jelemenský Ľ. [1], Myšiak J.[1]

[1]*Department of Chemical and Biochemical Engineering, Faculty of Chemical and Food Technology, Slovak University of Technology in Bratislava, Radlinského 9, 812 37 Bratislava, Slovak Republic*

e - mail: xvaliyeva@stuba.sk

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This work deals with ammonia as one of the main products of the global chemical industry. The nonlinear character of the ammonia synthesis process is studied, with a focus on analysing how the system responds to changes in operating parameters. Ammonia synthesis is a highly exothermic reaction, which can be dangerous under abnormal operating conditions. In this work, sensitivity analysis is carried out under both steady-state and dynamic conditions to evaluate process stability and to identify regions where unstable or unpredictable behaviour may occur. The Morris method is used to determine how individual input parameters affect the process and to identify the most important ones. A systematic identification of potentially hazardous operating states is performed using the HAZOP methodology, which is adapted for evaluating results from numerical simulations. The response of the ammonia synthesis loop to changes in selected process parameters within given ranges is also investigated. A steady-state simulation of the process is created in Aspen Plus, while a dynamic model is developed in Aspen Plus Dynamics to study how the process behaves over time under disturbances. The results show that combining dynamic modelling with sensitivity analysis is a useful approach for improving process safety and better understanding the behaviour of the system.

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