Sustainable Production of VCM from Ethylene through a Hierarchal Approach

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INTRODUCTION

Vinyl chloride monomer (VCM) is an important chemical as it is the key component for production of the plastic PVC. The annual worldwide production of VCM is roughly 42.7 million tons and is expected to increase in the coming years. This makes optimization of the VCM production interesting and potentially profitable. Equally important, even small environmental progress in this process would have great beneficial impact on the environment, and increase the sustainability of the extensive VCM production.

CONTENT

A systematic hierarchal decomposition method is applied to design a sustainable and environmentally friendlier plant for production of VCM from the raw materials ethylene and chlorine. The method consists of 12 sequential tasks, which take into account all stages of conceptual design. Tasks 1-4 cover the consideration of qualitative aspects of the process flowsheet and preliminary calculations. Tasks 5-8 determine the detailed process simulations, equipment sizing, costing, economic evaluation, sustainability and LCA assessment of the designed process. In task-9 (the economic analysis), the base case design is investigated for improvements with respect to heat integration and process optimization. In the final task-12, a sustainability and LCA analysis is performed to assess the environmental impact of the process design. The analyses are performed on the key sustainability and LCA measures such as sustainability metrics for environment, economic and social; carbon footprint; safety index. In addition, a commercial simulator is used for process simulation (for verification of design), ICAS for property prediction and analysis of design options, and ECON for cost and economic analysis, which is based on the Guthrie method. The 12-tasks design method helped to perform the process design related work systematically and efficiently, where first design decisions were based on collected information and then verified through simulations. This procedure can be applied to design and/or analysis for new or existing chemical or biochemical processes. The process design of a VCM producing plant was performed as part of a MSc-level course on process design at the Department of Chemical and Biochemical Engineering at DTU.

Conclusion

The annual profit of base case is estimated to be about 30 million US$ with a payback time of 5 years for production rates of 1.9 MM. tons/year of VCM. The capital and operating costs are divided into the individual cost items in order to provide easy overview of equipment and utilities that contribute significantly to these costs. It is found that the distillation columns are the most expensive equipment contributing to capital costs, and raw materials are the main contributor to the total operating cost. This information is used as target for process improvement by heat integration and process optimization, thus increasing the annual profit and reducing the payback time. The environmental impact analysis identifies impact due to the release of chemicals and points to the need of better control mechanisms through the sustainable/LCA analysis. The LCA analysis has illustrated how the process can become more sustainable, which has led to the environmentally improved design.