Progress rapport

Institute for Sustainable Process Technology

Progress report (Public)

1. Acknowledgement

"Het project is uitgevoerd met Topsector Energie subsidie van het Ministerie van Economische Zaken en Klimaat, uitgevoerd door Rijksdienst voor Ondernemend Nederland. De specifieke subsidie voor dit project betreft MOOI-subsidie ronde 2020 "

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Secretary and authors	This report has been drafted by Richard Cooper (Shell), Kees Biesheuvel (Dow), Robert de Boer (TNO) Paco Rutten and John Harinck (ISPT - Secretary to the project) on the 25th of July 2023. The report is published by the secretary to the project.

2. Introduction

The e-missi0n MOOI project is part of the ongoing development of electrified cracking technology, where Shell and Dow joined forces with TNO and ISPT. The goal of this project is to research two routes that will lead to the electrification of the steam cracking process. The first route investigates how existing furnaces can be retrofitted with electrical heating, while the second route uses first principles to identify the ideal electrical furnace. This innovation, including the optimization of heat integration of the furnace section, and a study towards the system integration of the technology can potentially reduce CO_2 emissions by up to 3.4 million tons per annum.

3. Update on the project

In the first activity the capability of specific heating concepts is tested. An experimental unit was designed and built to test the most promising heating concept. Two test programs were executed on the experimental unit, and the CFD model was validated against the test data. Close agreement was obtained between the CFD model predictions and the data. Heat losses from the unit were larger than initially expected and have been accounted for in the model. The impact of grey gas on the heat transfer rate was investigated as well as coil circumferential heat flux uniformity and the impact of convection heat transfer. A preliminary report has been written describing the initial results. Two further test programs are currently in progress. The validated CFD model will be used to scale up and design a pilot unit at the MW scale. Several alternative reactor materials are tested in a lab-scale cracking simulator (LCS), as part of the 'novel2 track'. The first set of results indicate high conversions of the feedstock and very low coke formation, providing favorable and promising perspective for use of these alternative materials. Tests in the LCS with tubes and variations in feedstock and cracking conditions are ongoing, combined with conversion modelling. This will provide an overview of the most suitable materials in electrified crackers as well as enable further reactor geometry optimization.

The second activity targets the recovery and re-use of high temperature heat from the cracked gases. Various new heat recovery, re-use schemes and concepts are developed towards a basic design and evaluated against the selected criteria. The various concepts are ranked against performance, reliability and energy efficiency criteria. High-ranked concepts are further analyzed based on criticality with mitigation activities being deployed to handle key technical challenges. Experimental testing of the basic heat transfer characteristics of the new heat recovery methods is ongoing. Modifications of the experimental setup and the measurement instruments were done to enable the full determination and control of heat balances over the heat exchanger. The test results will be used to validate the main heat transfer model assumptions of selected heat recovery schemes.

In the third project activity the materials of the heating concept are tested. The test plan in which critical chemical and mechanical properties are to be tested and the required test methodology were finalized. The test rigs were designed and constructed. Long material lead times caused by Covid led to delays in the construction of the rigs. The test program is currently in progress The last activity of the project aims to assess the impact of, and requirements for integration of electrified cracking technology in the surrounding energy and materials systems. Currently, system dimensions are being analyzed through methodology called 'techno-economical assessment of complex option spaces'. A dynamic model is developed to assess how the renewable power generation, storage and conversion techniques fit and to quantify their optimal size, when exposed to wind and solar generation profiles.

4. The contribution to society

The project is strongly recognized in the innovation missions of the Climate Agreement, specifically within 'MMIP 8' innovation target 8.4.d 'development and piloting of electrification of high temperature furnaces, for example for the manufacturing of olefins and aromatics. The topic of this project heavily contributes to the achievement of that target. Potential spin-offs and benefits that revolve outside this target are currently not yet identifiable.

5. Further information and grant acknowledgement

Results, news items and scientific articles that will be published for external use can be found on the project page [LINK] This website also contains contact information for further questions.