Master thesis proposal spring 2018

Power-to-gas concepts integrated with SNG production through gasification of forest residues – Cost evaluation and optimization

Project description

A future where a significant fraction of the energy needs of the transportation sector will be covered by electricity is likely, but many studies indicate that more energy-dense fuels (liquid or gaseous) will also be required, e.g. for long haul shipping and for air freight [1, 2]. One alternative for production of such fuels is through gasification of forest residues. A substantial development of intermittent electricity production is currently ongoing in Northern Europe, including Sweden. For instance, electricity produced by wind power (2015) has increased by 830% since 1997, and the Swedish Energy Agency forecasts that this development will continue. As the share of intermittent electricity of the total electricity mix increases, it becomes increasing difficult to maintain electricity grid stability. Periods with a production larger than the demand will occur, especially within areas where the transmission possibilities to other parts of the country are limited, as in the northern parts of Sweden or on the island of Gotland. Fluctuations in the electricity production will increase challenges related to balancing the electricity grid. One idea to achieve a better balance is to produce hydrogen from water through electrolysis at times when there is an over production of electricity. Hydrogen could then for instance be used in a fuel cell, when there is a deficit of electricity. Hydrogen could also be reacted with carbon dioxide for production of so called electrofuels. Such a possibility would benefit from integration with biofuel production processes. By integrating hydrogen production through electrolysis with biofuel production, the overall fuel production efficiency could potentially be significantly improved.

In a previous master thesis work, a basic process model for integration of an electrolyser into a direct, oxygen blown, gasifier was developed. The results include four different process scenarios, process integration calculations and quantification of energy and exergy efficiency and running costs. The subject of the master thesis project proposed here is to continue that work by evaluating the process costs and determine the optimal process design scenario from a cost perspective.

The project will be two-fold, where the first part will consist of a literature study to quantify the investment cost of the different process scenarios, based on previous modelling work. The second part will be to develop a cost calculation tools (preferably in Excel) to identify which process scenario that is most cost efficient depending on a forecasted, hourly, electricity price. Depending on time availability, the second part of the project can also include development of an optimization model for the process design, depending on the electricity price. Such a model will include the possibility to store hydrogen, to decide how the process should be designed. The optimization model will be developed using the GAMS high-level optimization modelling system tool.

Required education and potential course requirements

The applicants should have a background in chemical or mechanical engineering with focus on process modelling and optimization. Experience with Aspen and/or GAMS (or similar) is desirable.

Starting time and supervision

Preferable project start is January/February 2018. The duration of the project can be 20 calendar weeks (or decided according to RWTH Aachen conditions). The student(s) can receive support by the IDEA league agreement between Chalmers and RWTH Aachen. The examiner at RWTH-Aachen will be Prof. Alexander Mitsos and the supervisor at Chalmers will be Assoc. Prof. Stavros Papadokonstantakis (Division of Energy Technology).