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Coach	**Supervisor(s)**	**Funding**
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Power-to-olefins: electrification of steam cracking

Aim

Computational assessment of the occurrence and impact of unsteady flow behaviour and secondary flows in a novel power-to-heat reactor design for olefin production with zero CO_2 emissions.

Justification

Ethylene and propylene are the most important olefins and are produced in large amounts (1.5×10^8 and 8×10^7 tonnes, respectively, and increasing at a rate of 5% per year) by steam cracking. Being the most important petrochemical process, it is consuming large amounts of energy causing it to be one of the major contributors to CO_2 emissions in Flanders. It contributes 50% of the total CO_2 emitted by the chemical industry, some 5 million tonnes/year of CO_2 equivalents. Combustion of fossil fuels, to produce the required heat, amounts to 75-93% of the CO_2 produced by steam cracking. As the Belgian government committed itself to the Paris Agreement, Flanders aims to reduce its greenhouse gas emissions by 30% by 2030 and 80-95% by 2050. Reducing CO_2 emissions related to olefin production will be crucial to accomplish this goal. In this respect, the electrification of steam cracking is a promising and future-proof concept that is strongly supported by the industry.

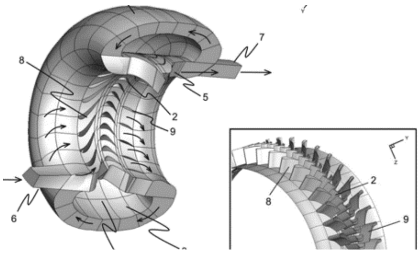

Figure 1: Electrified rotor stator reactor.

The current idea of the power-to-heat reactor can be described, in layman's terms, as a 'bad' compressor that causes an increase in temperature but not in pressure. To achieve this goal the e-RSR exists out of 2 major components, which are the rotor and the stator blades. Even though the novelty of this reactor, the large resemblance with traditional turbomachines (e.g. compressors and turbines) gives us a preliminary overview of the occurring phenomena within this reactor. One of these phenomena is the inherent unsteadiness due to the rotational movement of the rotor. As such, the relative positioning of the rotational and stationary vanes is changing periodically. Consequently, this periodicity causes flow distortions that have a significant impact on the stage efficiency, blade loading (i.e. the work added/extracted due to the vanes), metal fatigue, heat transfer, and noise generation of this reactor. Moreover, the complex 3D geometry of this reactor is prone to the occurrence of 'loss factors'. One of the most important losses is the occurrence of secondary flow (i.e. flow streams that deviate from the main flow path). These losses cause a reduction in work added to the fluid. Hence, reducing the potential of this reactor to increase the temperature of the fluid leading to a larger reactor design and smaller economical benefits.

Program

- Literature survey on the unsteady behaviour and loss factors within a traditional turbomachine. The main focus should be on how to accurately grasp these phenomena during CFD-simulations given the large difference in length and frequency scale.
- Implementation of secondary flow losses in a validation case
- Analysing the effects of the unsteady behaviour and secondary losses in the electrified rotor-stator reactor.
- Adapting reactor geometry to reduce the negative impact of unsteady behaviour and losses.