Upgrading Waste Streams with Compression Resorption Heat Pumps

Objective
To develop a compressor prototype suitable for operation in compression-resorption cycles for heat recovery from process waste streams.

Fig 1. Twin screw compressor.

Motivation
Waste heat recovery in the industry is still negligible. For many applications, compression-resorption heat pumps (CRHP) are an attractive option.

Status
Homogeneous thermodynamic model including entropy production for each leakage path has been developed.1

Fig 2. Example of entropy production of each leakage path in a twin screw compressor.

Fig 3. Simplified P&ID of the experimental set-up.

Initial testing of components and controls has been performed. The payback period when replacing a boiler with a CRHP has been estimated.

Fig 4. Payback period as a function of the gas and electricity price when upgrading 90 to 130 °C.

Ongoing work
- Integrate all compression resorption heat pump components into an optimization model based on entropy production minimization.
- Perform experiments for evaluation of the compressor prototype performance.
- Additionally confirm the benefits of NH₃-CO₂-H₂O versus NH₃-H₂O.
- Compare the optimized design with reference system (boiler).

References:
Cost Reduction
Industrial Heat Pumps

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Budget: 689,381€
Planning: October 2016 – December 2018

Objective:
- The overall objective is to develop and implement heat pump technology that is able to generate heat in an economically feasible way for industrial applications, using waste heat.
- More specific, this project wants to demonstrate that a cost target of 150-200 €/kWth can be achieved.

Motivation:
- Heat pumps allow for the recycling of waste heat, by upgrading the temperature level of this waste heat.
- The CAPEX of industrial heat pumps presently hampers the widespread implementation of this technology.
- The broad implementation of heat pumps in the Dutch industrial sector can annually save a staggering 87 PJ of energy.

Project scope:
- End-user demands & system integration
- Cost reduction options (components, engineering, manufacturing, measurement & control)
- Experimental verification of two heat pump concepts (compression, thermoacoustic)
- Market potential & consortium for follow-up

Applicability:
- Targeted markets are the refining, chemical, food, paper & pulp and steel sector.
- Temperature levels up to 200°C.
- New worldwide business opportunities for equipment manufacturers and technology providers

Status & Outlook:
- Market potential & standard sizing determined
- Investment costs < 200 €/kWth seem feasible for compression heat pumps
- TA cost reduction study shows 270 €/kWth, further reduction needed
- TA experiments planned for Q4
- Compression heat pump experiments delayed
DEI-Demonstration project
Polymer Heat Exchanger

Project objective
This project aims to demonstrate the innovative technology of HeatMatrix in the business process of BioMCN. The goal is on the one hand to achieve direct energy savings at BioMCN and on the other hand to create a reference project for HeatMatrix as a prelude to repetition and further commercial rollout for similar applications.

Project scope
BioMCN in Delfzijl produces bio methanol based on bio feedstock. The flue gases of the steam reformers have a temperature of 300°C. This corresponds to an energy volume of 38,4 MW. BioMCN has investigated technical and financial feasible possibilities to extract the energy from the flue gases and re-use this energy.

Scientific challenges
Conventional metal heat recovery systems do not function in the temperature range of 200°C - 85°C because of acid condensation. HeatMatrix produces so-called polymer Heat Exchangers. The chosen material (plastic) and the design are specifically intended for this temperatures range. In recent years, various scale sizes have been built, however not yet for this application at this scale.

Technology needs
In order to implement the product innovation of HeatMatrix, a consortium has been formed with Stork as a so-called EPC contractor (Engineering, Procurement & Construction) in order to implement these polymer heat exchangers which can deal with acidic circumstances.

Sustainability targets
The energy saving of the DEI-project for BioMCN is calculated at 0.31 PJ. The main objective of this project is to prove the operation of the total design and to identify another 1,2 PJ of direct energy savings with other energy intensive industries.