Annex 58 | High-Temperature Heat Pumps

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Qpinch Heat Transformer

Qpinch BV

Figure 1: Several Qpinch Heat Transformer units

Summary of technology

The Qpinch Heat Transformer (QHT) is based on the reversible reaction of phosphate oligomerization inspired by the adenosine triphosphate – adenosine diphosphate (ATP-ADP) cycle in all living cells. This chemical principle is brought to a continuous industrial process in the form of a phosphate *absorption heat transformer*. The system consists of a closed loop phosphate oligomerization and hydrolysis loop, shown schematically in **Figure 2**. The QHT has reached TRL 9 in June 2021 with 3 commercial installations live.

Low temperature residual heat (from industrial processes) drives the whole system. Only ~25 kWh electrical power is used to generate 1 ton of steam. This power is consumed in centrifugal pumps as no compressors are used in this technology.

Applications are found in energy intensive process industry (oil&gas, chemical, metal, food): residual heat, nowadays lost to the environment through air or water cooling, is turned into reusable process heat such as steam, saving CO_2 emissions. Specific applications are the reuse of condensation heat in distillation column overheads as steam to feed the column bottom reboiler, and turning low temperature heat from exothermic reactions into high temperature reusable process heat.

The QHT is flexible in design: the technology can use residual heat from liquid or condensing process streams or a combination thereof. The output, CO_2 neutral process heat, can be in the form of steam, hot thermal oil or hot water.

As the QHT technology is composed of mostly static equipment, operational flexibility is a unique selling point. QHT units can cope with fluctuations in design capacity down to 10% of the initial duty and are able to vary in temperature lift between residual heat source and process heat sink in a safe and automatic way. Concerning start-stop times, from complete shutdown till full-load operation can be achieved within 4 hours, whereas shutdown is just a button push. Additionally, different operational modes can be run so a complete shutdown is often not required and operational continuity is guaranteed.

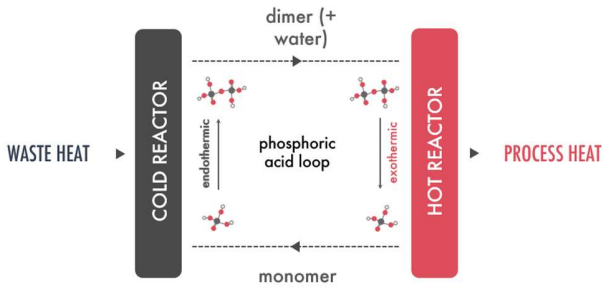

Figure 2: The QHT cycle

The QHT technology does not contain any flammable, explosive, toxic, carcinogenic compounds. It's considered a safe technology both by petrochemical industry as well as food industry. QHT units can be standardized modular skids or completely customized to have the best possible tie-in with a brownfield situation.

For a heat transformer, the coefficient of performance (COP) is defined differently than for electrical heat pumps, hence it cannot be compared. A heat transformer transforms medium temperature waste heat Q_{in} to part high temperature process heat $Q_{out,high}$ and part low temperature waste heat $Q_{out,low}$. COP is then defined as

$$\text{COP}_{\text{heat-transformer}} = \frac{Q_{out,high}}{Q_{in}}$$

As heat transformers use no compressors, elecrical power consumption is low, which typically results in low operating costs.

Table 1: Performance

$T_{source,in}$	$T_{source,out}$	$T_{sink,in}$	$T_{sink,out}$	$COP_{heat-transformer}$
[°C]	[°C]	[°C]	[°C]	[-]
139	124	140	185	0.45
117	106	140	165	0.42
113	110	117	154	0.46

Project example

The goal of the project at Borealis Antwerp was to turn low temperature heat from an exothermic ethylene polymerization reactor and a low pressure steam vent into valuable medium pressure steam (MPS). The project was successful and feedback from the end user was very positive.

To this end, three different residual heat sources were combined via a secondary hot water loop that feeds the QHT unit. This heat is lifted to steam at 3 to 10 bar G. Due to highly fluctuating residual heat production and MPS pressure set point, the designed QHT had to show a lot of flexibility, reliability and ease of operation.

Operational COP values between 0.15 and 0.45 were found. Electrical power consumption was very low, with values around 3-5% of the process heat output.

Possibilities of adjustments and extensions are:

- 3 different residual heat sources are combined into one secondary loop that feeds the QHT. Additional residual heat sources can be coupled to this secondary loop.
- Control software revisions and operational excellence to increase COP is possible.

FACTS ABOUT THE TECHNOLOGY

Heat supply capacity: > 2MW

Temperature range: input waste heat > 80°C, output process heat < 230 °C

Working fluid: water, H_3PO_4 and derivatives

Specific investment cost for installed system without integration: 1 to 2 M€ per MW of process heat production

TRL level: 9

Expected lifetime: 20 years

Size:

2 MW process heat installation: 36 m² footprint, +/- 300 tons weight in standardized steel structure.

10 MW installation: 100 m² footprint, +/- 1000 tons weight.

Contact information

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All information were provided by the supplier without third-party validation. The infomation was provided as an indicative basis and may be different in final installations depending on application specific parameters.