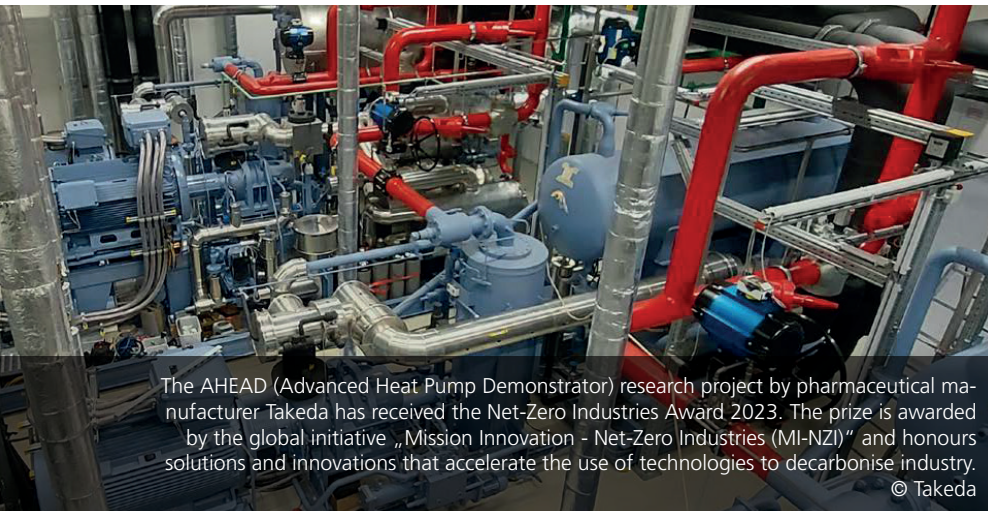


High-temperature heat pump for industry

Generating process temperatures of up to 200 °C from existing waste heat



The AHEAD (Advanced Heat Pump Demonstrator) research project by pharmaceutical manufacturer Takeda has received the Net-Zero Industries Award 2023. The prize is awarded by the global initiative „Mission Innovation - Net-Zero Industries (MI-NZI)“ and honours solutions and innovations that accelerate the use of technologies to decarbonise industry. © Takeda

High-temperature heat pumps can recycle unused waste heat from production processes and use it to generate process heat in the form of steam and hot water at temperatures of up to 200°C. Industrial heat pumps thus increase energy efficiency and reduce CO2 emissions.

Around one-fifth of total industrial energy demand is accounted for by the generation of process heat up to 200 °C. In order to achieve the EU climate targets and reduce CO2 emissions, a significant lever for industry lies in efficient heat generation, e.g. by utilising existing waste heat. Unfortunately, this is often only available in the form of low-temperature waste heat, which is not sufficient for many industrial processes and is therefore usually wasted or even has to be cooled with additional energy input. High process temperatures above 100 °C are still mainly generated using fossil fuels. One solution is the ThermBooster from SPH Sustainable Process Heat in Overath, an industrial high-temperature heat pump that can raise existing low-temperature waste heat to temperatures of up to 200 °C.

Heat pumps utilise low-temperature waste heat efficiently

The heat pump system is simple and efficient: a liquid refrigerant extracts energy from the heat source and heats up. Due to its low boiling point, it vaporises and is compressed in a compressor, causing it to heat up considerably. A heat exchanger transfers the resulting high heat to the application system (steam or hot water), the heat sink. In a continuous cycle, the refrigerant liquefies again, cools down and can absorb heat again. If the heat pump is operated with electricity from renewable energy sources, CO2-free heat generation is even possible.

High-temperature heat pump for industry

Until now, heat pumps in industry

were limited to temperatures of up to around 100 °C and therefore could not be used for many industrial processes. The ThermBooster is an innovative high-temperature heat pump that can generate temperatures of up to 200 °C or saturated vapour pressures of up to 6 bar absolute thanks to a special piston compressor. Its modular design allows components such as the evaporator, compressor and condenser to be individually selected and flexibly adapted to the respective production environment. The modules can also be interconnected several times if a very high output is required.

The industrial heat pump in practice

High-temperature heat pumps can be used in industry wherever process

heat of up to 200 °C is required and constant waste heat is available. This applies in particular to sectors such as the food, paper and chemical industries, in which heat-intensive processes such as drying, sterilisation, pasteurisation or distillation play an important role. The heat generation system has already been delivered to several companies and is currently being utilised and further developed as part of two international research projects.

Gelatine production with savings of 4.8 GWh of natural gas and 550 tons of CO₂ per year

In the production of gelatine, particularly the drying processes require high temperatures. Until now, a gas-fired steam generator and several combined heat and power units (CHP) supplied the required heat on two heating rails: A steam rail at 2 bar absolute (around 120 °C) exclusively for process heat, and

a hot water rail at 85 °C for some of the process heat as well as for heating the rooms. As the demand for room heating fluctuates seasonally, a large proportion of this heat remained unutilised. The integration of the heat pump into the cycle makes all the waste heat on the hot water rail constantly usable for production and space heating. Over the course of a year, the plant generates around 6,500 tons of steam, which corresponds to 4.1 GWh of thermal energy. Assuming an efficiency of 85% – based on a standard gas-fired steam boiler – this saves around 4.8 GWh of natural gas per year and therefore around 550 tons of CO₂. Even higher CO₂ savings are possible with electricity from renewable sources.


Recycling industry: saving 10.8 GWh of natural gas and 2,400 tons of CO₂ per year

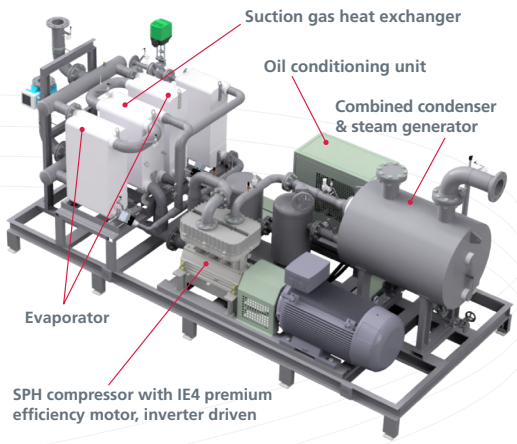
An innovative recycling process breaks

down previously unusable household waste into its basic components and combines them into a thermoplastic composite material. Temperatures of 130 °C are required to dry the material. The recycling plant’s heat utilisation concept bundles various waste heat streams and uses them as a source for the heat pump. It comprises various cooling and heating circuits at different temperature levels, which are all interconnected. At the end is the ThermBooster, which produces hot water at 130 °C to provide the 1.5 MW of heating power for the drying process. With a planned annual utilisation period of approx. 8,000 hours, this corresponds to a saving of 10.8 GWh of natural gas per year. As the plant is operated exclusively with CO₂-neutral electricity, 2,400 tons of CO₂ per year are avoided compared to natural gas-fired process heat generation.

Gelatine

Final drying processes with steam generation





TECHNICAL DATA

- Installation Q1 2024
- Source: 85/70 °C
- Steam at 2 bar
- 4.1 GWh thermal energy per year
- Savings of 550 t CO₂ per year using electricity generated by CHP unit


STEAM

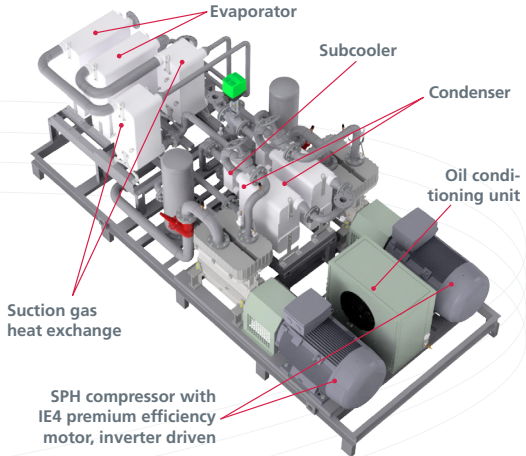
Performance data

- Heating capacity: 514 kW (812 kg/h)
- Cooling capacity: 407 kW
- Electrical power: 118 kW
- COP: 4,4

Recycling industry

Thermoplastic from recycled household waste





TECHNICAL DATA

- Installation in Q1-2024
- Delivery of 2 heat pumps
- Target: CO₂-free production of thermoplastic from waste
- 1.5 MW power requirement

WATER

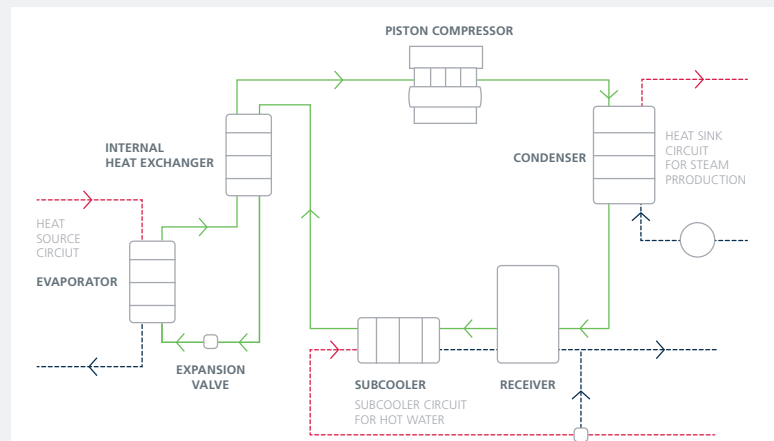
- ~10.8 GWh ~ 39 TJ heat per year
- Savings of 1.25 Mm³ natural gas per year
- Savings of ~2400 t CO₂ per year through use of „green“ electricity

Steam and hot water generation with heat pump

The ThermBooster system is designed as a compression heat pump with an internal heat exchanger. Highly efficient plate heat exchangers serve as evaporators for the refrigeration circuit and as internal heat exchangers. A plate heat exchanger or alternatively a plate-and-shell heat exchanger is used as condenser, which also acts as a vapour generator for the heat sink. The system is therefore suitable for generating both hot water and steam. To increase efficiency, an additional subcooler can be integrated, which extracts further energy from the refrigerant that can be used, for example, to preheat feed water or to feed into another heating circuit. A special oil conditioning system ensures a long service life and low maintenance requirements.

The heart of the heat pump is a specially developed 4-cylinder

piston compressor with a displacement of approx. 540 m³/h at 1,500 rpm. It is designed for up to 35 bar on the high pressure side and 18 bar on the low pressure side. Hot gas temperatures of 250 °C and suction gas temperatures of 200 °C are possible without any problems. The compressor achieves high levels of efficiency and is optimised for the latest generation of synthetic, environmentally friendly HFO (hydrofluoroolefin) refrigerants (e.g. R1233zd, R1336mzz-Z) and natural refrigerants (e.g. hydrocarbons). A patented valve system makes optimum use of the available surface area and minimises pressure loss while keeping the dead space volume low.



Structure of the ThermBooster © SPH

Project AHEAD: Temperatures up to 200 °C for pharmaceutical production

In pharmaceutical production, a significant proportion of the process heat requirement has so far been covered by natural gas. The AHEAD (Advanced Heat Pump Demonstrator) research project in Austria aims to achieve sustainable pharmaceutical production at the biopharmaceutical company Takeda's site in Vienna. In future, AHEAD will utilise the existing heat from the Takeda heating water system to generate steam using the heat pump. This will be specially adapted for the use of natural refrigerants and will generate steam, which will be brought to the 11 bar(a) and 184 °C required at Takeda by means of steam compression. This solution achieves a CO₂ reduction of up to 90% and is completely CO₂

emission-free for around seven months of the year. This corresponds to an annual saving of 1,900 tons of CO₂.

Push2Heat project: paper drying with recycled waste heat

The EU Push2Heat project promotes the utilisation of waste heat in industry. One of the project partners is a manufacturer of speciality papers. In the paper mill, the steam required for the paper machine (around 130,000 MWh per year) is currently generated by a central, natural gas-fired boiler. Some of the waste heat from the paper machine is already efficiently utilised in a water-glycol cycle for heat recovery. In future, another part of this waste heat in the range of 30 to 50 °C will be utilised with a two-stage heat pump system to generate steam at 2.2 bar and 123 °C, which will be fed directly into the paper

machine. The achievable COP (coefficient of performance) is approx. 2.3.

Efficiently from waste heat to process heat

A large proportion of the energy required in industry is used to generate process heat, particularly in energy-intensive drying processes. Industrial high-temperature heat pumps such as the ThermBooster enable waste heat to be efficiently converted into high-quality process heat. Thanks to its modular design, the system can be flexibly integrated into different production processes and enables temperatures of up to 200 °C to be achieved. It not only makes a significant contribution to lowering energy costs, but also significantly reduces CO₂ emissions and therefore plays an important role in achieving climate targets in industry.