HTHP IN FINLAND

Technologies and R&D

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HTHP INDUSTRY IN FINLAND

Two heat pump manufacturers providing HTHP over 100°C

HotLevel® high-temperature heat pump revolutionized energy production.

The heat pump produces up to +130°C temperatures with good efficiency, even from low-temperature sources.
HTHP INDUSTRY IN FINLAND

- Companies providing components also for HTHP
  - Vahterus for Plate and shell heat exchanger
  - Luwe group for air coolers, condensers
- Several engineering companies, system integrator and consultants
Finland aims to be carbon neutral in 2035
- Fosters the need for new technologies and transition to use of renewable energy and high energy efficiency
- The policy makers have supported transition for using electricity in district heating by decreasing electricity taxation for heat pumps, electric boilers, and geothermal heat production.
  - Taxation rules have been changed on 1st of July 2022
- Availability of renewable energy is very good and electricity price is expected to be low

Finnish Heat Pump Association SULPU statistics 2022
The Finnish market for HTHP will be mainly in district heating and in different industrial sectors.

Pulp and paper industry is the main user of industrial heat.

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DEVELOPMENT PERSPECTIVES

To achieve higher temperatures with heat pumps, it is anticipated that there are three main development fields:

- Working fluids, compressors and heat exchangers/heat collection.

Based on the new legislation and regulations in European Union (F-Gas regulations and PFAS regulations) the use of natural working fluids, such as CO2, ammonia and different hydrocarbons, seems to be favored in heat pump systems in the future.

Currently, there is a clear need for compressors that are capable for high temperature lifts and high pressure ratios:

- The compressor technologies need to be further developed and more compressor suppliers are needed in the market.
- In Finland, there are research and development projects going on for developing oil-free, hermetic turbocompressors for high temperature heat pumps.
DEVELOPMENT OF NEXT GENERATION LARGE SCALE HEAT PUMP SYSTEMS (NEXTHEPS)
Project general information

- Research project on large-scale (few MW heating power) high temperature heat pumps
- Project duration 9/2022-8/2024
- Funded by Business Finland
- Project partners:
  - LUT University
  - Yaskawa Environmental Energy / The Switch
  - Vahterus
  - Fincoil LU-VE
  - Suomen tekojää
  - Nevel
  - Suur-Savon Sähkö
  - Finnish heat pump association.
Project goals

To investigate and develop design methods and new technological solutions that can be adopted in large-scale, high-temperature heat pump systems (condenser temperature from 90 to 150 °C)

The project can be generally divided to four main research topics
1. Heat collectors and heat delivery
2. High-speed compressor technology
3. Integration of large-scale heat pumps to energy systems
4. Market environment and business opportunities
WP1 - Design of heat collector and heat delivery processes

- Task 1.1 Low global warming potential (GWP) refrigerant research and development
  - Investigation of low GWP fluid's properties

- Task 1.2 Industrial heat integration and design of evaporator/condenser heat exchangers
  - Development of heat exchanger models
  - Design of evaporator and condenser for heat pump system with several low GWP fluids

- Task 1.3 Air source collectors and collector field design
  - Development of heat exchanger network models
  - Design of air source heat collector system for heat pump
  - Investigation of operation principles of the network
WP2: High-speed turbo compressor and electrical motor development to create a hermetic high-power component for future heat-pump systems

- Task 2.1 Compressor aerodynamic design
- Task 2.2 Motor design
- Task 2.3 Rotor dynamics of AMB-supported integrated heat pump compressor
- Task 2.4 Coupled design of the whole heat pump system

Combined design method including compressor aerodynamic design, electric motor, active magnetic bearings and rotordynamics will be generated
WP3 Energy system integration

- Task 3.1 Plant-level design and optimization of a heat pump system
- Task 3.2 Heat pumps as part of community energy systems
WP4 Market environment and business opportunities for heat pump technologies

1. Digital service architectures for energy sector
2. Energy & Digital business ecosystems
3. Energy & Heat pump supply chains
4. Commercialization opportunities
Contact info and project web page

Web page

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EMBER

Efficient, magnetic and bearingless heat pump for industrial and residential heating
Ember – Heat Pump technology

- High-speed oil-free compressor
- High efficiency at high temperatures
- Bearingless technology
- Shorter rotor, smaller footprint
- Less components, potentially lower cost and higher reliability
Key benefits of Ember - Heat Pump

- Higher efficiency will lead into cost savings.
- Easy to use containing automated monitoring and maintenance.
- Green and sustainable, no harmful pollutants.
- Hybrid use opportunities from various heat

Low and easy maintenance costs, long service life and high product reliability are the key buying customer objectives for the product (Turo Valkama, Imatran Lämpö Oy).
Interdisciplinary design process

- Process design
  - $\Delta T$, Power, Working fluid etc.
- Compressor design
  - Type, rotational speed, dimensions, performance etc.
- Motor and drivetrain design
  - Dimensions, performance, rotor dynamics, control etc.

COMPRESSORS

Design values of the LP compressor

- Mass flow rate 2.09 kg/s
- Pressure ratio 3.21
- Rotational speed 26400 rpm
- Impeller diameter 157.0 mm and blade height at impeller outlet 4.3 mm

Design values of the HP compressors

- Mass flow rate 2.74 kg/s
- Pressure ratio 1.87
- Rotational speed 26400 rpm
- Impeller diameter 112.6 mm and blade height at impeller outlet 4.6 mm
COMPRESSORS

Performance maps

LP

HP
DESING OF TURBOCOMPRESSOR

- Internal losses of electric motor are transferred to working fluid and cooling liquid
- Cooling of the electric motor is studied
  - Working fluid cooling system is designed
- Internal leakages are studied
  - Labyrinth seals are designed
- Performance of the heat pump is studied
- Compressor performance analysis is done
TESTING

- Designed compressor unit is manufactured
- Simple loop for testing the compressor is designed
- Testing is going
SUPERCRITICAL CO$_2$ RESEARCH
LUTSCO2 EXPERIMENTAL FACILITY

Supersonic test section
- Expansions from supercritical conditions with non-equilibrium condensation
- Further availability of validation test cases for numerical modeling of non-equilibrium condensation in highly non-ideal thermodynamic regions

Heating test section
- Heat transfer across the Widom line
- Development of new heat transfer correlations for supercritical buoyant flows
CO₂ HEAT TRANSFER MODELING – DESOLINATION

- Development of numerical models for the study of carbon dioxide heat transfer in the supercritical and two-phase region
- Validation of test cases by means of real gas CFD simulations

Supercritical CO₂ with external heat source uniformly distributed

Planned: performing the testing of heat exchangers at lab scale in the LUTsCO₂ test setup

PCHE - Supercritical CO₂ (hot side) and water (cold side)

Evaporating CO₂ with external heat source – Inhomogeneous Eulerian model with non-equilibrium boiling model