Reversed Stirling Cycle

Olvondo Technology AS

Figure 1: Production of the HighLift high temperature heat pump at Olvondo.

Summary of technology

The configuration of the heat pump is a double-acting alpha Stirling engine of the “Franchot” type. “Double-acting” means, that the working medium is acting on both sides of the pistons. The Franchot type means in contrast to a “Rinia” or “Siemens” type configuration, one of the cylinders is always containing cold gas and one of the cylinders is hot gas.

The driving energy is waste heat with an electrical motor for the piston compressor. The most relevant applications for this technology are food & beverage, process and chemical, pharmaceutical, distilleries, and district heating. Compared to compression and absorption heat pumps, the working medium in a Stirling process is a gas throughout the process. This implies that the process is independent of the evaporation and condensation temperatures of the working medium.

The refrigerant used is R-704 (Helium), which is a natural refrigerant. Helium has both global warming potential (GWP) and ozone depletion potential (ODP) equal to zero and the toxicity and flammability classification of Helium is "A1". The working medium stays a gas throughout the cycle, which makes the heat pump process very suitable for use as very high heat pump’s, while the heat pumps are highly adaptive to any changes in the sink or source temperatures.

Example of the performance of the technology can be seen in table 1.

Table 1: Performance.

$T_{source,in}$	$T_{source,out}$	$T_{sink,in}$	$T_{sink,out}$	$COP_{heating}$
[°C]	[°C]	[°C]	[°C]	[-]
36	34	178	183	1.7
90	85	139	144	2.6
60	55	154	159	2.1
60	55	178	183	1.9

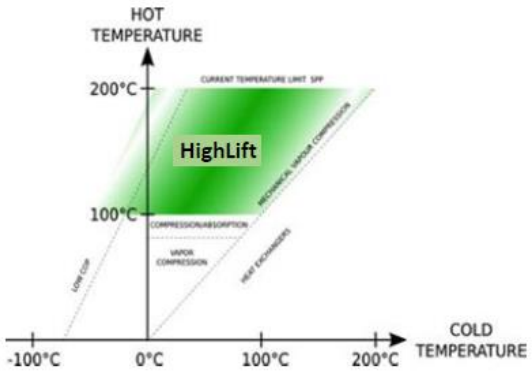

Figure 2: The HighLift high temperature heat pump - recycle low temperature, low value waste heat to high temperature, high value process heat.

The HighLift heat pump can produce steam and cooling in one process, which enables high temperature lifts and delivers very high sink temperatures. The operating range can be seen in figure 2.

Project example

A project example is heat pumps at AstraZeneca, Gothenburg, Sweden. They have historically used fossil fuel for steam production, but have made a conversion from oil to natural gas in 1997. In 2018 a new conversion took palace, this time from fossil natural gas to biogas, to produce steam with a low carbon fuel.

A technical part of the upgrade was to pursue steam production using high lift heat pumps - a more efficient, more robust, less expensive and if possible, even more sustainable solution.

To do this, the site has installed 3 HighLift heat pumps. Each with a capacity of 500 kW_{th} at 10 bar steam system pressure and rejected heat from the chillers for the air condition as a heat source. Another heat pump is scheduled for 2021 with a capacity of 750 kW_{th}.

The pilot installation at AstraZeneca's R&D center in Sweden aims at increasing the TRL level from 7 to level 9.

FACTS ABOUT THE TECHNOLOGY

Heat supply capacity:
Capacity of 500 kWt_h at 10 bar steam system pressure and rejected heat from the chillers for the air condition as a heat source. Additional heat pump capacity up to 750 kW_{th} is scheduled for 2021.

Temperature range: Heat source: 0 - 100 °C Heat output: 100 – 200 °C.

Working fluid: Helium gas, R-704.

Compressor technology: Piston (double acting).

Specific investment cost for installed system without integration: € 1200 /kW.

TRL level: TRL 9

Expected lifetime: 20 years.

Size: 13 tons and 20 m^2 for each HighLift heat pump

Contact information

Olvondo Technology AS
info@olvondotech.no
+474650 8888

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