Compressors and blowers for open loop MVR cycle and steam heat pumps
Piller Blowers and Compressors

Figure 1: left: PILLER High Performance Blower, right: Multi-stage system in operation

Summary of technology

In contrast to conventional heat pumps, that use chemical refrigerants, the heat pump solution provided by PILLER uses the existing process fluids, either the vapor from the process or water.
If vapors are compressed directly and then used for heating, the basic principle corresponds to classic mechanical vapor compression (MVR) process (Figure 2).

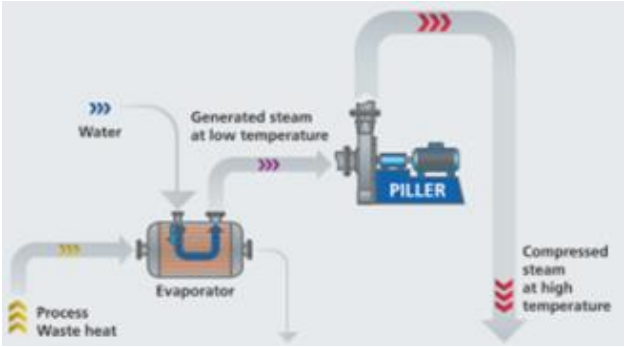

Figure 2: PILLER mechanical vapor compression

In addition to being used for process heating, the compressed vapor can also be used in another process or for the generation of steam or hot water. If it is not a gaseous waste heat stream or if the vapor cannot be compressed, the innovative heat pump cycle with evaporator can be used. PILLER uses water as a working fluid in order to generate steam in the evaporator at a low pressure and temperature (Figure 3).

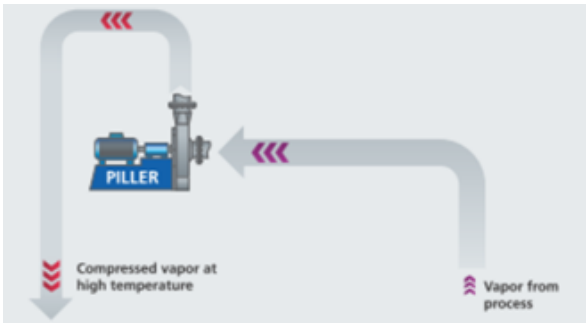

Figure 3: PILLER steam generation

The High Performance Blowers by PILLER bring the steam to the pressure and temperature to drive the process or heating system needs.
The key element of this Industrial Heat Pump Technology is the compression with the PILLER High Performance Blowers (Figure 1, left). The design of the individual blowers and compressors and their interconnection in a multi-stage system (Figure 1, right) are perfectly adapted to achieve the needed compression of the working fluid. With the retrofitted process, vapor can now be compressed while preserving energy and feeding it at the lowest cost into the processes. A multi-stage system also enables the integration of additional heat sources into intermediate stages. More and more companies are successfully relying on this solution with up to eight stages.

- Driving energy: Electric or by steam turbines
- Most relevant applications: Food and beverages, chemical and petrochemical industry, paper industry.
- Compressor technology: radial turbomachine series of single stages
- Lubrication type: Forced-Oil lubricated bearings, no oil in contact with refrigerant/working fluid/process vapors
- Development status: spinning in field since 1980
- Core components of the machines are highly standardized, solutions and systems are custom engineered. Heat exchangers are specifically sized to the needs (third party production).
- Solutions for large industrial plants with high temperature steam demand or direct vapor recompression for heating column reboilers and evaporators
- Possible combination with low temperature heat pumps for upgrading the first cycles heating duty (condenser) into steam at usable temperature level
- Flexible integration into industrial sites, installation on rigid steal structures above existing equipment
- Outdoor and Installation in hazardous area possible

Table 1: Performance.

$T_{source,in}$	$T_{source,out}$	$T_{sink,in}$	$T_{sink,out}$	$COP_{heating}$
[°C]	[°C]	[°C]	[°C]	[-]
92 (hexane/ water/ vapors)	63.9	80 (Water to steam generator)	126/130 saturated steam on two levels	4.38
94.7 (Flash Vapor)	NA – direct compression	94.7 (Flash Vapor)	130.8 saturated steam	7.27
100.3 (Cumene vapors)	86.2	80 (Water to steam generator)	158.5 saturated steam	3.50
53 EtOH/ Water vapors	NA – direct compression	100 (Water to steam generator/ Reboiler)	100 saturated steam	4.56

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Project example

EPDM plant: Steam is used for stripping units where solvents from the reaction process are separated from the product. By introducing steam into the stripping unit, a mixed overhead vapor (OHV) containing steam and solvent vapor evaporates. The OHV is then condensed to recover the solvent. Instead of transferring the heat released by condensation into the environment through cooling towers, it is reused to produce low pressure steam in an evaporator. With a multi-stage mechanical vapor recompression (MVR) system, the steam is compressed back to the pressure level that supplies the stripping unit. The Heat Pumping Technology allows integration of additional heat sources between the stages. In this project, flash vapor was fed into the system in the middle of a Steam Compression Cycle. A special evaporator design and the high flexibility of PILLER Blowers guarantee reliable heat recovery, saving over 80 % in energy consumption and reducing CO2 emissions by 62 % in this single project. In addition to the reduction in steam consumption, the Heat Pump System also reduces cooling water demand, decreasing the overall energy consumption on site. Saving more than 4 Million € annually by retrofitting their existing plants with the Heat Pumping Technology has provided our customer with a payback period of 1.7 years.

FACTS ABOUT THE TECHNOLOGY

Heat supply capacity: > 1MW

Temperature range: 40 – 230°C (212°C saturated steam, 20 barA)

Working fluid: R718 (water), and process vapors (ethanol, methanol, IPA, mixtures, on demand)

Compressor technology: turbo

Specific investment cost for installed system without integration: for > 5MW: 850 €/kW_{th}

TRL level: 8/9

Expected lifetime: 20+ years

Size: Individual (>>1 t, >>10 m²)