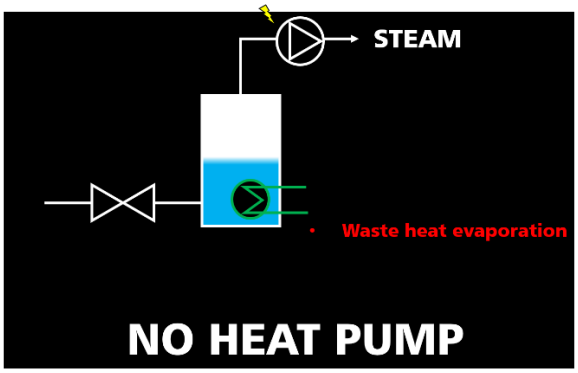
NTB
Interstaatliche Hochschule für Technik Buchs
FHO Fachhochschule Ostschweiz

SCCER EIP EFFICIENCY OF INDUSTRIAL PROCESSES

Steam Generation from Waste Heat

In the SCCER networking event 2016, I presented a study NTB-IES made on the comparison of the process which can be used to produce water steam at 3 bar. The conclusion was that the so-called waste heat evaporation process was the most efficient in terms of energy and the less prawn to emit CO_2.



The interest to produce low-pressure steam for industrial purpose using heat pump technology is growing. More and more research groups are working on it in China, the Netherland and other countRies.

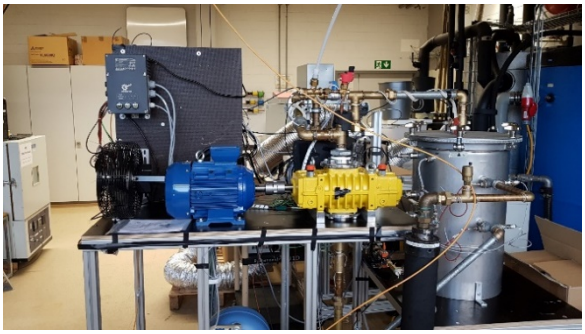
There are however only two heat pumps on the market, which are really designed to generate steam, the SGH120 and SGH165 heat pumps from Kobelco.

Kobelco has already installed some of their heat pumps in two factories in Japan. In Hokkaido Bioethanol Co. Ltd. where the heat pump is using the condensation of the ethanol gas as a heat source and creating steam for the distillation tower. In the company Meito Sangyo Co., Ltd. a similar process is also used where the steam is the heat source of their methanol distillation tower.

These two case studies confirm that steam production from heat pump technologies is coming.

At NTB Buchs, in the institute IES, as of 2019, two experimental setups are producing steam. The high temperature heat pump made by Dr. Cordin Arpagaus. This heat pump was built to test the new HFO/HFCO refrigerants at temperature as high as 150°C.

The other experimental setup making steam is the open loop heat pump using water as refrigerant built by Ralph Kuster. This was built to demonstrate the feasibility of evaporating water below 90°C and compressing it to steam of up to 115°C. This experiment validated the simulation of the system, which was previously made. The result shows a high consistency with the simulation.

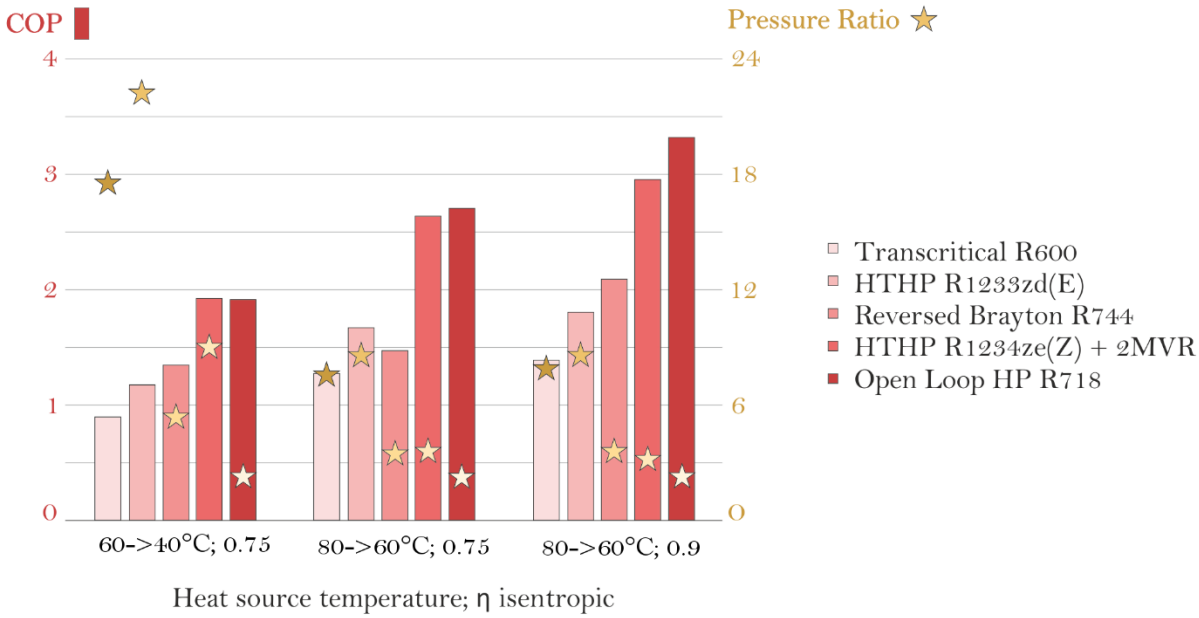


These two experimental systems validated the previous studies, which showed that a high temperature heat pump combined with mechanical vapour recompression is the most beneficial method of generating steam in terms of efficiency and technology readiness level. However, in building the open loop water heat pump, it has been confirmed that there is a lack of steam compressor availability in the actual market.

The technologies of generating steam using heat pumps works and has been validated but the lack of steam compressor is slowing the progression and the adaptation of this method.

The IES Institute from NTB is continuing to increase its competence in steam production. To do so, a steam test stand is being built in order to better characterise the steam producing devices in the future.

Dr. Frédéric Bless and Dr. Cordin Arpagaus are working on a study of heat pump cycles comparison in order to produce steam at 150°C. The graph below displays a summary of the main results of this study so far.



The graph shows the COP of different cycles producing steam at 150°C. The analysed cycle are:

1. transcritical heat pump using R600 (Butane) as refrigerant,
2. high-temperature heat pump (HTHP) using R1233zd(E), a HFCO refrigerant,
3. reversed Brayton cycle using R744 (CO_2),
4. combination of HTHP using R1234ze(Z) producing heat at 110°C with 2 serial mechanical vapour recompression (MVR) steps, and
5. open loop heat pump using R718 (water).

The graph shows the COP of each of these technologies for two different heat source temperatures 60°C and 80°C. The simulation use a temperature glide of 20°C in the heat source. That means that a heat source of 60°C is simulated as a heat source input of 60°C and a heat source output of 40°C. This is very important when the heat pump method has a temperature glide in its source heat exchanger, as it is the case for the reversed Brayton cycle. A pinch point of 5K was taken in each heat exchanger in the simulation. The open loop water heat pump needs 6 compression steps for the 40°C heat source and 4 compression steps for the two 60°C heat source.

The graph also shows results for two different isentropic efficiencies (0.75 and 0.9) of the compressor of the heat pump or the steam compressor.

The pressure ratio indicated in the right y-axis is the pressure ratio before and after the compression step. In the case of the combination HTHP + MVR, the value given is the pressure ratio of the HTHP.

The graph shows that the HTHP + MVR and the open loop water HP are the most efficient and practical solution to produce steam at 150°C in terms of efficiency and pressure ratio.