Do Heat Pumps go industrial?

According to the International Energy Agency (IEA), global primary energy demand is projected to rise by 1.5% per year between 2007 and 2030, the major users being the building, transport and industry sector. The IEA Heat Pump Centre gives the example of the Netherlands, where heat represents 80% of the final energy use, temperatures below 100°C being used mainly for space heating and temperatures above 100°C driving industrial processes. In these industrial processes a lot of heat (around 105 PJ) is lost in waste heat from conversion processes like combined heat and power stations. This waste heat, however, can be used by heat pumps to upgrade and deliver again high temperatures for more industrial processes, recycling used energy resources effectively.

Operating conditions for Heat Pumps

Pinch temperature

The Pinch temperature is where the smallest temperature difference occurs between the hot and the cold curves. Pinch temperature analysis maps heat flows and thermodynamic opportunities for heat exchange between process flows and analyses energy use in industrial processes. For heat pumps to render processes more energy efficient they must transfer heat from temperatures below the Pinch temperature to temperatures above.

Above Pinch temperature

Industrial processes such as the production of steel, glass, ceramics concrete etc. very often demand high temperatures of above 600°C. The temperature of heat used for heating raw materials and driving separation processes is generally between 100°C and 250°C. Most common are these processes in the chemical, food processing and pulp and paper industry. According to the IEA Data services (World Energy Balances 2007) raw materials heating and separation processes make up about 50% of the world's industrial energy use.

Below Pinch temperature

Heat pumps in general use sources of heat that can be upgraded. The waste heat from industrial processes that is typically between 50°C and 150°C (except for waste heat from flue gasses which is above 200°C) is one such source. Heat pumps can be applied for heat production of 100-250°C and should manage temperature lifts of up to 100°C.

Classification and developments

Heat pumps can be divided into

- work driven

- thermally driven
- hybrids

In work driven heat pumps temperature lifts are realised through mechanical work, powered by an electric motor. The Energy Research Centre of the Netherlands (ECN), for example, is developing a thermoacoustic heat pump in which a linear motor converts electrical power into acoustic power driving the heat pump. Wide temperature ranges (-100°C to 600°) and high temperature lifts (up to 100K) can be achieved.

Thermally driven heat pumps use with the help of heat transformers waste heat with minimum temperature levels of around 100°C to generate temperature lifts. Compared to conventional sorption heat pumps, higher operating temperatures and larger temperature lifts can be achieved. Heat pumps that use the reversible absorption of ammonia in salts or hydrogen in metalhydrides can even deliver temperatures above 200°C. ECN is developing a prototype high-temperature heat transformer system that uses a combination of LiCL and MgCI2 with ammonia and achieves temperature lifts from 130°C to 200°C.

Ever scarcer resources and rising energy prices increase industry's motivation to opt for alternative technologies. Policy makers, too, slowly start to acknowledge the potential of heat pump technology to help achieve our energy saving and climate targets, especially in combination with the use of ammonia. For the latter, some countries' restrictive safety regulations are still a major hindrance for wide-spread uptake. But luckily, this is slowly changing too as proven by France, which just recently dismantled some unnecessary hurdles in their ammonia regulations.