The power of collaboration: Making heat pumps work for the paper industry

Jori Ringman, Director General, Cepi

INTRODUCTION:

A recent collaboration between associations representing the European paper manufacturing and heat pump sectors, Cepi and EHPA, has resulted in innovation which could produce energy savings of 50% in paper manufacturing. It could also be key in further decarbonising one of Europe's energy-intensive sectors. But EU regulators need to speed up incentives for affordable clean energy.

Heat pumps are enabling energy savings for many industries.

Photo: Courtesy of SPH Sustainable Process Heat GmbH.

Already today, heat pumps are enabling energy savings for many industries. They provide about 10% of final industrial energy demand in Europe, and help to lower industrial emissions across many sectors. A recent development is that commercially available large heat pumps and steam compressors can now heat up to 200 °C, meeting the pulp and paper industry's needs.

The innovation has been encouraged by exchanges between both industries at European level. A joint working group between members of the European paper and heat pump industries calculated potential energy savings in paper drying of more than 50%, and a joint Cepi-EHPA paper detailing how heat pumps could be integrated into paper mills has now been published and available on Cepi website.

The European paper industry runs about 1,200 paper machines altogether, each of which produces an average of 80,000 tonnes of paper a year. As part of the production process the industry generates waste heat from the paper machines' drying section. One area of particular impact would be to use it as a source to heat the condensate coming from the cylinders into steam for further drying needs.

Decarbonisation through collaborations

The partnership between EHPA and Cepi tells the story of how collaboration can result in innovation breakthroughs, with real decarbonisation impacts. This is the purpose of Cepi's Energy Efficiency Solutions Forum (EESF), hosting the joint working group, where front-running companies can exchange and learn from each

other's efforts to implement cutting edge technologies. The format of the EESF is frequently hailed as a model for other industries' collaborative decarbonisation efforts.

"When Cepi launched the EESF in 2020, heat pumps were investigated but were not yet reaching high enough temperatures. Through the candid collaboration between both sectorial associations, the technology now matches our needs. It will be an important building block in reducing the energy needs in the paper industry," says Jori Ringman, Director General of Brussels-based Cepi, the trade association of European paper industry.

Why heat pumps?

The most common type of heat pump is the compression heat pump. It transfers and upgrades thermal energy from waste heat sources, to 'heat sinks' using a small amount of additional 'driving' energy - usually electricity.

The thermal energy from the heat source is transferred via a refrigerant liquid. Inside what's called a 'heat exchanger' the refrigerant turns into a gas. The gas reaches a 'compressor' which, with the help of a small amount of extra energy, 'squeezes' the gas to a high pressure, causing a rise in temperature. This hot and highly pressurised refrigerant gas then releases its heat into the 'heat sink', the refrigerant turning back into a liquid as it cools. Its pressure is lowered, and the cycle begins again.

The efficiency of a heat pump is expressed as the Coefficient of Performance or COP. It is the relationship between the power input and the useful heat output of the heat pump. The higher the number, the more efficient a heat pump is and the less energy it consumes. This COP highly depends on the temperature difference between the heat source (TC) and the heat sink (TH), where the 'Carnot curve' indicates the theoretically maximum efficiency (COP), depending on the source and sink temperature. For example, a heat pump system with a COP of 2,5 means 60% energy savings can be achieved.

$$COP_{heating} = \frac{T_H}{T_H - T_C}$$

How would it work in a paper mill?

The ideal heat source would be exhaust air of drying hood. Currently 60 °C is the maximum dewpoint in paper production. This is an ideal source of waste heat that heat pumps could use.

Developments are ongoing to reach higher dewpoints to improve the system COP. This requires further closing the drying hood. Airless or superheated steam drying would result in the optimum energy efficiency.

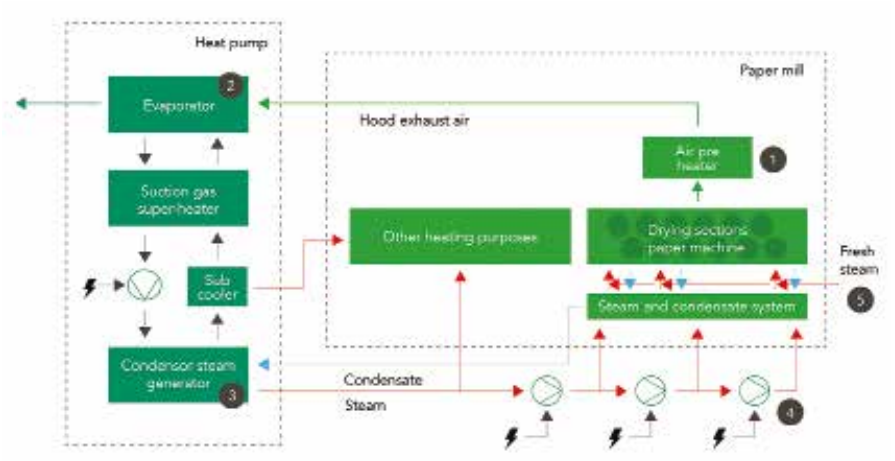

Figure 1: How a heat pump can be integrated into the paper production process

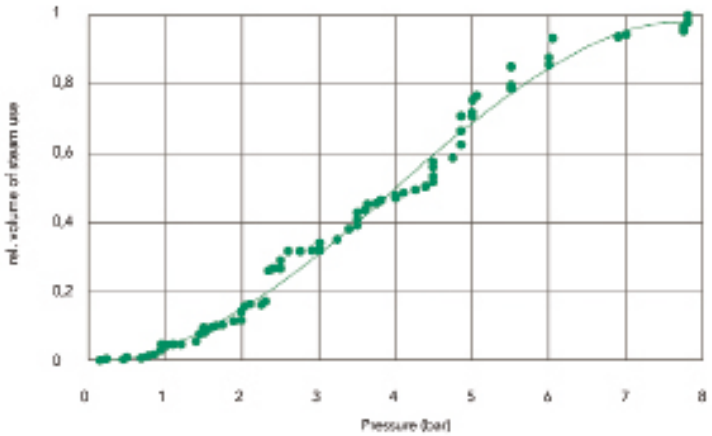

Figure 2: Range of typical steam pressures in a paper machine. 70% of steam use in the European paper industry is below 5 bar.

The heat sink in paper machine would be steam heated cylinders. The amount of steam sections depends on the product manufactured, but paper machines normally have four to six drying sections. The drying is done by steam-heated cylinders.

On average, the total electricity needed for the steam used by one paper mill is 30 MW. The cylinders normally require between four tonnes to more than 70 tonnes per hour of steam each.

Typical steam pressures range from 0 to 8 barg. In most paper mills, steam pressures are different in each drying section, with low pressures in the first sections and higher pressures in the last drying sections. Pressure levels also fluctuate by a maximum of 20% depending on paper grades and grammages.

Using lower steam pressures in paper drying, by decreasing the heat sink temperature, also increases the heat pump system's efficiency.

Business case requires correct policy

"The progressive phase-out of the fossil fuel alternative in industrial applications will be essential to building a business case. It will also be driven by high energy costs and the increasing CO2 price where clean energy clearly offers a beneficial solution," said Thomas Nowak Secretary General of European Heat Pump Association at the launch of the collaboration results.

Whether or not heat pumps can be rapidly deployed in paper mills across Europe now depends on the regulatory incentives that national government and EU Institutions can provide for electrifying the sector, which will require large amounts of affordable clean energy to meet the challenges set in the recently announced EU Green Deal Industry Plan.

"The industry will continue doing its part in reducing energy consumption and heat pumps can play an important role in that. Combined with access to affordable fossil-free energy heat pumps will allow for a full transition towards a decarbonised and circular economy based on bio-products," says Ringman.