Task 2 – Sector Collaboration: Integration possibilities of HTHPs

[Pulp & Paper] – Felix Schoeller in Osnabrück, Germany

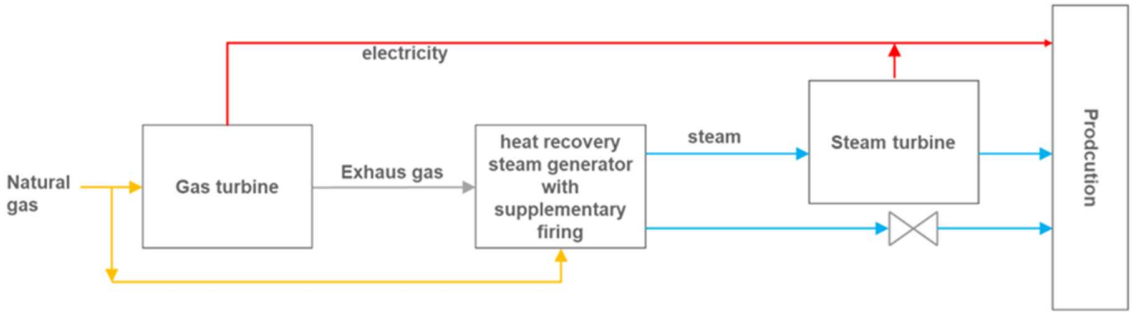

Figure 1: Typical production processes with combined heat and power supply on side

Overview of Key Production Processes

The specialty paper factory of Felix Schoeller GmbH & Co. KG in Osnabrück is located in the free state of Lower Saxony in Germany. 860 employees on that side are producing around 120.000 t of paper a year. Steam is currently produced by means of a central boiler that burns natural gas. With a consumption of nearly 120.000 MWh/a of steam the paper machine 1 (PM1) has the main energy demand in the mill. Most of that heat is used for the drying process. The paper factory has a yearly demand for natural gas of 280 GWh (0,0382 Gm3 NG). The yearly demand for electricity and process heat accounts for 84 GWh_{el} and 220 GWh_{th} (steam). The CO_2-emissions for providing these process energies are 57.000 tCO_2 per year. 100% of these process energies is provided by Combined Heat and Power (CHP) units installed on site.

The CHP supply system consists of one gas turbine and a steam turbine producing in total 8 MW_{el}. Steam is generated at two flue gas fired steam boilers with a maximal production capacity of 80 t/h. Figure 1 shows the simplified CHP system at the demo site. Steam is generated at the pressure levels of 6 bar(a) and 11 bar(a). An overall thermal efficiency of 0,8 can be assumed for the process steam production.

Integration concept system/process

The HTHP system will be integrated to recover the waste heat from the moist air leaving a paper drying machine, and to provide steam to the main steam circuit supply, as a partial replacement of the fossil fuel (natural gas) used on-site. This will be led to less CO_2 emissions related to the thermal energy supplied by the new heat pump system.

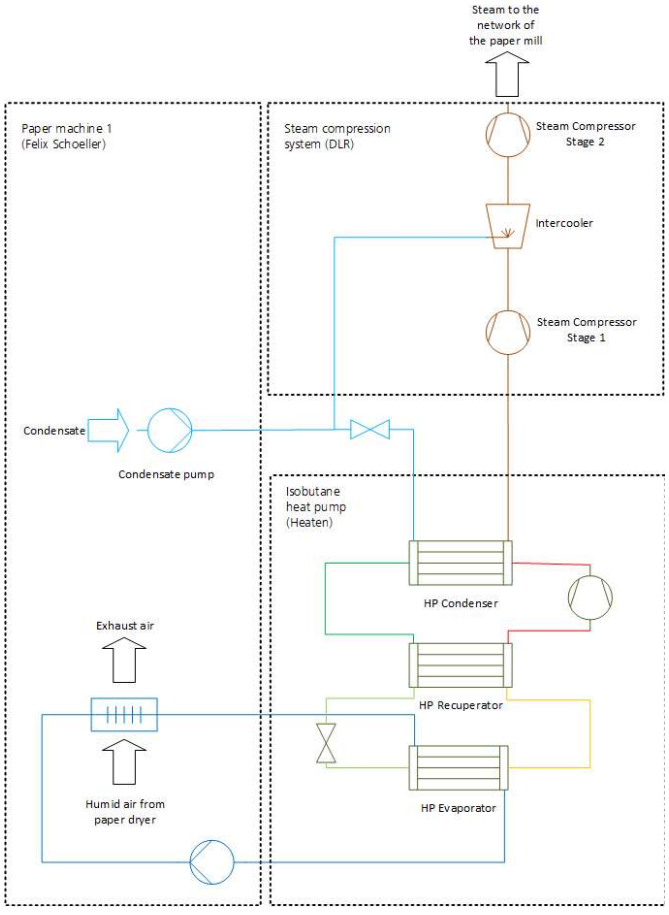

Figure 2: Integration concept of the HTHP system

The HTHP system consists of a bottom HTHP with isobutane as its working medium that will directly generate steam at 100 °C to 135 °C, without flash tanks. The steam from the bottom HTHP will then be further compressed by a two-stage turbo compressor. The bottom HTHP is provided by HEATEN based on their own piston compressor, and the steam compressors will be developed by DLR. After the first compressor stage, the steam will be at 2.4 bara (132 °C), the supply conditions needed by the paper mill, thus achieving a pressure ratio of 2-2.3 with a single stage centrifugal compressor, which is low compared to typical installations in the pulp and paper industry. The second compressor stage will further raise the pressure to 11 bara (~271 °C), thus reaching a compression ratio of 5-6 with only two compression stages in series. The aim of the second stage is to develop a replicable integrated system, specifically designed for the needs of the pulp and paper industry that HEATEN can then potentially integrate to its own product portfolio. This builds on DLR's experience from design and operation of two similar smaller compressor stages in its own pilot facility, which will be leveraged within EEETHOS to bring the technologies to a TRL of 7. DLR expects to reach a total efficiency of around 75 % for the first stage and around 70 % for second stage, while the integrated (bottom HTHP + compressors) will have a COP of ~2.2 for the delivery of steam at 11 bara.

FACTS ABOUT THE CONCEPT

Heat Sink: 10 – 11 bar(a) at test rig, 5 – 6 bar (a) in the demo case

Heat Source: Humid air from paper dryer, Hot water cycle and Condensate for intercooler, 70 °C up to ~ 50 °C

Bottom heat pump by HEATEN: Isobutane heat pump with recuperation, Source: 55°C up to 50°C, Sink 95°C up to 125°C, up to 2.5 bar(a)

Compressor system by DLR: 2-stage steam compression with intercooler, Design and 200h operating hours for 11 bar(a), Process steam integration up to 6 bar(a) at demo case

Main advantages: CO_2 reduction

Main challenges: Control, Paper breaks

Maturity: Development perspective of TRL7

Demonstration cases: Felix Schoeller GmbH & Co. KG in Osnabrück, Germany