

Future Focus – Steam Generation and High Temperature Heat Pumps

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Steam in industries is generated using oil or gas-fired boilers and even sometimes electrical heaters. A theoretical analysis has been made to compare several processes for a low-pressure steam network of 3 bar. A standard boiler, a high temperature heat pump (HTHP), and a low-pressure evaporation system combined with a steam compression stage, using either a heat pump or waste water as heat source, were analyzed in terms of energy consumption, operating cost, and CO₂ emission. Figure 1 depicts the different processes. Results show that, when existing waste heat is available, low-pressure evaporation processes are better in all the factors. The HTHP shows a good compromise in terms of CO₂ and energy consumption between the low-pressure evaporation processes and the standard boilers. The operating cost is slightly lower than a gas-boiler depending on the heat source temperature of the heat pump. Another advantage of the HTHP is that it does not need any steam compressor.

In addition, the current state of the art and actual R&D activities of HTHPs are reviewed. More than 20 commercial HTHP models from over 10 manufacturers have been identified. A few heat pump suppliers already manage to supply 120°C heat. The heating capacities extend from about 20 kW up to 20 MW. Great potential is found in processes of the food, paper, metal, and chemical industries. Most heat pump circuits are 1-stage and differ in the used refrigerant and compressor type. COP values of 2.4 to 5.8 are reached for a temperature lift of 95 to 40K. Various laboratory scale HTHPs have been built and tested to demonstrate the technical feasibility of reaching higher sink temperatures. R1336mzz(Z), R718, R245fa, R1234ze(Z), and R601 are the mostly investigated refrigerants. Outstanding high temperatures of 160°C are reached with the HFO R1336mzz(Z). Based on the developed literature study, a concept is proposed to set up a laboratory HTHP demonstrator prototype within the next phase of SCCER-EIP (Figure 2).

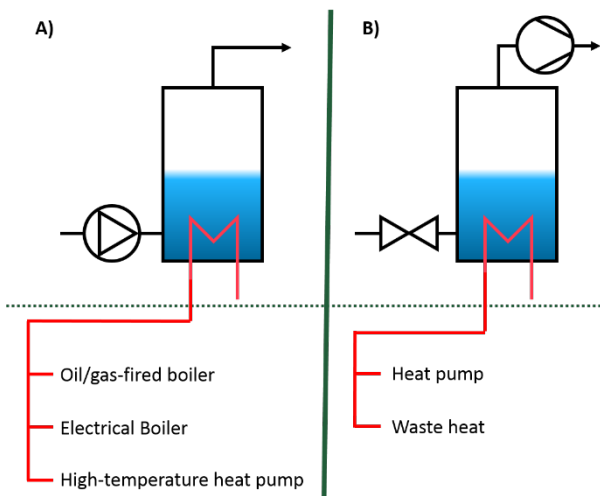


Figure 1: A) high-pressure and B) low-pressure evaporation processes to generate steam.



Figure 2: High temperature heat pump demonstrator prototype in construction at NTB Buchs.