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Pinch-Analysis
Cerbios-Pharma SA, Barbengo (Lugano)

Heat Recovery in a Production Site for Chemical and Biological Ingredients

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1 Summary

Cerbios-Pharma SA (Cerbios) is a privately held company located in Lugano that specializes in the development and manufacture of both chemical and biological compounds. The production and its auxiliary processes cause an annual electricity consumption of 4.6 GWh. Process- and building heating consumes 5.6 GWh of natural gas.

The entire natural gas is consumed by two steam boilers which produce saturated steam at a pressure of 8 bar, which corresponds to a condensation temperature of 175°C. The generated steam then is distributed to a total of 8 different building-modules where it is used either directly for process heating or for heating the hot water circuits of the heating and ventilation systems by a steam converter. Due to the particularly strict air quality requirements in the pharmaceutical industry, about 45% of the total heat is used for heating and ventilation, the other 55% for production processes.

During the Pinch-Analysis all relevant heat sources and sinks have been analyzed, as well as all the heating circuits in the different buildings. Based on this information a heat recovery concept was developed, the energy savings calculated, and the investment cost estimated.

Passive heat recovery is limited to the flue gas of the steam boilers, which can be used to heat two fluidized bed dryers next to the boiler house, saving 430 MWh of natural gas annually. However, with the installation of a 730 kW heat pump, natural gas consumption for heating and ventilation can be almost completely substituted. The largest source of waste heat for the heat pump are the two ammonia chillers for the preparation of the ice slurry, which covers most of the cooling demand on the entire site. Additionally, the waste heat of a second chiller and the exhaust air of two fluidized bed dryers will be used.

Since the heat generated by the heat pump cannot be distributed via the steam network, its realization is only possible if a low-temperature heating network is installed at the same time. This considerably increases the total project costs. Nevertheless, Cerbios has decided to further study this approach.

With implementation of the recommended measures the annual consumption of natural gas is reduced by 2’930 MWh (52%), using an additional 560 MWh of electricity for the heat pump. This results in a reduction of the total energy costs by 117’000 CHF per year. With estimated investment costs of around 1.6 million the payback time is 14 years. Considering additional earnings from selling CO_2 certificates through a CO_2 Compensation Project the payback time is lowered to 10 years.

2 Performed activities

- Analysis of existing data and schematics
- Creation of a simplified principle schematic (current situation)
- Modelling of heat sources and sinks (input PinCH-Software)
- Design of the theoretically optimal heat exchanger network (Pinch-Method)
- Design of the technically feasible heat exchanger network, derived from the theoretical optimum (also considering the distances to be covered by new pipes)
- Creation of a schematic diagram of the heat exchanger network (optimized situation)
- Specification of the heat pump (heat output and operating temperatures)
- Specification of all connections to existing systems (hot water circuits / cooling system)
- Definition of locations for the main components
- Calculation of the resulting energy and cost savings
- Estimation of investment costs for pipe work, connections, and water/water heat exchangers
- Estimation of revenues from the sale of CO_2 certificates

3 Results and recommendations

Passive heat recovery

The flue gas of the two steam boilers (2x 2’100 kW) is the only source of waste heat suitable to be used directly in another process. Two fluidized bed dryers, which are installed right next to the boiler house, serve as heat sinks. In one of them, ambient air must be heated up to 140°C to regenerate an adsorption wheel. In the other, process air must be heated up to 70°C after it has been dehumidified in a cooling coil at 3°C.

The proposed heat recovery system is designed as a closed loop system in which the two flue gas heat exchangers and the two finned tube heat exchangers of the dryers are connected in parallel. As a result, 430 MWh of natural gas for the steam boilers are substituted annually. Excess waste heat is transferred to the cold storage tank of the heat pump via an additional heat exchanger.

In principle, the waste heat of the air compressors (2x 55 kW_{el}), which are located directly next to the boiler house, could also be integrated into this circuit. However, this is only implemented when the compressors need to be replaced, since the modification of the existing compressors is to expensive compared to the available waste heat of 150 MWh. Nevertheless, the corresponding connections should already be provided when realizing the heat recovery of the flue gas.

Low temperature heating network

Currently, the entire heat is generated by two steam boilers and distributed to the different building-modules by a steam network at 8 bar (175°C). The heat distribution for heating and ventilation inside the different buildings, on the other hand, is achieved by a total of 6 independent hot water circuits at a supply temperature of only 50°C to 60°C.

Since heating and ventilation accounts for 45% of the total natural gas consumption, it is the most important consumer of waste heat at low temperatures. But while the heat consumption is distributed across all buildings, the waste heat is mainly generated in the central technical building.

Due to the high temperature level, however, the steam network is not suitable for distribution of the waste heat to the different buildings. To use the waste heat produced in the technical building, the existing heating circuits must be connected by a new low-temperature heating network.

Active heat recovery with heat pump

The largest source of waste heat are the two ammonia chillers for the preparation of the ice slurry, which covers most of the cooling demand on the entire site. These dissipate annually about 2’500 MWh of heat to the ambient. Due to the low temperature level of the waste heat between 25°C and 40°C, the installation of a heat pump is necessary to use the heat for heating and ventilation at temperatures of 50°C to 60°C.

To balance the load changes between heat sources and sinks, a system with a heat pump and a storage tank on its cold and warm side is proposed. The cold storage tank is operated at a temperature of 15...20°C, which allows the additional use of waste heat from another chiller and the exhaust air from the two fluidized bed dryers. Based on the available heat sources, a heating capacity of 730 kW and an annual natural gas saving of 2’500 MWh was calculated for the heat pump.