Optimal retrofit of a heat recovery network at a pulp and paper mill for minimizing energy and water consumption

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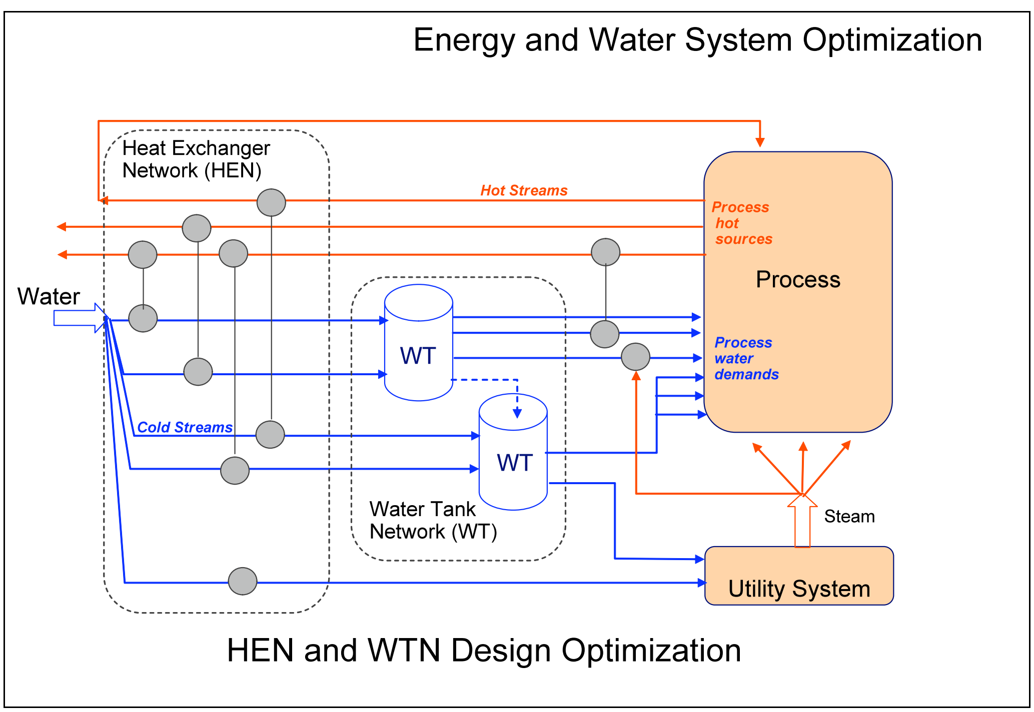
Abstract
The overall energy efficiency of a pulp and paper mill is directly influenced by the design of both the water system and the heat transfer network. In this industry, energy and water systems are linked through the water tank network, and consequently, the production of warm and hot water should be carefully evaluated to identify design improvements. In order to identify the best plant modifications, one requires a systematic retrofit approach that identifies and evaluates the water and energy interrelations; the goal of this approach is to design a water system minimizing the overall energy consumption of the mill. The figure below illustrates the main elements that influence the overall energy consumption at a Kraft pulp mill.



In the diagram it can be seen that there are given water sources (maybe a single one) whose temperatures and flow rates are known. The water follows various paths in parallel through heat exchangers and storage tanks; note that some of the water is then required at the process units and it is assumed that the temperatures and flow rates of the demands are also given. The heat transferred to the freshwater streams is also dictated by the cooling process needs and is known. Additional constraints pertain to the temperature of the effluents from the mill.

The energy demand is represented in this diagram by the steam provided by the utility system to complete the heating of the water streams (since heat recovery provides only part of the required heating). Clearly a poor design of the heat recovery network will lead to an increase in the consumption of fuel for steam generation.

The main options available to the design engineer include the following.

1. Redesigning the heat exchanger network (that is, designing an alternative set of matches between hot and cold streams).
    - Adding new heat exchangers.
    - Replacing the parallel structure of the network by a serial structure or a combination of both types.
    - Replacing the heat exchangers by direct heat transfer.
    - Splitting streams and bypassing some units.
2. Retrofitting of the water allocation problem.
    - Water sources to tanks and on to the process.
    - Reusing the water between processes.
    - Adding new tanks.
    - Modifying the temperature of the tanks.

Here are a few additional elements that could also be included in the analysis to produce better solutions.

1. The utility system involves the generation of steam at various pressure levels that are used to satisfy heating demands and to generate electricity; there is an interesting trade-off between energy savings and power generation that could be added to the model.
2. There is a close link between the use of steam as heating agent and the use of water as raw material; this link must be included in the evaluation.

3. The water and steam demands depend upon the time of year and the operating conditions; the proposed design should be robust, i.e., it should minimize the consumption of resources regardless of the expected variation in water and steam demands.