Abstract

Sappi's Ngodwana integrated Kraft pulp and paper mill was used as case study for the application and evaluation of the water pinch technique. The technique of water pinch originates from energy pinch, but uses mass flow and contaminant concentration to identify water and effluent reduction opportunities. The classical meaning of pinch, as defined by energy pinch has however been changed to a more modern meaning. Historically the terms water or energy pinch was used to refer to the points where two composite curves touched on energy or water graphs. This graphical meaning of pinch is gradually being replaced to refer to the optimal point proposed by a numerical solver beyond which improvement of the water network is no longer possible for the given inputs. The water pinch technique was applied by means of a numerical solver that used mixed integer non-linear programming to optimise to the minimum cost for running the water network under investigation. The problem definition was defined in terms of costs associated with the use of utilities, raw material, treatment facilities and process units. It was also possible to define factors such as environmental impact, corrosion, fouling, scaling, cooling tower treatment cost, legal risk etc in terms of a penalty cost. The water pinch technique has been refined in software packages that are user friendly, capable of handling multi-contaminants and suitable for varying flows. The software package WaterPinch™ by Linnhoff March was used. The case study was applied on Ngodwana mill that has an already highly closed water system with effluent generation rates as low 20 kL per ton of pulp and paper. The pinch study included sodium, chloride, calcium, suspended solids and COD as contaminants. The study investigated different applications of the pinch technique. The following was concluded:

- The mill's understanding of its current restrictions, or pinch points, of its water network was confirmed. No new pinch points have been identified of which the mill was not aware. This indicates that the mill was already highly knowledgeable about its water system. This was expected of a mill that has a very low specific-effluent-generation rate. Water pinch was unable to significantly improve on the effluent generation rate of the mill.
- The pinch analysis has identified opportunities of mixing small quantities of waste streams into process water streams to replace fresh water. These changes can introduce minor water savings and new risks to the process that have to be understood better before implementation.
- The mill has progressed far with the design and costing of a proposed effluent treatment plant (ERP1). The integration of this treatment plant into the water network was investigated using the pinch technique. The pinch solver suggested a totally different approach to the integration of the ERP1 plant compared to design of the mill. The mill's design revolves around the treatment of low chloride streams in the ERP1 plant and using of the treated water as make-up to the cooling towers. Sodium was recovered as raw material from the cooling towers' blow-down. Pinch proposed treatment of the high chloride containing streams and returning the streams to users suitable of using high chloride water. The network proposed by mill's design generates 8.2 ML/day effluent less than the pinch proposal, and recovers sodium as raw material. The proposal presented by pinch is not recommended and points to the difficulty in simulating factors, such as raw material recovery, in a pinch analysis.
- Users for the excess storm water were identified using water pinch and will be suitable for implementation. The mill has however decided on alternative sinks for the storm water based on considerations such as process inter-dependency, risks associated with contamination and general management philosophy for the different systems in the mill. These considerations could have been included into the pinch solver, but were not because it was of interest what the second best option would be.
- The pinch investigation proved useful to confirm certain understandings of the mill. The investigation confirmed the difficulty of improving the water systems of the mill due to the fact that Ngodwana is already a highly closed and integrated mill. Numerous smaller process changes have

been identified by the pinch solver and could be investigated further for smaller process improvements.

- It is recommended that pinch technology be applied again when the mill plans to make major process changes or expansions. It is also recommended to use water pinch on a more frequent basis in smaller sections of the mill or for other evaluations in the mill. As a group Sappi could benefit from the use of water pinch, especially in situations where the water network of the mill is not already water efficient.
- The recommendations and conclusions in this report have not been subjected to technical and economical feasibility studies. Extensive further studies must be conducted before implementation of any of the results. Further studies must include impacts from process dynamics, long term effects, impacts from other contaminants that have not been simulated, etc.

Keywords: Water pinch, energy pinch, water network, composite curves, kraft pulp and paper mill