Abstract

Pulp and paper mills are facing the possibility of stricter effluent discharge limits. End-of-pipe treatment for discharge no longer guarantees compliance, nor is it the most cost-effective way of solving mills' effluent problems. In this dissertation, water pinch analysis is used as a tool to determine the optimum effluent treatment conditions to ensure compliance at the least cost to the mill. It is also shown that the environment and the mill can benefit simultaneously if the correct effluent discharge philosophy is implemented.

Mill simulation results were used to set up a water pinch analysis model. Maximum permissible inlet concentrations were specified for all process units. Mass transfer equations were used to describe the relationships between inlet and outlet concentrations of the process units. A number of generic effluent treatment units with preset performance specifications were added to the pinch model. These treatment units can be sized and used in an optimal way by the pinch model to obtain an optimum effluent treatment and recycling scheme. Capital and operating costs for different treatment units were included in the analysis. The capital cost for treatment units decrease as the volume treated by the unit decreases. The operating cost is generally expressed in terms of volume; however, certain treatment units have treatment cost expressed on load treated rather than volume.

The validity of the results obtained from *WaterPinch*™, the pinch analysis software used for building the pinch model, was checked by using a process simulation package, *WinGEMS*™, to simulate the proposed effluent treatment scenarios. This step ensured that the mass transfer relationships used in the water pinch model were valid. This was an important part of the work, as the results generated by the optimisation model have to be reliable in order to make the results obtained applicable to the mill.

The verified water pinch model was used to find optimum treatment plant layouts for different effluent discharge volume and concentration specifications. This resulted in an optimum-cost profile for a range of effluent discharge volumes and concentrations.

Optimum-cost profiles could be a decision making tool in the negotiation between the mill and the regulatory authority to set effluent discharge regulations in such a way that the environment benefits without unnecessarily restricting economical and social development of the region.

Using optimum-cost profiles, the differences between a load-based and a concentration-based discharge permit was illustrated. Comparing the pinch analysis results for these scenarios showed that the mill has no financial incentive to reduce effluent volume if a concentration-based permit is in place. However, a load-based permit could make it financially viable for a mill to reduce effluent volume and load rather than to simply treat and discharge. It is also shown that both the mill and the environment (river) benefit from a load based permit.

The impact of possible future waste discharge charges on the economical feasibility of various effluent treatment options is also investigated. The results indicate that the implementation of waste discharge charges will only benefit the environment if it is linked with a load-based effluent discharge permit. This illustrates the usefulness of pinch analysis as a basic risk analysis and risk management tool.