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CAUTION:
This TIP may require the use, disposal, or both, of chemicals which may present serious health hazards to humans. Procedures for the handling of such substances are set forth on Material Safety Data Sheets which must be developed by all manufacturers and importers of potentially hazardous chemicals and maintained by all distributors of potentially hazardous chemicals. Prior to the use of this technical information paper, the user should determine whether any of the chemicals to be used or disposed of are potentially hazardous and, if so, the user should follow strictly the procedures specified by both the manufacturer, as well as local, state, and federal authorities for safe use and disposal of these chemicals.

Evaluating reverse osmosis for treating makeup to the boiler feedwater in a pulp and paper mill

Scope

Reverse Osmosis (RO) technology is consistently improving, making it feasible to reduce the cost of boiler feedwater make up treatment in an increasing number of systems. RO systems have their greatest economic advantage where the dissolved solids content of the raw water is high because the cost of treating water by RO is relatively independent of dissolved solids in the water supply. By contrast, ion exchange costs change nearly in proportion to the dissolved solids content of the water supply. To determine if RO will provide economic benefit in any given mill, it is necessary to perform a thorough technical and economic analysis.

This document describes a typical reverse osmosis system and discusses the various capital and operating costs that need to be considered when evaluating the potential economic benefits of an RO system.

Definitions

Crossflow filtration: the application of pressure to force water through a membrane while flow is tangential to the membrane surface.

Electrodeionization: a process that uses ion exchange resin, ion exchange membranes and electricity to remove ions from the product stream and concentrate them in the waste stream.

Reverse osmosis: a process in which water is forced through a semipermeable membrane by applying pressure in excess of the osmotic pressure.

Semipermeable membrane: a thin membrane that allows passage of water but few ions.

Safety precautions

Whenever people are working with chlorine or acidic or caustic solutions, extreme care must be taken to avoid inhalation of gas fumes or mist or direct contact with the skin or eyes.

Technical information

What is Reverse Osmosis?

Reverse osmosis (RO) is a cross-flow filtration system. The filter is a semipermeable membrane that removes contaminants as small as ions from water. In a typical RO system, the membranes are positioned in series in a pressure vessel (Figure 1). A number of pressure vessels are then positioned in parallel to form a stage and two or more stages are positioned in series to form an array.

Figure 2 shows a 4 – 2 array. In this array the total feedwater enters the first stage. As the flow passes along this stage progressively more of the stream passes through the membrane as permeate consequently, the flow rate of the feed stream diminishes and the concentration of the contaminants increases. Just before the flow rate becomes so low as to cause operating problems, the feed stream exits the first stage and enters the second stage that has about half the membranes as the first stage to increase the feed stream flow rate.

Permeate from both stages is combined to provide the treated water and the remainder of the feed stream is rejected to other uses or waste. RO systems are normally designed to remove about 98% of the dissolved solids in the makeup water. In some instances removal of 99% of the dissolved solids may be achieved. Dissolved gases such as carbon dioxide and oxygen are not removed.

What needs to be considered

Evaluations to assess the economic benefit of installing a reverse osmosis system need to include both the capital and operating costs of the total system. Costs for the RO unit, membrane cleaning and replacement, pre and post treatment, waste disposal and shelter all need to be considered in making the evaluation.

Capital costs

Reverse osmosis unit

Capital costs are primarily dependent on the amount of water to be treated, the design of the RO system, the type of pretreatment required and the required quality of the finished water. The membranes selected affect the design and ultimately the performance of the RO machine. Consequently, recommendations of the membrane manufacturers should be considered in the selection of the best membrane or membranes for the system. The operating pressure and design flux should be consistent with the recommendations of the membrane manufacturer. The units should be installed such that there is plenty of room for removing and installing membranes. At least one length of element is necessary between both the feed end and the brine end and any equipment, walls or supports.

Lines to handle the permeate should be stainless steel and the storage vessels should be either stainless steel or lined to avoid corrosion of equipment and contamination of the treated water with corrosion products. The units should be set up for easy sampling of all vessels permeates. These sample points should be set up so that a probe tube can be used to sample permeate along the length of the pressure vessels. Sample points on the feed, concentrate and interstage headers can help identify the location of any problems.

The sample points should be instrumented so that conductivity, pressure, temperature and flow measurements are made on the feed, concentrate and permeate of each stage. This data should be monitored regularly so that early signs of trouble can be detected and corrective action taken before the unit has to be removed from service.

Therefore, a comprehensive systems control package should be a part of the RO system and should include:

Programmable Logic Controller, Flow Controller, Conductivity Controller, pH Controller, Temperature Indication and Pressure Indication. All controls should be located on a central panel with either indicator lights or a Human Machine Interface (HMI).