



## Two Effect Vertical Tube Falling Film

### Overview

This describes a two effect vertical tube falling film system designed to concentrate a 32 wt% caustic soda solution to 50%. Some of the factors which were considered in the process selection and equipment design include:

- ? Utilizing partial recirculation to minimize capital and operating costs and allow for maximum turndown capability (to 18 tons/day as 100% NaOH).
- ? Minimizing material cost and corrosion by the flow sequence and the distribution of the differential temperature (delta-T).
- ? Selecting a control scheme for ease of operation.

### Vertical Tube Falling Film Evaporation

In falling film vertical tube evaporators liquid is distributed evenly over the top tube sheet and falls in a thin film down the inside of the tubes. Some of the water evaporates from this film as the liquid absorbs heat from condensing steam on the outside of the tubes. For every kilogram of steam that condenses, approximately one kilogram of water is evaporated from the liquid film. The driving force for this heat transfer is the delta-T, the difference between the boiling liquid temperature and the condensing steam temperature.

The steam is mostly water vapor but also contains air and other noncondensables. These noncondensables will stay in the vicinity of the tube walls and impede heat transfer unless swept away by sufficiently high vapor velocities and proper venting. A vent on the evaporator body continuously removes the noncondensables to maintain high heat transfer coefficients.

### Process Flows - NaOH

The 32% NaOH enters the system in the second effect where it is concentrated to about 38.5%. The 38.5% NaOH is pumped to the first effect where it is concentrated to the desired 50%. All concentrations are presented in weight percent (wt%).

Because the operating temperature in the second effect is only 88°C, 304L stainless steel can be used. The corrosion rate is less than 1 mil/year (0.025 mm/year). The first effect must be nickel because it operates at a much higher temperature (about 144°C).

The 304L SST surface area in effect 2 is greater than the nickel surface area in effect 1 to reduce system cost. There is a fixed differential temperature available for heat transfer. By increasing the heat transfer surface in effect 2, the surface in effect 1 can be reduced. Both effects use partial recirculation to achieve a sufficiently high wetting rate to keep the tubes evenly wetted during turndown conditions. At full capacity, however, a once-through flow sequence is used to maximize the available heat transfer driving force (delta-T).

### Process Flows - Vapor

The boiler steam entering the system condenses in the first effect tube bundle. This steam flow is regulated to maintain the final concentration at 50%. Water vaporized in the first effect serves as heating steam in the second effect. Water vaporized in the second effect condenses in a surface condenser.



The pressures vary from about 5.9 kg/cm<sup>2</sup>(abs.) in the shell of the first effect to almost a full vacuum in the condenser. The pressure difference is what allows the steam produced in one effect to generate more steam in the subsequent effect. Noncondensables vent from effect to effect to the final condenser and are removed from the condenser by a liquid ring vacuum pump.

### **Process Flows - Condensate and Distillate**

The condensate from the first effect flows through one of the liquor preheaters and leaves the system. The distillate from the second effect combines with distillate from the final condenser in the distillate level tank. A pump discharges the distillate from the system.

### **Preheating**

Three plate heat exchangers are provided which cool the 50% caustic soda and the condensate leaving the first effect and heat the feed to the first effect.

### **Controls**

Differential pressure type level controls regulate the flow of caustic entering each effect. Product concentration is maintained by adjusting the steam flow to boil off the correct amount of water. The concentration is inferred by measuring the boiling point rise of the concentrate.