# *Intermediate Evaporation Process and Operational Data*

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## Introduction

At the production site an intermediate evaporation process is used in order to increase the productivity of the major evaporation process. The intermediate evaporation system is composed of two evaporators connected in concurrent flow configuration, as seen in Figure 1. The black liquor is concentrated from 0.20 kg/kg to 0.34 kg/kg in the 2 stages. The inlet steam to the first evaporator has the saturation temperature of 90°C and the cooling water to the condenser of the second evaporator has a nominal temperature of 10°C. The feed comes from the pre-evaporation process upstream and the outlet from stage 2 goes to the final evaporation process, the thickener process.

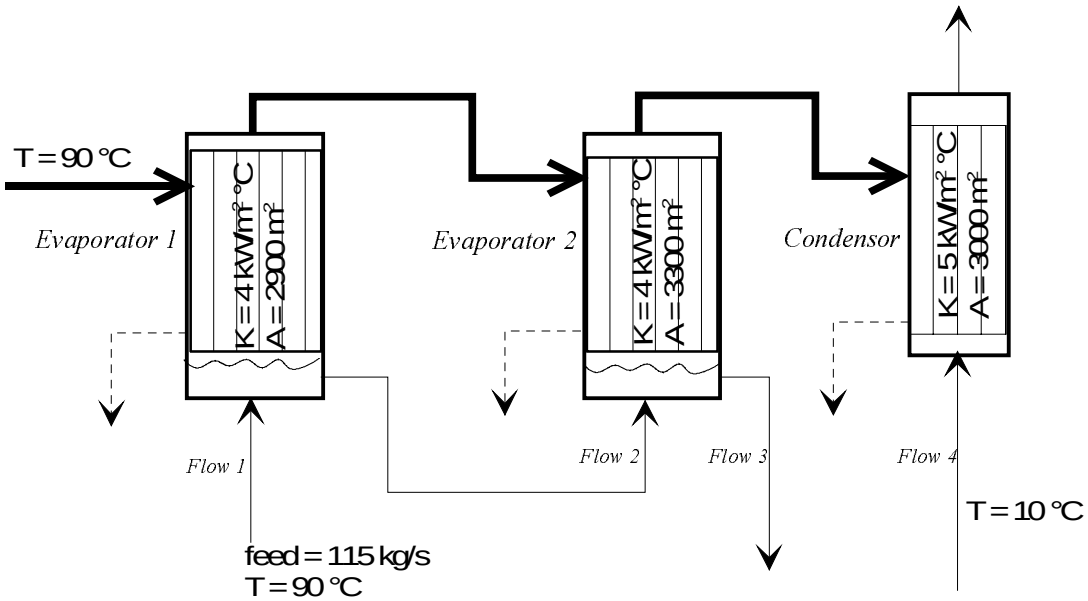


*Figure 1 - 2-stage evaporator system*

## Design Parameters

The evaporation process has the following design parameters:

- The evaporators are of a falling-film type with internal forced recycle. The liquor volume in each stage is supposed to be about 5 $m^3$.
- Heat transfer coefficients are assumed to be *4 kW/m² °C* in the both stages. The condenser is assumed to have *5 kW/m² °C*

- Heat transfer area are as follows: evaporator 1: $A = 2900\ m^2$ , evaporator 2: $A = 3300\ m^2$ , condenser: $A = 3000\ m^2$

- The liquid flow valves on flow 1-4 are all design to give 50% open at the nominal flow rate. Assume linear valve characteristics.

## Process Requirements

The evaporation process has the following requirements

- The primary requirement is that the composition of the output from evaporator 2 is assumed to be 34% (on dry weight basis) with a mass flow rate of 67.6 kg/s.

- A secondary requirement is the possibility to increase outlet composition to 40%.

- It is also interesting to handle a decrease in production to half of the nominal feed flow rate, i.e. a flow rate of 65 kg/s.

## Nominal Operational Conditions

Nominal external operational conditions for the plant are

- Feed to the evaporator 1 is a mass flow of 115 kg/s, composition of 20% (on dry weight basis) and temperature of 90 $^{o}$C.

- Steam to the evaporator 1 is a saturated water steam at 90 $^{o}$C.

- Cooling water to the condenser has the nominal cooling temperature of 10 $^{o}$C.

## Process Disturbances

All the nominal conditions vary more or less. Assume following disturbances

- Feed changes of about 30% of the nominal value.

- Steam changes of about 10 degrees lower temperature.

- Note that if the feed and steam comes from the same evaporator then these disturbances occur simultaneously.

- During summer the cooling water temperature rises (hopefully) to 25 $^{o}$C.

- Fouling in the heat transfer tubes is a serious problem. The fouling can be modelled as decrease of the overall k-value. It can also be modelled as blockage of tubes and results in decreased heat transfer area.