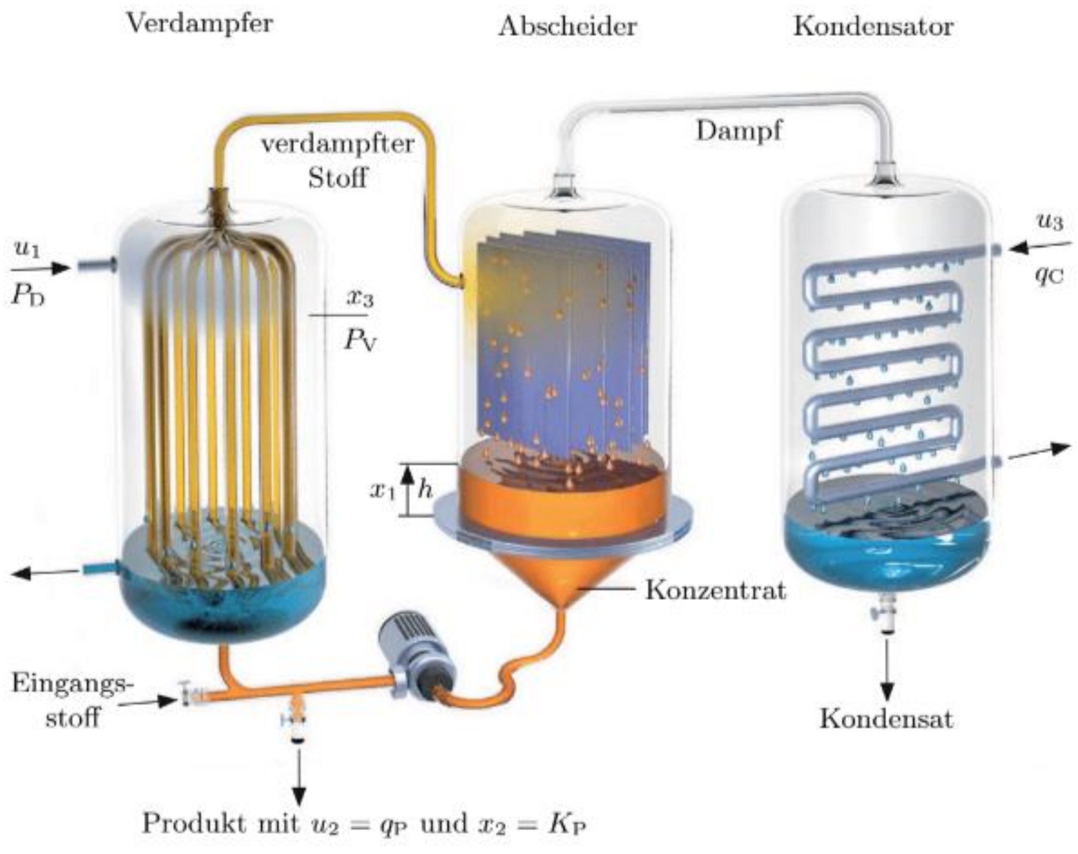
As an example, we consider an evaporation plant, such as is used for the production of syrup in sugar factories [221, 314].As shown in Fig. 6.10, the plant consists of an evaporator, a separator and a condenser. The feedstock, raw juice from sugar beets, is fed to the evaporator, which is designed as a heat exchanger. The heat exchanger is heated with steam at pressure PD. The raw material heated under pressureP in the evaporator leaves the evaporator as a mixture of vapor and liquid and then enters the separator. Here, the vapor is separated and fed into a condenser. Cooled by water flowing into the condenser at the inflow rateqC , the vapor condenses and is discharged from the plant. The concentrate collected in the separator has the levelh there. Part of this concentrate with the concentrationKP is now removed from the process at the volume rateqP as a product, but by far the greater part is returned to the evaporator mixed with the feedstock.



The system can be described by a third-order nonlinear model. Here x1=h, x2=KP and x3=PV are the state variables and u1=PD ,u2=qPand u3=qC are the manipulated variables of the system. We measure x1in m, x2 in%, x3and u1 in kPa and u2 and u3 in kg min-1. The model has the following expression:

$$\dot{x}_1 = a_1 x_3 + a_2 x_2 - b_1 u_1 - b_2 u_2 - k_1,$$
$$\dot{x}_2 = -a_3 x_2 u_2 + k_2,$$
$$\dot{x}_3 = -a_4 x_3 - a_5 x_2 + b_3 u_1 - \frac{a_6 x_3 + b_4}{b_5 u_3 + k_3} u_3 + k_4.$$

The Parameters oft he System are

$$\begin{aligned}
a_1 &= 0.00751, & b_1 &= 0.00192, & k_1 &= 0.01061,\\
a_2 &= 0.00418, & b_2 &= 0.05, & k_2 &= 2.5,\\
a_3 &= 0.05, & b_3 &= 0.00959, & k_3 &= 6.84,\\
a_4 &= 0.03755, & b_4 &= 0.1866, & k_4 &= 2.5531,\\
a_5 &= 0.02091, & b_5 &= 0.14, & &\\
a_6 &= 0.00315. & & & &
\end{aligned}$$

The state variables are also the output variables. variables y 1 = x 1 , y 2 = x 2 and y 3 = x 3 of the process. Both the state variables and the manipulated variables are subject to constraints of the form

$$\begin{aligned}
0\,\mathrm{m} &\le x_1 \le 2\,\mathrm{m},\\
0\,\% &\le x_2 \le 50\,\%,\\
0\,\mathrm{kPa} &\le x_3 \le 100\,\mathrm{kPa},\\
0\,\mathrm{kPa} &\le u_1 \le 400\,\mathrm{kPa},\\
0\,\mathrm{kg\,min^{-1}} &\le u_2 \le 4\,\mathrm{kg\,min^{-1}},\\
0\,\mathrm{kg\,min^{-1}} &\le u_3 \le 400\,\mathrm{kg\,min^{-1}}.
\end{aligned}$$

The operating point xR and ur

$$\boldsymbol{x}_{\mathrm{R}} = [1 \quad 15 \quad 70]^T,$$

$$\boldsymbol{u}_{\mathrm{R}} = \begin{bmatrix} 214.13 & 3.33 & 65.40 \end{bmatrix}^T$$

We consider the initial state to be controlled

$$\boldsymbol{x}(0) = \begin{bmatrix} 1 \\ 25 \\ 50 \end{bmatrix}.$$