Chapter 39

Process models

In the following sections, mathematical models of various physical processes are presented. Some of these models are used in examples and in problems in the book. They may be used in aditional problems, and as a basis of dynamic simulators.

39.1 Wood chips tank

39.1.1 System description

Figure 39.1 shows a wood chips tank with a feed screw with continuous feed of wood chip, conveyor belt, which runs with a fixed speed. There is a continuous outflow of wood chips.[1]

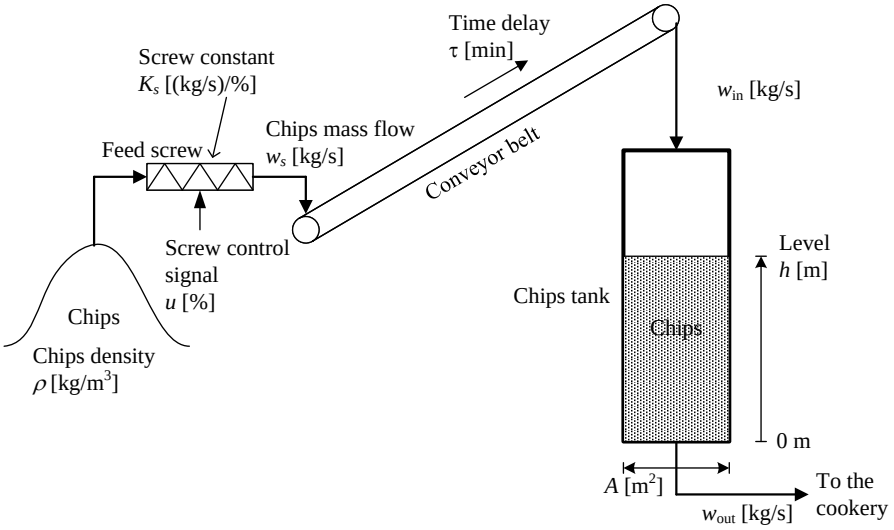

Figure 39.1: Wood chips tank.

The conveyor belt makes up a time delay or transport delay from the screw to the tank.

39.1.2 Variables and parameters

Variables and parameters of the wood chip tank are defined in Table 39.1.[2] We assume that there is an overflow if the level exceeds the maximum level.

Table 39.1: Wood chips tank: Variables and parameters.

Symbol	Value (default)	Unit	Description
h	10	m	Wood chips level
-	[0, 15]	m	Range of level
u	50	%	Control signal to feed screw
w_s	25	kg/s	Feed screw flow (flow into conveyor belt)
w_{in}	25	kg/s	Wood chips flow into tank (from belt)
w_{out}	25	kg/s	Wood chips outflow from tank
ρ	145	kg/m^3	Wood chips density
A	13.4	m^2	Tank cross sectional area
K_s	0.5	(kg/s)/%	Feed screw gain (capacity)
τ	250 s	s	Transport time (time delay) on conveyor belt

39.1.3 Overall block diagram

Figure 39.2 shows a block diagram of the wood chips tank.

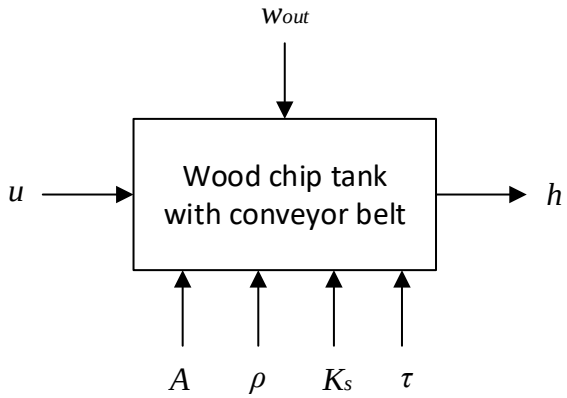

Figure 39.2: Block diagram of the wood chips tank.

[1] Typically, there is such a wood chips tank in the beginning of the production line of a paper and pulp factory.

[2] Courtesy of earlier Sødra Cell, and even earlier Norske Skog, Tofte, Norway.

39.1.4 Mathematical model

The chips flow through the feed screw, w_s, is the inflow to the conveyor belt. w_s is assumed being proportional to the control signal, u:

$$w_s = K_s u \tag{39.1}$$

The outflow from the belt, which is also the inflow to the tank, is the same as the inflow to the belt and the screw flow, but time delayed:

$$w_{\text{in}}(t) = w_s(t - \tau) = K_s u(t - \tau)$$

The outflow from the tank is w_{out}.

A mathematical model of the tank based on material balance of the wood chips in the tank is:

$$\rho A h'(t) \quad = \quad w_{\text{in}}(t) - w_{\text{out}}(t) = K_s u(t - \tau) - w_{\text{out}}(t) \tag{39.2}$$

3

4