# Model for rolling mill

The following 6th order state space representation is a model for the rolling mill at The Danish Steel Works Ltd. The model includes the linear model for the rolling stand and a linearized model for the hydraulic positioning systems. Inputs to the model are the control signals for the the north and south roll positioning systems $x_{vn}$ and $x_{vs}$. The roll positions are $z_n$ and $z_s$ and the outputs are the thickness 10 cm from the north and south plate edges $v_n$ and $v_s$, see figure 1.

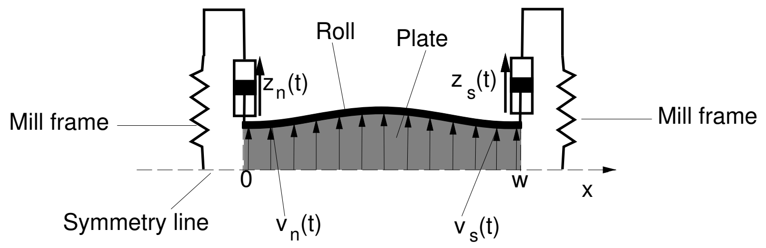


**Figure 1.** Conceptual diagram of the rolling mill (rolling direction into to paper).

The state space description is:

$$\left[\begin{array}{c|c} A & B \\ \hline C & D \end{array}\right] = \left[\begin{array}{cccccc|cc} -1.00e3 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1.00e3 & 0 & 1 & 0 & 0 & 0 & 0 \\ -1.83e5 - 5a_{m1} & -\gamma a_{m1} & 0 & 0 & -5.99e4 & -5.99e4 & 0 & 0 \\ -\gamma a_{m1} & -1.57e6 - 5a_{m1} & 0 & 0 & -4.53e4 & 4.53e4 & 0 & 0 \\ 0 & 0 & 0 & 0 & -5.00e1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & -5.00e1 & 0 & 1 \\ \hline -2.98 & -4.26 & 0 & 0 & 2.47e-2 & 2.05e-2 & 0 & 0 \\ -2.98 & 4.26 & 0 & 0 & 2.05e-2 & 2.47e-2 & 0 & 0 \end{array}\right]$$

The model varies with the plate dimensions and the material hardness. The above state space matrices are for 6.37 mm thick and 2.16 m wide plate rolled under normal conditions.

The control problem is to minimize the variations in outgoing plate thickness due to variations in the plate hardness. These hardness variations can be seen as variations of the parameter $a_{m1}$. Typical values are

$$a_{m1} \in [2 \times 10^4, 2 \times 10^5].$$

The variations of the plate hardness can be both symmetric and asymmetric. For $\gamma = 0$ symmetric conditions are present. Typical asymmetric conditions are introduced by setting $\gamma = 0.57$.

The variations of $a_{m1}$ during rolling can be chosen as:

$$a_{m1}(t) = \bar{a}_{m1} \sin(4\pi t)$$

where $\bar{a}_{m1}$ is the mean value of the plate hardness during that rolling. The parameter variation is caused by thickness variations due to cold zones (known as skid marks) from the reheat furnaces. On thin plates there are also disturbances of a more high frequent character due to pointwise cooling by the roller tables. These disturbances can be modeled as impulses:

$$a_{m1}(t) = \overline{a}_{m1}\delta(t)$$

where $\delta$ is the unit pulse. These variations are a lot harder to cope with in connection with the thickness control.