Bark Boiler Process Models

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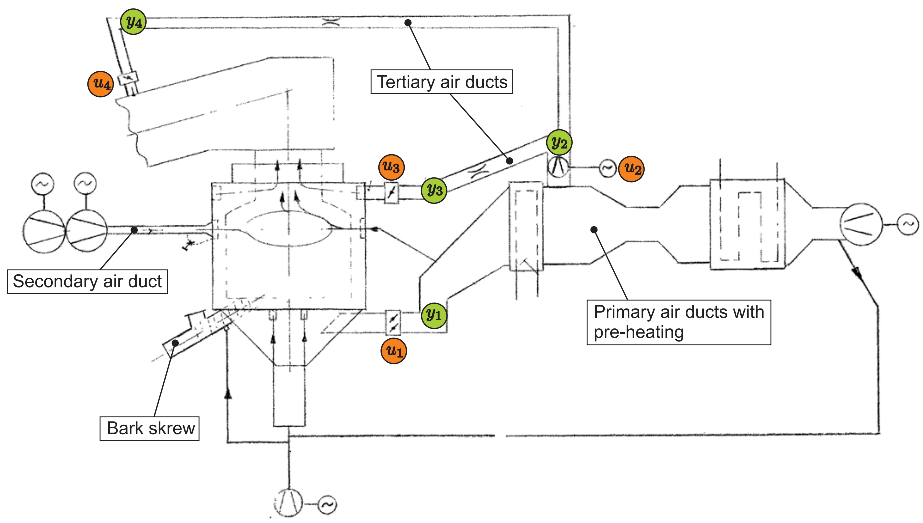

Figure 1: Schematic drawing of the bark boiler. Figure obtained from [Castaño et al., 2011]

A bark boiler is used in the pulp and paper industry to burn rest products from debarking of wood in order to produce steam. If there is an over production of steam which is not used within the production processes, electrical power is produced from remaining steam. Nowadays, these boilers are operated with hard environmental constraints on the composition of the flue gases, resulting in trade-off between optimal steam production at low cost while producing minimal exhaust gases like CO, CO_2 and NO_x.

The air control system of a bark boiler at SCA Obbola, Sweden is documented here. A simple sketch of the boiler is given in Fig.1. There, the primary, secondary and tertiary air ducts are indicated. The tertiary air is tapped from the primary air after the first heater using an extra fan to achieve a desired flow. Subsequently, the air flow is split in an upper an lower part to be supplied in the exhaust gas duct. A good control performance of the air system is a prerequisite to achieve a stable operation of the bark boiler.

The model for the bark boiler was created by Wolfgang Birk and has been introduced in [Castaño et al., 2011] where it was used to estimate a gramian-based Interaction Measure called Participation Matrix. Alternative state-space models were later created by Wolfgang Birk and intrudocued in [Birk and Dudarenko, 2016].

The process model for the complete air system is given as a 4×4 transfer function matrix:

$$G = \begin{bmatrix} \frac{0.301e^{-0.838s}}{1.120s+1} & \frac{-0.025e^{-0.527s}}{0.2283s+1} & \frac{-0.014e^{-30s}}{68.69s+1} & \frac{-0.004e^{-0.178s}}{0.2633s+1} \\ \frac{1.199e^{-27.8s}}{280.2s+1} & \frac{0.076}{2.542s+1} & \frac{0.004e^{-0.615s}}{16.31s+1} & \frac{0.611}{145.2s+1} \\ \frac{(0.258s+0.708)e^{-28.6s}}{48.2s^2+280.4s+1} & \frac{(0.016s+0.045)e^{-0.814s}}{0.438s^2+2.714s+1} & \frac{(0.282s+0.022)e^{-4.48s}}{11.97s^2+14.57s+1} & \frac{(-0.009s+0.002)e^{-0.814s}}{s+0.007} \\ \frac{-0.035e^{-28.5s}}{602.3s^2+282.3s+1} & \frac{-0.002e^{-0.704s}}{5.465s^2+4.692s+1} & \frac{-0.003e^{-2.45}}{61.96s+1} & \frac{-0.5476}{2.689s+1} \end{bmatrix} \quad (1)$$

References

[Birk and Dudarenko, 2016] Birk, W. and Dudarenko, N. (2016). Reconfiguration of the air control system of a bark boiler. *IEEE Transactions on Control Systems Technology*, 24(2):565–577.

[Castaño et al., 2011] Castaño, M., Birk, W., and Halvarsson, B. (2011). Empirical approach to robust gramian-based analysis of process interactions in control structure selection. In *50th IEEE Conference on Decision and Control and European Control Conference (CDC-ECC), 2011.*