Power Plant Control and Flexible Generation

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Dynamic performance of power plants consist of dynamic characteristics of generation processes and applied control strategies. In this task analyzed power plant characteristics have been matched with control structures to manage the flexible operation of power plants focusing to maximal load change rate constrained by thermal stressing of boiler and turbine structures.

Energy storages and load change rate

Load tracking capacity of a steam power plant consists of the quick responding energy storages of the boiler and the control of combustion power. Exploitability of internal energy storages depend on heat transfer efficiency, steel mass, and volume of the evaporator and the drum. Dynamics of combustion process depends on fuel properties and combustion technology.

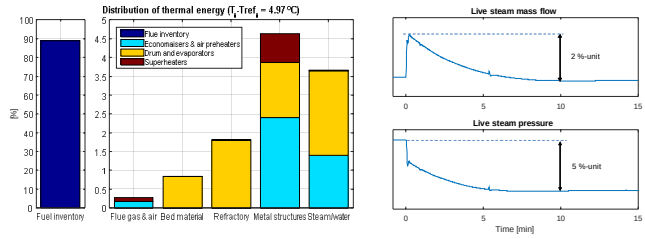

Fig. 1. Relative amounts of stored energy in a coal fired circulating fluidized bed drum boiler and a step response of a steam flow caused by a live steam pressure drop induced by opening a turbine control valve stepwise with constant combustion power.

The first "kick" during a load change is produced by the utilization of the storage capacity of the boiler. The amount of utilized storage capacity is limited by allowed, pressure change derived temperature change in the drum and the evaporator. The final ramping of the operation point is conducted by combustion control. Extensive utilization of energy storages of the boiler and accelerated ramping requires both improved performance of stabilizing control loops, such as drum level, steam temperatures, furnace pressure, and combustion air, and a coordinated boiler-turbine unit control.

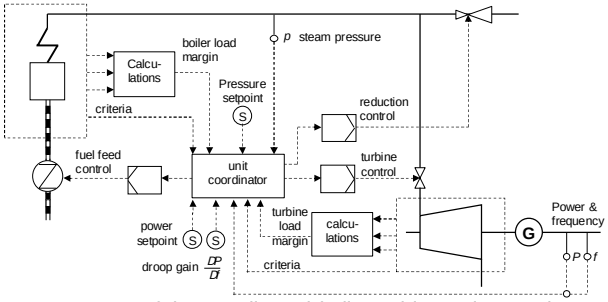

Fig. 2. Structure of the coordinated boiler-turbine unit control.

Model predictive control approach

Model predictive control (MPC) is a multivariate and optimal control method which can implicitly handle system variables related constraints. For improving the load tracking capacity of existing grate boiler units, an MPC control concept, based on the soft-sensor estimating released combustion power in real time, was developed.

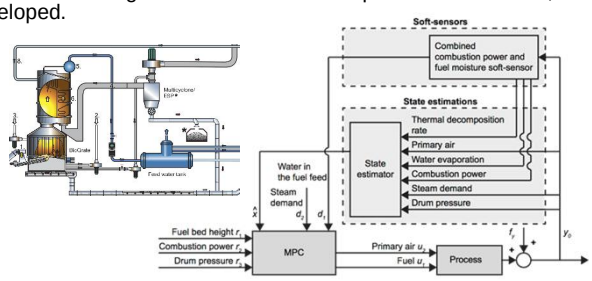

Fig. 3. Model predictive control concept for the load control of the grate fired boiler.

Fig. 4. Model predictive controller installed in the process automation system and control responses for simulated boiler process.

Conclusions

According to preliminary result achieved in the truncated program, the limiting factor for improved load tracking capacity of drum boilers is not process related constraints but insufficient stabilizing control performance of individual sub-processes and lack of advanced coordinated tracking control of boiler-turbine units. MPC based control concept is capable to optimally coordinate the operation of individual sub processes and handle constraints related to thermal stressing of boiler and turbine structures. Development of more efficient stabilizing control concepts for unit processes is still needed.