ABB's unit control solution MODAN/MODAKOND coordinates boiler and turbine by means of model-based set-point control and model-based feed-forward control to achieve fast load ramps and load frequency control with minimum/no throttling of the turbine inlet control valves. MODAKOND improves plant efficiency by 0.3% - 0.4% in comparison to modified sliding pressure operation mode, (frequency control by throttling the turbine inlet valves) by fully utilizing the energy reserves of the unit.

Stabilization of the grid frequency mainly depends on the dynamic behavior of the power units. The realization of the power unit's dynamic behavior is substantially influenced by the following factors:

- The demands on the unit dynamics in the seconds and minutes range
- The intended operating mode (sliding pressure, constant-pressure, condensation or heating mode)
- The unit design (boiler, turbine)

For improving the dynamic performance, the behavior of the power plant as a controlled system has to be examined in order to determine the required control reserves (of turbine and coal mill etc.). Unit control is intended to fully utilize the available dynamics and energy reserves of the unit for the regulation of the grid frequency and to ensure steady and flexible operation. Energy reserves generally come from reduced turbine extractions (bleeds) flow, e.g. LP/HP heaters or district heating heaters.

Challenge

The conventional solution to improve control performance and to make frequency control available for a power plant is to activate the modified sliding pressure operation mode (by throttling the turbine control valves). The major drawback of this method is a reduction of plant efficiency.

Available energy reserves need to be activated in order to significantly reduce or completely eliminate throttling of the turbine control valves (TCV) and/or to improve control performance and flexibility of operation. However, a perfect coordination of such reserves is required in order to maintain stability of operation.

Solution

ABB's unit control solution MODAN/MODAKOND takes full advantage of model-based set-point control and model-based feed-forward control to coordinate the boiler, the turbine and the energy reserves in order to achieve the required dynamics with minimum/no throttling of the turbine inlet valves and without compromising stability of operation.

MODAN significantly reduces required throttling of the TCV by using dynamic models of the steam generator's storage capacity and load change response.

MODAKOND further reduces or completely eliminates throttling of the TCV by activating additional energy reserves in the process.
Services
ABB takes over complete turnkey responsibility for engineering, installation, training, commissioning and support.

Attributes
An example of MODAKOND’s sequential activation of energy reserves for primary control is shown in the diagram below. Primary control is activated as grid frequency drops or increases. The magnitude of the load increment/reduction is given by a defined factor (k * Δf). In the above example stationary throttling of the TCV is reduced by 75 % thanks to condensate throttling (CONDSTOP) and throttling of the extraction line to the high pressure preheater. Other energy reserves include but are not limited to temporary throttling of the district heating system and a model-based fast retrieval of available pulverized coal from the coal mills.

The same load reserves can be used to boost the performance of the load control and to fulfill prequalification for secondary control.

The extraordinary performance of ABB’s unit control MODAN and MODAKOND is based on modern control algorithms, flexible system capabilities of state-of-the-art hardware and software accompanied with ABB’s extensive experience in power plant optimization and flexibilization and the expertise and dedication of its engineers.

ABB’s unit control MODAN and MODAKOND support controlled start-ups / shut-downs and load changes of a power plant unit under economically optimized conditions. The unit control can be implemented in power plants fired by any kind of fossil fuel (coal, lignite, gas, oil...) and running on fixed-pressure or sliding pressure. District heating, if available, is included as a variable in the control algorithms to ensure process stability and performance.

Integration
The unit control MODAN/MODAKOND can be implemented as an integrated control solution in units running on ABB control systems or as an optimization solution to upgrade power plants running on non-ABB control systems.

Control hierarchy and signal exchange is sketched in image 2.

Features
- Within the framework of primary grid frequency and secondary control, MODAN and MODAKOND deliver the energy produced by the unit on the basis of the dynamic response demanded by the load dispatcher (DVG Deutsche Verbundgesellschaft or UCTE Union for Coordination and Transport of Electricity).
- Model-based feed forward control and model-based setpoint control.
- Adaptive dynamic models to ensure accurate calculations even with dynamic behavior discrepancies caused by internal and external conditions (soot accumulation, problems with vacuum etc.).
- Mathematically optimized control algorithms based on open-loop plant characteristics guarantee maximum performance without loss of stability.
- Intelligent coordination of the boiler, turbine and energy reserves to take plant dynamics to the limit without compromising operation safety.
- Improved control screens with two levels of detail to provide a fast overview of the unit control operation and a deep insight into every control variable of corresponding subsystems.
- Most of the tests to identify static and dynamic characteristics of the plant can be made before unit shut-down (for refurbishing projects) to considerably reduce commissioning time.
- Documentation of tests and test results (plant’s characteristics) and achievement of required control accuracy.

Benefits of MODAN/MODAKOND
As a model-based unit control for the coordination of boiler and turbine Modan/Modakond provides
- Faster load ramps for increased flexibility
- Reduced minimum load for low load running
- Capability to provide grid services, in particular primary and secondary control and negative minutes reserve, making the unit attractive for the load dispatcher and increasing profitability
- Improved plant efficiency for primary frequency control through reduced throttling of the turbine control valves
- High precision of control variable manipulation results in a smoother operation of main components like pulverizers, FD- and ID-fans reducing plant operation costs and interruption of production

1 Sequential activation of energy reserves | 2 Exemplary control screen for MODAKOND
Customer savings
Savings as a result of implementation of MODAN/MODAKOND depend on installation design (feed-water tank and hotwell capacity, condensate valve manipulation time, available control flaps on turbine extraction lines, etc), operation mode and dynamic requirements (e.g. which grid services and with what magnitude are to be offered).
Assumptions:
- 700 MWel unit
- 250 bar rated live steam pressure
- 6,000 hours per annum in modified sliding pressure operation
- average load 88%
- 23 MW nominal power for the feedwater pumps
- 0.02 € / kWh generation costs
If MODAN can reduce an unnecessary throttling of turbine control valves by 3 bar, then following savings can be achieved: 1450 MWh/year = 29,000 € / year

If the MODAKOND variant can reduce the total throttling of turbine control valves by 18 bar, then following savings can be achieved: 8700 MWh/year = 174,000 € /year

NOTE: ABB offers economic analysis based on test with the actual process and/or dynamic simulations and current market prices to find out e.g. plant’s capabilities, best upgrade configuration for the installations, etc.

References
ABB’s unit control solution MODAN/MODAKOND is implemented in more than 80 power plants:

Rostock STPP, Germany
Coal fired unit, 550 MWel, district heating (300 MWth),
3 quick-acting rotary dampers:
- bled steam supply of the feedwater tank,
- bled pipes for the LP heaters 3 & 4

Schkopau STPP, Germany
Lignite fired unit, 373 and 391 MWel
extraction steam and operation of a railway steam turbine (16 2/3 Hz, 110 MW), 2 quick-acting rotary dampers:
- bled steam supply of the feedwater tank,
- bled pipe for the LP heaters 4

Heyden STPP, Germany
Coal fired unit, 920 MWel
unit with condensing turbine, condensate flow throttling

Altbach STPP + CCPP, Germany,
Coal fired unit, 350 MWel solo ST / 430 MWel combination, district heating (280 MWth / 367 MWth),
1 quick-acting rotary damper LP-preheater:
- bled steam supply of the feedwater tank
1 quick-acting rotary damper HP-preheater:
- bled pipe for the HP heater
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