ABB PSPG-E7
MODAKOND
More efficient and dynamic unit control
Conventional solution for frequency control (or to improve control performance for flexible plant operation):
- throttling the turbine control valves

Major drawback:
- Throttling losses reduce plant efficiency

How to activate available energy reserves in order to significantly reduce or completely eliminate throttling of the turbine control valves (TCV)?

Requires a perfect coordination of such reserves in order to maintain stability of operation
OPTIMAX® MODAKOND
Solution features

- Model based coordinated operation mode for boiler and turbine
- Feed forward strategy combined with dynamic decoupling of the closed-loop-control
- Integration of different actuators for economic provision of primary control like
  - Condensate throttling
  - Throttling extraction steam to HP preheaters
- Frequency control in boiler- or turbine- follow mode with initial pressure control or position control of the turbine inlet valves
- For sliding or fixed pressure mode or combined sliding/fixed pressure mode
Compliance with the Grid Code requirements
Variant I: coordinated boiler following mode for sliding pressure operation
Grid requirements for a fast grid-frequency support by fossil fired power plants (Grid Code in Europe)

Load increase requirement for high grid load (3GW sudden loss, total grid load 300 GW)

Load increase requirement for low grid load (3GW sudden loss, total grid load 150 GW)
Individual calculation of the boiler steam storage capacities using measured data

Measured responses for the boiler for a negative step of turbine load

<table>
<thead>
<tr>
<th></th>
<th>271 MW</th>
<th>168 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>unit load</td>
<td>271 MW</td>
<td>168 MW</td>
</tr>
<tr>
<td>utilized live-steam</td>
<td>987 kg</td>
<td>1483 kg</td>
</tr>
<tr>
<td>pressure increase</td>
<td>6.7 bar</td>
<td>10.0 bar</td>
</tr>
<tr>
<td>steam storage capacity</td>
<td>147.0 kg/bar</td>
<td>148.3 kg/bar</td>
</tr>
<tr>
<td>steam storage time constant</td>
<td>72.8 s</td>
<td>112.0 s</td>
</tr>
</tbody>
</table>
OPTIMAX® MODAKOND
Achieved results with MODAKOND at a 550 MW PP

- Setpoint fuel flow
- Current boiler load
- Utilized energy by MODAKOND
- Restored energy for MODAKOND
- Utilized energy by throttling
- Restored energy for throttling
- Simulated grid-frequency drop
- Load
- Setpoint generator load
- Model boiler load
Efficiency gain by MODAKOND (ABB patent)

- Enhancement of overall efficiency owing to reduction in auxiliary load in comparison with an unit control system without a valve position controller in the modified sliding pressure range.

- Numerical example for a 700 MW unit:
  - 6,000 hours per annum in modified sliding pressure operation with an average load of 88 %, 3 bar throttling pressure error at the turbine inlet valves, 250 bar rated live steam pressure, 23 MW power rating of the electrical feed water pumps
  - MODAN leads to approx. 1.2 % less pump power consumption
  - Result: Reduction in annual auxiliary load by 1,450 MWh
Features of model-based unit control MODAKOND

- Full-coordination of boiler and turbine
- Applicable for power plants with fixed-pressure or sliding pressure, which also may have district heating (additional extraction steam)
- Including the coordinated boiler and turbine following modes with/without throttle-pressure control
- Application does not use the live-steam flow measurement
- Application runs on different HW/SW platforms (also on non-ABB control systems)
- Primary frequency control
  - fulfilling the Grid Code requirements
  - without using the throttling reserve for unit load ramps
- Secondary and tertiary control support (remote dispatcher)
Variants
MODAKOND variant for existing units (only condensate stop without additional actuators)
Efficiency increase up to 0.4% through MODAKOND
(ABB-CONDSTOP: coordin. condensate & ext. steam stop)

Coordinated boiler following operation mode
The fuel over-firing can be reduced by reducing the steam flow to the HP heater and condensate stop. The parallel operation of the condensate stop and HP-heater "throttling" is reducing the necessary turbine throttling by 75% auf 760 MWs (without this countermeasures a throttling reserve of 3.100 MWs are necessary).
Ranking of the measures for primary frequency support depending on the grid-frequency deviation

- HP heater
- Condensate stop
- Throttling of the turbine
OPTIMAX® MODAKON
Benefits

- Increase in economic efficiency by reducing the throttling of the turbine inlet valves
- Faster load ramps for increased flexibility
- Feasibility of primary and secondary frequency control
- Gentle operation of the main components with minimized control work
- Reduced minimum load for low load running
## Reference plants for MODAKOND (I)

<table>
<thead>
<tr>
<th>Power plant</th>
<th>Nominal power (gross)</th>
<th>Constant/sliding pressure</th>
<th>Fuel</th>
<th>Boiler type</th>
<th>Project status</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDK 7 (Germany)</td>
<td>550 MW</td>
<td>modified sliding pressure</td>
<td>hard coal (oil)</td>
<td>Benson supercritical</td>
<td>completed 1985</td>
<td>quick-acting condensate control valve and 3 rotary dampers: gland steam supply of the feedwater tank, bleed pipes for the LP heaters 3 &amp; 4 (scope of supply: concept and basic design of the ABB-CONDSTOP)</td>
</tr>
<tr>
<td>Rostock (Germany)</td>
<td>550 MW</td>
<td>modified sliding pressure</td>
<td>hard coal (oil)</td>
<td>Benson supercritical</td>
<td>completed 1995</td>
<td>district heating (300 MWth), 3 quick-acting rotary dampers: gland steam supply of the feedwater tank, bleed pipes for the LP heaters 3 &amp; 4</td>
</tr>
<tr>
<td>Schkopau (Germany)</td>
<td>1 x 373 MW, 1 x 391 MW</td>
<td>modified sliding pressure</td>
<td>brown/lignite coal (oil)</td>
<td>Benson supercritical</td>
<td>completed 1996</td>
<td>extraction steam and operation of a railway steam turbine (16 2/3 Hz, 110 MW), 2 quick-acting rotary dampers: gland steam supply of the feedwater tank, bleed pipe for the LP heaters 4</td>
</tr>
<tr>
<td>Westfalen unit C (Germany)</td>
<td>320 MW</td>
<td>modified sliding pressure</td>
<td>hard coal (oil)</td>
<td>Benson</td>
<td>Completed 1997</td>
<td>rehabilitation, unit with condensing turbine, 1 quick-acting rotary damper only for the gland steam supply of the feedwater tank</td>
</tr>
</tbody>
</table>
## Reference plants for MODAKOND (II)

<table>
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<tr>
<th>Power plant</th>
<th>Nominal power (gross)</th>
<th>Constant/ sliding pressure</th>
<th>Fuel</th>
<th>Boiler type</th>
<th>Project status</th>
<th>Remarks</th>
</tr>
</thead>
</table>
| Staudinger 5  | 550 MW                | modified sliding pressure   | hard coal (oil) | Benson supercritical | 1999 completed | district heating, ABB-Condstop with 3 quick-acting rotary dampers:  
| Germany       |                       |                             |               |                   |                 | gland steam supply of the feedwater tank,  
|               |                       |                             |               |                   |                 | bleed pipes for the LP heaters 3 & 4.                                      |
| Heyden        | 920 MW                | modified sliding pressure   | hard coal (oil) | Benson supercritical | 1999 completed | unit with condensing turbine, only condensate flow throttling          |
| Germany       |                       |                             |               |                   |                 |                                                                         |
| Zolling       | 450 MW                | modified sliding pressure   | hard coal (oil) | Benson             | 2001           | cogeneration plant (district heating) only condensate flow throttling  |
| Germany       |                       |                             |               |                   | (pre-study with site tests and simulation) |                                                                         |
| Weiher III    | 703 MW                | natural sliding pressure    | hard coal (heavy oil) | Benson | 2002           | unit with condensing turbine, only condensate flow throttling          |
| Germany       |                       |                             |               |                   |                 |                                                                         |