Flexibility of new and optimized fossil fired Power Plants

Seminar on Adaption of Thermal Power Plants to Fluctuating Renewable Energies

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Major Efficiency and Flexibility Measures

- Fuel change, Blending, Fuel handling
- Optimisation/adaption of the combustion
- Technical optimisation, modification operation regime
- Choosing new material
- Optimisation of the turbine
- Optimisation of Flue gas cleaning system
- Optimisation of instrumentation and control system
- R&D activities regarding efficiency increase and flexibility
Technology retrospect
RWE made in the last decade a lot of effort to increase the availability, flexibility and efficiency of the PF Boilers – Example Lignite:

<table>
<thead>
<tr>
<th>150 MW-Blöcke</th>
<th>300 MW-Blöcke</th>
<th>600 MW-Blöcke</th>
<th>1000 MW-BoA-Block</th>
</tr>
</thead>
<tbody>
<tr>
<td>η: 31%</td>
<td>32-34%</td>
<td>35-36%</td>
<td>&gt; 43%</td>
</tr>
<tr>
<td>Kohle: 1,2 kg/kWh</td>
<td>1,1 kg/kWh</td>
<td>1,1 kg/kWh</td>
<td>0,9 kg/kWh</td>
</tr>
</tbody>
</table>

Next Project: 2x 550 MW Pre-dried lignite CFBC Units
What does Flexibility mean?

High flexibility can be described as follow:

**Dynamic**
- high operational gradient (load change speeds)
- short start-up minimum and nominal load
- short minimum downtime

**Operational**
- high starting number and load cycles at reduced Lifetime consumption
- lowest possible minimum load at high efficiency
- uniform, high efficiency curve across the load
Load Change Rate between minimum and nominal load

- **OCGT** (open Cycle + NOx Cat)
- **CCGT** (combined Cycle + NOx Cat)
- **LIGNITE** (BoA 2&3, 2x 1100 MW)
- **HARD COAL** (WES, EMS, 2x 800 MW)
- **PDL** (Pre dried Lignite, 2x 550 MW, synchron operation)

Load Change Rate Graph

- **OCGT**
- **LIGNITE**
- **PDL**
- **CCGT**

Time [min]

- Min Load = 17.5%

- t=0 Demanding by Dispatcher
Load Change Rate - Cold Start

- OCGT (Lingen)
- CCGT (VGT Lingen)
- Gas + GT (VGT Lingen)
- Hard Coal (Wes)
- Lignite Pre-dried (2 synchron boiler)
- Lignite (BoA 2&3)

**Time [min]**
- Start Command
- Pre-airing
- Ignition Coal Fire
- Increasing load Gas and Steam Turbine
- Heating up Turbine
- Increasing thermal load
- Heating up Steam System
- Turbine Synchronisation
## Short Minimum Downtime

<table>
<thead>
<tr>
<th></th>
<th>With high Life Time reduction</th>
<th>With low Life Time reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCGT</td>
<td>&lt;&lt; 30 min run out of the GT is the time leader</td>
<td></td>
</tr>
<tr>
<td>Hard Coal</td>
<td>min. 30 min</td>
<td>&lt; 240 min</td>
</tr>
<tr>
<td>Lignite</td>
<td>min. 30 min</td>
<td>&lt; 240 min</td>
</tr>
<tr>
<td>Pre-dried Lignite</td>
<td>min. 30 min</td>
<td>&lt; 240 min</td>
</tr>
</tbody>
</table>

> After command " fire off " measures must be carried out to bring the unit back into the " Ready " operating state. Hereby, the condition of the unit must be considered.
> Time leader in coal firing is the pre-ventilation due to security.
> Gentle cooling of the steam generator before air purging, which increases the life time but it is time-consuming. This measure avoids the temperature stresses.
> Lifetime consumption is considered in the design of our plants.
Design Specifications new Power Plants
Example: Power Plant Westfalen

Operational Characteristics (Hard Coal, 800 MW)
> Base and medium load
> Plant runs through in times of low demand
> Minimum load 25 - 30%, 7,500 operation hours per year

<table>
<thead>
<tr>
<th>Operation Mode</th>
<th>Per year</th>
<th>40 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold Starts</td>
<td>6</td>
<td>240</td>
</tr>
<tr>
<td>Warm Starts</td>
<td>42</td>
<td>1,680</td>
</tr>
<tr>
<td>Hot Starts</td>
<td>84</td>
<td>3,360</td>
</tr>
<tr>
<td>Load Cycles</td>
<td>1,200</td>
<td>48,000</td>
</tr>
</tbody>
</table>
Future design priorities

The prioritization is based on the value of flexibility!
The Plant is designed for the rated nominal operation point (optimum efficiency)

- Efficiency drop occurs in part load operation for all plants
- Operating efficiency decreases with frequent part load trips

**Efficiency vs. normed Power**

- CCGT: Operation not allowed for emissions reasons (NOx, CO)
- Hard Coal (Wes)
- Lignite (BoA 2&3)
## Determined Potentials to increase the Flexibility

<table>
<thead>
<tr>
<th>Plant</th>
<th>CCGT</th>
<th>Coal fired</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operating gradient</strong></td>
<td>Potential ± 7 %</td>
<td>Potential ± 6 %</td>
</tr>
<tr>
<td>Measures</td>
<td>Wall thickness reduction</td>
<td>Separation of milling and</td>
</tr>
<tr>
<td></td>
<td>Once through steam</td>
<td>combustion process</td>
</tr>
<tr>
<td></td>
<td>generator</td>
<td>Wall thickness reduction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Matched components design</td>
</tr>
<tr>
<td><strong>Minimum Load</strong></td>
<td>Potential approx. 0% load</td>
<td>Potential approx. 20% load</td>
</tr>
<tr>
<td>Measures</td>
<td>NOx- Catalysator</td>
<td>Increasing the number of mills</td>
</tr>
<tr>
<td></td>
<td>Post-combustion of CO</td>
<td>Improving the milling process</td>
</tr>
</tbody>
</table>
Flexibility improvement by Optimizing the Power Plant Portfolio - Example Combi Unit (Gas + GT)

Existing Unit
> Only steam turbine Controlled (GT drives at nominal load, 55 MW)
> From > 150 MW operating gradient about 40 MW / min.
> Full flexibility of the Plant is not accessed today from the dispatcher, although the plant is in the secondary control mode

Modernisation
> Replacement of the V93 turbines by 2 Trent aero derivative turbines allows higher gradient
I&C Optimisation makes modern Power Plants even faster

Lingen CCGT (875 MW)
> Increase in start-up gradient 4 MW/min → 12 MW/min

Neurath lignite-fired plant (600 MW)
> Reduction in minimum load of 20%-points
> Increase in load change rate 5 MW/min → 15 MW/min
New advanced Materials allow Increase in Flexibility or Efficiency

Efficiency development of lignite-fired plants

High efficiency
- Increase in steam parameters for newbuild power plants (700° C power plant)

High flexibility
- Constant steam parameters in existing plants and newbuilds (600° C live steam temperature)

Use of nickel-base alloys depends on operating conditions of future power plants
R&D Activities related to Flexibility Increase

- New materials for thin-walled flexible components

- New measurement methods and IT based monitoring to assess the life consumption to avoid damage of highly stressed components

- Predictive Maintenance: monitoring of components using Big Data

- Temporary electricity storage, when the produced electricity from conventional power plants is not required

- New combustion systems for lignite based dry lignite in order to increase the flexibility
THANK YOU VERY MUCH FOR YOUR ATTENTION