Case studies of air cooled vacuum steam condensers performance improvements

2013 ACCUG Meeting
October 14-17, 2013
CASE 1 - ACC CLEANING SYSTEM & FAN OPTIMISATION
Situation ACC until 2010

- Cleaning of ACC until 2010 was max. 2 times/year
- Simply cleaning in a fixed period without looking at loss of performance

Reduction in production of steam due to poor condensation

<table>
<thead>
<tr>
<th>Temperature up to 25°C</th>
<th>Percentage reduction in steam compared to maximum design temperature at 25°C</th>
<th>Reduction of steam compared to maximum steam flow at 25°C</th>
<th>Reduction in waste incinerated with steam flow at 25°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 to 28°C</td>
<td>Up to 6.23%</td>
<td>Up to 2.65 kg/s</td>
<td>Up to 3.24 t/h</td>
</tr>
<tr>
<td>29 to 32°C</td>
<td>Up to 14.54%</td>
<td>Up to 6.18 kg/s</td>
<td>Up to 7.67 t/h</td>
</tr>
<tr>
<td>33 to 36°C</td>
<td>Up to 22.86%</td>
<td>Up to 9.70 kg/s</td>
<td>Up to 12.02 t/h</td>
</tr>
</tbody>
</table>

Revenue losses through loss in electricity production
Example of calculations for loss of revenue (minimum case)

30 days temperatures over 25 °C approx. 10 h/day

300 h x ca. 5t/h loss of waste throughput

= 

1500 Tons less throughput

+ 

5kg/s steam = approx. 5MW * 300h

= 

1500 MWh less electricity throughput per year
Situation in 2011

- 1. Cleaning after winter
- 2. Cleaning after middle pollen phase
- 3. Cleaning after end of pollen phase
- 4. + 5. Cleaning in summer
- 6. Cleaning in Autumn
- 7. Cleaning before winter
Comparison between 2010 & 2011

The diagram shows the comparison between 2010 and 2011 with respect to Freischwefelproduktion (Frischdampfmenge) and Außentemperatur. The data points for 2010 are represented by blue diamonds, and the data points for 2011 are represented by green triangles.
Challenges for 2012

Mission

- Faster cleaning
- Improved efficiency of fan system → more condensation capacity
Optimization Winter 2011-2012

**Original cleaning system**

- Flexible hoses with check valves
- HP unit working pressure = 110 bar
- Number of nozzles for cleaning head = 12
- Incorrect position of nozzles versus bundle and nozzle orientation
- No option to rinse plenum chamber (after cleaning) and bottom rows bundle
Optimization Winter 2011-2012

*Improved cleaning system*

- Removed check valves and installed ball valves
- New high capacity HP unit working pressure *incl. Soft-start* = 120 bar
- Number of nozzles for cleaning head = 24
- Correct position of nozzles versus bundle and nozzle orientation
- Tube union Tee for HP gun (rinsing off dirt inside plenum and lower rows of bundle)
Optimization Winter 2011-2012
Optimization Winter 2011-2012
Improvement made by modification cleaning machine

- Before it took 7 hours to clean 1 side (2 fans) and with new optimized system is took only 3 hours for 1 side
  - Only 1 passage for cleaning head now versus 2 passages before due to higher pressure and better positioning & orientation of the nozzles
  - Cleaning head approx. 2 times wider then original cleaning head
- Better cleaning result per cleaning
- 4 cleaning sessions per year (versus 7 in 2011) due to improved cleaning results
Optimization Winter 2011-2012

**Original fan system**

- Margin over on motors
- Fairly low pressure capacity of existing fans → as soon as ΔP increases due to wind or external fouling, fans was starting to cavitate/stall

**New Situation fan system**

- Increase by 15% in fan RPM by increasing frequency of VSD’s from 50 Hz to 57.5 Hz.
- Decrease in pitch angle from 19.1° to 14.0°
- Improved airflow of minimum 8-10% versus original situation
- Improved pressure capacity of fan to cope with wind and especially external fouling
Evaluation 2012

LUKO-Auswertung MHKW 2012

Frischdampfmenge in kg/s vs. Außentemperatur °C
Comparison between 2011 & 2012

LUKO-Auswertung MHKW
2011 zu 2012

Frischdampfmenge

Außentemperatur
Evaluation 2010 / 2011 / 2012

LUKO-Auswertung MHKW
2010 zu 2011 und 2012

Frischdampfmenge

Außentemperatur
Evaluation 2010 / 2011 / 2012 (Back pressure)
Consequence of improvement
CASE 2 – INSTALLATION OF VARIABLE SPEED DRIVES

Existing situation
- No variable speed drives
- No room for VSD in sub-station (MCC)
- Pitch angle: 19°
- Fan tip speed: 30.9 m/s
- Motor power: 162 amps
- Temperature range: -20°C + 30°C

Average measured data
Airflow: 534 m3/s  Static pressure: 55 Pa  Amperage: 136 Amps

Traditional Solutions
- New fan with more blades or wider blades AND/OR
- New higher rating motor AND/OR
- Increased heat transfer surface
ELFLOW BV solution

- Increased tip speed of fan by 20% (50 to 60 Hz)
- Decreased pitch angle from 19° to 16°
- Fully loaded motor to 158 Amps
ELFLOW BV SOLUTION ADVANTAGES

New IP20 VSD with IP66 casing inside each cell instead of in sub station

Savings

- No new sub-station
- No new fans, motors or bundles
- No costly DU/DT filter (close to motor)
- No costly Sinus filter (close to motor)
- No extra cooling as fan is cooling VSD
- No cabling from sub-station to motor (if VSD is installed in sub station)
Advantages

- No need anymore for extra capacity on motor → Fans will turn slower in winter as cooling is not an issue at -20°C!!!!!!! This power can be utilized to increase airflow during summer operation
- Lower noise level during night/cooler period (when it is cooler and when noise limitations are stricter)
- Decreased total power consumption required by ACC during a year as regulation is optimized by VSD
- Strongly reduced load on fan blades, gearboxes and motor when running at lower RPM
- No wind-milling (fans will only run slower)
- Reduced maintenance costs of gearbox and fans (no start-stop)
- Ability to increase fan RPM by approx. 20% (50 to 60 Hz or 60 to 70 Hz) and therefore efficiency and pressure capacity
- Increased pressure capacity of fan by approx. 40%
- Increased static efficiency of fans by 6%
- Increased airflow of fans by 14% versus original situation
Abdampfdruck in Abhängigkeit der Aussentemperatur 2008

Abdampfdruck in Abhängigkeit der Aussentemperatur 2011
CASE 3 – ADIABATIC COOLING FOR ACC IMPROVEMENT
Adiabatic cooling

Typical ACC performance curve (Alstom turbine) illustrating improvement in vacuum with increments of 5°C in air temperature (at same steam flow rate)
Price of electricity varies with air temp.
Reduce ambient air temperature

Proper chilling system depends on .....
Possible Reduction in ambient air temperatures using COOLINGMIST™ system