Balancing of rotors, hard or soft

VGB Dampfturbinen Fachtagung 2012 - 15 bis 16 Mai
L.R. Janzee B-Eng
ENERGYMIX NETHERLANDS

GDF SUEZ Energy Nederland

- 5.103 MW total installed capacity
- A competitive portfolio for the production of electricity
- A flexible and powerful production park with low CO₂ emissions
- Development of the production of electricity based on natural gas, wind and coal
- Strong field of technical expertise

Total installed production capacity Electrabel end 2010 (in GW)

- 3.5% Biomass
- 0.5% Wind
- 88% Gas
- 8% Kohl

5.1 GW
LARGEST PRODUCER in the NETHERLANDS

Emscentrale
- Gas 2085 MW
- Wind 27 MW

Centrale Bergum
- Gas 664 MW

Head Office Zwolle
- Office

Centrale Harculo
- Gas 349 MW

Eemscentrale

Centrale Groningen

Head Office Zwolle

Centrale Harculo

Windpark Eems

Hoogeveen B2C

Maxima-centrale

GDF SUEZ Energie Nederland

21-5-2012
L.R. Janzee B.Eng
Balancing of rotors, hard or soft

- **Starting point:**
  - Our Steam Turbines are all above 150 MW
  - Only working at 3000 rpm = 50 Hz
  - All turbine rotors are direct coupled, no flexible connections
  - Average weight of the rotors:
    - HP turbine = ± 10 tonnes
    - IP turbines = ± 20 tonnes
    - LP turbines = ± 50 tonnes, heaviest = 95 tonnes
  - Average length between the bearings = ± 5 till 10 meter
Balancing of rotors, hard or soft

- The combination of the rotor length and the rotor weight gives in our cases a “stiff” rotor with only the first critical speed visible on site during the start up and shutdown.

- The second critical speed can sometimes be seen in the balancing pit between 3000 and 3600 rpm.
Balancing of rotors, hard or soft

- Judgement of the balance state of the rotors is done with ISO 11342 paragraph 9.2.2 – Evaluation at multiple speeds based on modal unbalances.
- Today it is common practice in balancing facilities to judge the unbalance status for flexible rotors using vibration values measured at certain positions of the rotor-bearing system.
  - These are: Vibration amplitude 0 – peak or peak - peak
  - Vibration velocity RMS or Veff
  - Acceleration
- These vibration values depend strongly on the boundary conditions of the rotor-bearing system, this means on bearing suspension stiffness, damping and other parameters.
- With changing damping characteristics with additional stiffness on a Schenck facility the change in vibrations values can be even 50%.
- The modal unbalance is a property of the rotor, but the vibration values (amplitude, velocity, acceleration) are a property of the rotor – bearing – system.
- Therefore we use the calculated residual unbalance in an Excel sheet with G=2,5
Balancing of rotors, hard or soft

Balance plane positions to choose from
Balancing of rotors, hard or soft

- According to ISO11342 we always propose the following procedure:
  - Initial run till 110%
  - First test run with a test weight on 1 balance plane till 110% (test weight must be large enough to see a good change in amplitude and phase)
  - Continue first test run with balance weight changes to the other balance planes. (place and take out every run the weights)
  - Calculate in Excel file the influence coefficients for each test run
  - Use the best balance planes to reduce the different modal unbalances
  - Final run to check the balance state of the rotor.
- This complete process is witnessed by GDF Suez!
Balancing of rotors, hard or soft

Balancing test of a Rotor

Rotor: Date: 25-jan-12

Job: HP turbine

Final balancing after overspeed test at 120%

<table>
<thead>
<tr>
<th>Plane</th>
<th>rpm</th>
<th>bearing #</th>
<th>balancing</th>
<th>Weight (gr.m)</th>
<th>angle (°)</th>
<th>A1 situation before balancing</th>
<th>Angle before balancing</th>
<th>A2 situation after balancing</th>
<th>Angle after balancing</th>
<th>A2 - A1 angle</th>
<th>Influence coeff. (µm /gr.m)</th>
<th>Angle influence coeff.</th>
</tr>
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<tbody>
<tr>
<td>Plane 160</td>
<td>160</td>
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<td>315</td>
<td>mm</td>
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<td>-28</td>
<td></td>
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</table>

| Plane 460 | 160 | grain | 315 | mm | | | | | | | | |
| low | 1570 | WE.Ai.VE.a | DE | 56,7 | 75 | 315 | 125 | 148,9 | 119 | 18,97 | -50 | 0,1540 | 18 |
| WE.Ni.VE.a | NDE | 56,7 | 75 | 119 | 164 | 11,7 | 95 | 12,5 | -46 | 0,4871 | 23 |
| low critical | 1900 | WE.Ai.VE.a | UA | 56,7 | 75 | 214 | 216 | 27,7 | 190 | 22,46 | 77 | 0,2060 | 43 |
| WE.Ni.VE.a | NDE | 56,7 | 75 | 29,5 | 271 | 24,0 | 193 | 29,90 | -60 | 0,4071 | 27 |
| nominal | 3300 | WE.Ai.VE.a | DE | 56,7 | 75 | 2,7 | 59 | 11,7 | 196 | 10,42 | -76 | 0,0638 | 223 |
| WE.Ni.VE.a | NDE | 56,7 | 75 | 11,7 | 266 | 10,6 | 310 | 2,65 | -49 | 0,9641 | -27 |
| overspeed | 3300 | WE.Ai.VE.a | DE | 56,7 | 75 | 2,7 | 59 | 11,7 | 196 | 10,42 | -76 | 0,0638 | 223 |
| WE.Ni.VE.a | NDE | 56,7 | 75 | 11,7 | 266 | 10,6 | 310 | 2,65 | -49 | 0,9641 | -27 |

Calculation of the allowed residual unbalance according to ISO11342

<table>
<thead>
<tr>
<th>rpm</th>
<th>Bearing</th>
<th>Influence coeff. (µm /gr.m)</th>
<th>Phase</th>
<th>Amplitude</th>
<th>Effective residual unbalance in gr.m</th>
<th>Max. residual unbalance in gr.m</th>
<th>result</th>
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</thead>
<tbody>
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<td>WE.Ai.VE.a</td>
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<td>0,2307</td>
<td>0,0</td>
<td>135</td>
<td>4</td>
<td>57</td>
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<td>0,0</td>
<td>135</td>
<td>4</td>
<td>57</td>
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<tr>
<td>1900</td>
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</tbody>
</table>

21-5-2012

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Balancing of rotors, hard or soft

• During the complete balancing process in a Schenck facility do NOT change the stiffness of the bearing pedestals. The facility can use the additional hydraulic cylinders for emergency stops after a sudden balance change.

• Without additional stiffness you get (soft):
  • Higher vibration measurements during the process
  • Sharper critical speed(s)
    • Easier to balance

• With additional stiffness you get (hard):
  • Lower vibration measurements (you reach earlier the OEM criteria)
  • Slightly wider critical speed(s)
    • More difficult to balance correctly
Balancing of rotors, hard or soft
Balancing of rotors, low or high

- According to our experience in the past 12 years we advise the power plant manager to balance the existing rotors only in a low speed balancing facility (LSB)
- Big advantage for the turbine overhaul is
  - A LSB takes less time than a HSB, normally 1 day as compared to at least 3 days or more.
  - The financial costs are much lower for LSB than HSB
- Important is always the quality of balancing
  - Our advise is to start with weight in the midspan of the rotor and NOT with a weight set on the 2 outer balance planes
  - Keep the unbalance always in the same phase corner.
Balancing of rotors, low or high

- Polar plot with the balance reduction but without the over shut of the phase angle.
Balancing of rotors, hard or soft

- Example with a HP turbine with corrosion damage
- First LSB and added 2.8 kg of balance weights
- Second HSB and added 120 gram of balance weights
Balancing of rotors, low or high

- Example with LP turbine 1 and 2 of CG power plant
- LSB balanced with 1200 gram for LP1 and 470 gr at LP2
- HSB balanced with only 160 gram
Balancing of rotors, summary

- For new built rotors always use high speed balancing
- For existing rotors low speed balancing is technical and financial the best to perform

- Keep a close look to the complete balancing process
- Follow the correct balancing procedure
- Check always with the influence coefficients the residual unbalance
- Do not use the vibration measurements as acceptance criteria

- Always check the stiffness set up of the balancing pit when they have Schenck bearing pedestals.
- Do NOT change this stiffness during the balancing process.

- Thank you for listening.