Vibro-Acoustic Diagnostics and Monitoring of Hydro-Turbine Cavitation
Korto Cavitation Services
Luxembourg

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Turbine Cavitation Diagnostics and Monitoring

WHY?
Visual inspection in overhaul: Total erosion originating from various loads

Vibro-acoustic test or monitoring: Erosion dependence on load (e.g. power and water levels)
Details?

A good vibro-acoustic method shows details:

# Existence of different cavitation mechanisms

# Role of different turbine parts
Cavitation characteristics of “identical” turbines, used in “identical” operating conditions can differ substantially.

Model tests do not show this. Vibro-acoustic tests and monitoring do.
Unit 6

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Model test vs. Vibro-acoustic...

- Model test
- Prototype vibro-acoustic test
- Turbine operation range

Discharge (m³/s)

Net head (m)
Permanent cavitation monitoring:

- Running estimate of the accumulated erosion
- Condition-based maintenance
Permanent cavitation monitoring:

- Ageing effects
- Incidents

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EXAMPLES

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(1) Turbine operation optimization

Francis 650 MW
(2) Plant operation optimization

6 x 48 MW Francis
(3) Cam optimization

Kaplan 27 MW
Cam defined in model tests

Cam optimized on prototype
(4) Diagnostics

Kaplan 27 MW
Radial coordinate: Normalized cavitation intensity
Angular coordinate: Angular position behind spiral
(5) Diagnostics

Bulb 40 MW
Strong once-per-rev. power fluctuations:

Explosive rise of developed cavitation on one blade
(6) Diagnostics

Kaplan 60 MW
62 ?
65 ?
Power statistics

Erosion rate

100 %
Up to 60 MW

Total erosion

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HOW?
Korto’s answer:

Multidimensional technique
(in monitor implemented in FPGA/RT technology)
(1) High number of spatially distributed sensors

(2) Complex signal and data processing
Monitoring: Typically 6
Why this many sensors?
Results of measurements by means of sensors in different positions

Quantity used for cavitation description
Why is complex signal and data processing necessary?
Colour: Cavitation intensity

Power setting

Instantaneous runner angular position
Power setting

Instantaneous runner angular position
Power setting

Instantaneous runner angular position

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Power setting

Instantaneous runner angular position
Analysis – Synthesis
<table>
<thead>
<tr>
<th>Technique</th>
<th>Simple</th>
<th>Multidimensional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of sensors in a good diagnostic test</td>
<td>1</td>
<td>1 on each guide vane</td>
</tr>
<tr>
<td>Number of sensors in permanent monitoring</td>
<td>1</td>
<td>typically 6</td>
</tr>
<tr>
<td>Signal and data processing algorithm</td>
<td>simple</td>
<td>complex</td>
</tr>
<tr>
<td>Delivers mean erosion rate estimate</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Delivers accumulated erosion estimate</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Represents <strong>all locations</strong> in a turbine</td>
<td><strong>no</strong></td>
<td>yes</td>
</tr>
<tr>
<td>Recognizes different <strong>cavitation mechanisms</strong></td>
<td><em>negligible</em></td>
<td>yes</td>
</tr>
<tr>
<td>Delivers <strong>diagnostic details</strong> (runner blade quality, etc.)</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Relative <strong>sensitivity</strong> in detecting deterioration effects</td>
<td>~1</td>
<td>~80</td>
</tr>
<tr>
<td>Overall <strong>accuracy and reliability</strong> of results</td>
<td>low</td>
<td>high</td>
</tr>
</tbody>
</table>
Conclusions

The multidimensional method for cavitation diagnostics and monitoring
Accurate assessment of total cavitation intensity
Distinguishes between cavitation on different runner blades
Distinguishes cavitation in different positions behind the spiral casing
Distinguishes the influence of different guide vanes
All this as a function of turbine operation conditions
Monitoring: Ageing effects assessment
Monitoring: Early high-sensitivity detection of deterioration effects
Monitoring: Accumulated erosion assessment
Application

(1) Turbine/plant operation optimization
Application

(2) Maintenance optimization
(accumulated erosion)
Application

(3) Identification of parts responsible for cavitation
Thank you for your attention!
More information:
Korto        Booth 226
VibroSystM   Booth 1220

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