Refurbishment of Hydro Power Plants

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Agenda

• 1st topic      Hydropower in Africa : fleet per country and age
• 2nd topic      Why a refurbishment ?
• 3rd topic      Refurbishment process
• 4th topic      Turbine refurbishment
• 5th topic      Generator refurbishment
Agenda

• 6th topic  Balance of Plant refurbishment

• 7th topic  Specific issues

• 8th topic  Examples

• 9th topic  Conclusions
Hydro Power Plants in Africa
Historic of orders in MW

25,000 MW of installed and under construction HPP
22,000 MW of HPP in commercial operation

Ageing average: 33 years
Hydro Power Plants in Africa Fleet by Country: Volume & Age

22,000 MW of HPP in commercial operation
Ageing average: 33 years

<table>
<thead>
<tr>
<th>Country</th>
<th>Volume in MW</th>
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<tbody>
<tr>
<td>Madagascar</td>
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<td>Malawi</td>
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<td>Zimbabwe</td>
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Why a refurbishment?

- Extend remaining life duration
- Improve profitability
- Get higher output and efficiency
- Provide greater flexibility

Refurbishment increases the value of your plant
Why a refurbishment?

- Increase availability
- Reduce operational and maintenance costs
- Adapt the plant to specific operation (peak production, grid regulation)
- Minimise downtime

Refurbishment increases the value of your plant
Refurbishment process

- Step by step approach for total plant refurbishment
  1. Customer expectations
  2. Preliminary determination of refurbishment potential
  3. Plant data acquisition and condition assessment
  4. Condition assessment analysis
  5. Feasibility study and solutions definition
  6. Method statement
  7. Financing

Step by step approach
Refurbishment process

Several issues have to be considered during feasibility study

- Base or peak operation
- Environment, new regulations
- Increase output, focus on output and/or efficiency
- Return on Investment analysis, financing,
- Reduction of maintenance costs
- Optimisation of unit shutdown during refurbishment works

Feasibility study: a detailed and accurate analysis
Refurbishment process

General philosophy

✓ Refurbishment presents more challenging design requirements than that of new units

✓ Interfaces between old & new equipment have to be considered

✓ Existing unit must be synthesized

✓ Collection of reliable data for existing units is absolutely necessary for a successful project

Site assessment is the key factor for success
Refurbishment process

General philosophy

✓ Site visit absolutely necessary for:
  • Measurements and visual inspection of unit (existing performances)
  • Assess the installation environment & limitations
  • Collection of additional data, eg maintenance records, test & operational data, OEM drawings, etc.
  • Discussion of refurbishment requirements and Q & A with customer engineers

Site assessment is the key factor for success
Turbine refurbishment

Design methodology

✓ Deep inspection of all components
✓ CFD calculations carried-out on separate components
✓ Comparison of water passages between existing layout and a model-tested design
✓ Hydraulic transient calculation

CFD remains the main tool for analysis
Turbine refurbishment

Design methodology

- Cavitation studies
- Fluid dynamic analysis of the static components (spiral case, stay vane, distributor and draft tube)

CFD remains the main tool for analysis
Turbine refurbishment

Possible improvements

✓ Oil-less hub for Kaplan
✓ Water lubricated bearing(for Kaplan & Bulbes)
✓ Hydrostatic bearing
✓ Fish friendly Kaplan turbine
✓ Efficiency
✓ Uprating
Generator refurbishment

Main problems on generators

- Insulation ageing
- Pollution
- Partial discharges
- Slot wedging defect
- Loosening of the magnetic core
- Excitation regulation problems
- Mechanical defects
- Magnetic core distortion
- Conductors wear or break
- Rotor coils insulation effects
- Interpolar connections defects
Generator refurbishment

Main components concerned by refurbishment

Major Failures

- Stator: 45% (Fault: Others 3%, Excitation 5%, Bearings 5%, Rotor 12%, Stator 50%)
- Lamination: 5%
- Winding Joints: 45%
- Insulation: 50%

Reliability of generator components

Mainly stator core, winding, rotor poles and excitation are concerned
Balance of Plant refurbishment

Control system

✓ Diminution of the quantity of operators and size of control rooms
✓ More data at real time for operation and maintenance
✓ Communication with National Dispatching Centre improved
✓ Storage of information not limited
✓ Redundant control systems with easy maintenance

Improvement of Operation and Maintenance
Balance of Plant refurbishment

Control system

✓ Redundant control systems with easy maintenance
✓ Installation of monitoring systems (vibration, partial discharge analyser, air gap monitoring…) in order to plan the outages for maintenance.
✓ Reduction of control cabling

Improvement of Operation and Maintenance
Balance of Plant refurbishment

✓ No more oil in the rivers
✓ Improvement of water treatment
✓ Reduction of noise in the power plant
✓ Diminution of auxiliary power
✓ Fire fighting and fire detection in accordance with last regulations

Environmental aspects
Specific issues

Several specific issues have to be analyzed:

- Environmental considerations
- Refurbishment period (depending on season)
- Refurbishment time schedule (to limit units shutdowns)
- Asbestos, Lead, … treatment
- Optimisation of erection bay utilisation
- New regulations (noise, ….)

Refurbishment: the way to optimize the power plant
Examples

Cahora Bassa, Mozambique

5 Francis turbines 415 MW -
Mechanical retrofit
Modernization of governing systems
New excitation systems
New Control Systems

Complete refurbishment Turbine / Generator / BOP
Examples

Kafue, Zambia

6VG – 200MVA – 375rpm
Output upgrade of six generators
From 150 up to 200MVA

+33% output
Examples

Kariba North, Zambia

4 Francis turbines 155 MW
Mechanical retrofit
4 units upgraded to 183 MW
Modernization of governing systems

+18% output
Examples

Kariba South, Zimbabwe

6 Francis turbines
Full refurbishment and uprating from 90 to 127 MW

+41% output
Conclusions

✓ Refurbishment is required to extend life of aging equipment and to increase the value of the plant in terms of performances (higher output and efficiency, greater availability)

✓ An accurate methodology for refurbishment feasibility study and execution is the key of the success

✓ Integration between Generator and Turbine is essential for good results in refurbishment projects

Greater availability, no environmental impact
Conclusions

Refurbishment will:

✓ Improve profitability of the power plant
✓ Achieve higher output
✓ Increase availability
✓ Provide greater flexibility
✓ Lower the operating costs
✓ Minimise downtime
✓ Improve the value of plant

The way to give a second life to your plant