KONČAR
in Hydro Power Plant Refurbishment
Reasons, approach and benefits of hydro power plant (HPP) refurbishment

Hydro power plant refurbishment is usually performed due to two basic reasons:
• obsolescence and wearing out of equipment
• to increase efficiency.

Generally speaking, refurbishment may result in achievement of multiple effects such as:
• increased reliability
• reduced production costs
• increased power and generation of electric energy
• increased static and dynamic stability
• extended service life
• increased efficiency
• extension of operation area - operating diagram.

Refurbishment process comprises different activities that are shown in the diagram below. Approach to refurbishment is different for each hydro power plant, therefore refurbishment process can differ in some degree from one power plant to another.

Refurbishment process
Refurbishment of a hydro power plant is a very profitable investment. Investment is refunded within the period of 3 to 5 years or even earlier.

Diagnostics of the existing plants condition on the basis of the data obtained from:
• technical documentation
• documentation on “operation history”
• operating staff
• inspections and checking
• specialised measurements and testing

Analysis of the condition of the main electrical parts related to water flow and output power of HPP:
• determination of remaining service life
• determination of possible scope of improvement (increase of water flow or power) for each component separately

Harmonisation of the scope of improvement for the main components in accordance with the criterion of technical and economic optimum

Necessary financial investment

Requirements set by:
• legal provisions
• electric power market
• electric power system
• operation and maintenance

Elaboration of basic solution for refurbishment

Working out of feasibility study

Working out of technical and commercial documentation for public bidding

Invitation for tenders, collecting offers, selecting a contractor

Implementation of refurbishment
Civil engineering segment

Civil engineering segment of a hydro power plant (reservoir, dam, water supply and drainage facilities, power house, etc.) remain the same, except in certain cases. Usually, only indispensable rehabilitations and adaptations, as well as necessary improvements are carried out.

Turbine equipment

Refurbishment of turbine and turbine governor represents a starting point for refurbishment of other energetic components of the power plant. Increasing of turbine power and/or rpm belongs to the key data for rehabilitation of the generator and other electrical equipment.

Electrical equipment

From the point of view of refurbishment, electrical equipment can be divided into two groups:

- Main equipment that determines the output power of the HPP (generators, excitation system, transformers, switchgear)
- Other equipment.

It is possible to refurbish the existing main equipment and to improve its characteristics by implementation of changes in the project and bigger or smaller reconstructions and replacement of individual parts or, in extreme cases, by production of new equipment. In majority of cases, the other equipment is to be completely replaced by new equipment.

Generators

The scope of refurbishment of a generator may go from replacement of worn out parts to the replacement of the whole generator. In majority of cases refurbishment comprises the following parts:

- Replacement of stator core and windings and sometimes stator frame, especially if it is necessary to decrease duration of erection works at site due to losses of generation of energy
- New pole windings and sometimes new poles
- Replacement and/or reconstruction of bearings
- Reconstruction of cooling system
- Replacement of the shaft, in certain cases
- Replacement of the complete generator, especially in the case of a possible change of rpm.

By selection of an optimised project solution, usage of new high quality materials and implementation of the most recent technological processes, it is possible to increase power even up to 25%, efficiency up to 1%, as well as improve other generator characteristics. Selection of an optimised solution is based on the comparison of the price of refurbishment and profit based on the improved characteristics: increasing of power and efficiency, extension of service life, extension of operating area - operating diagram and increase of static and dynamic stability.
Excitation systems

Excitation systems with classic rotating DC exciter with magnetic voltage regulators, due to obsoleteness, shortage of spare parts and qualified maintenance staff, are usually replaced by new ones. In the new systems electronic power converters (most frequently thyristor bridges) and automatic digital voltage regulators (AVR) are implemented. A partial refurbishment of excitation system is also possible, e.g. replacement of voltage regulator and related equipment, if the rotating DC exciter is in good condition. Recently, it is more and more frequent that the replacement of static excitation systems with analogous regulators (manufactured in 70-es and earlier) is performed due to obsoleteness of the component base.

New excitation system parameters should satisfy excitation requirements of the re-furbished generator and enable its connecting into the power system with increased requirements regarding system stability.

Transformers

Old transformers in the most cases have a significant reserve in power. By reconstruction of cooling system it is possible to achieve a further increase in power. But, in the most cases, old transformers should be replaced with new ones. There are various reasons for that and the most important are increased reliability and reduced power losses of new transformers. Since new transformers are of smaller dimensions there are no problems regarding their placement.

Switchgear

Together with the enlargement of power of electric energy system short circuit currents are increasing. On the other hand, through refurbishment of a power plant, the power increases as a rule. That is the reason why checking has to be performed to determine whether the existing equipment coresponds to the new values of rated and short circuit currents. Unsuitable equipment has to be replaced. Older equipment, not in the production any more, with reduced reliability and shortage of suitable spare parts should be replaced by new one.
AC/DC low voltage auxiliary power supply equipment

Existing plants, due to obsolete equipment, do not satisfy requirements set by a modern designed and equipped power plant. Therefore they have to be completely replaced by new equipment.

Control

Under the term “control” the equipment for local control, signalisation, measurement, protection, regulation, data processing, higher level control and remote control is understood.

Automated operation and remote control are often important goals of rehabilitation and modernisation of a power plant. It is usually performed together with interventions on the primary equipment, but very often independently as well, because that equipment becomes obsolete earlier than the primary equipment.

As a rule, the existing equipment is replaced with new one with inevitable introduction, improvement or extension of automated functions. Distributed control, numeric technology and modern way of visualisation (monitors) are applied to all levels. Through the application of new communication standards, the distributed control system is connected to process peripherals, with subordinated subsystems (excitation, turbine governor, protection) and other PC based systems (e.g. monitoring) into a unique local area network with almost unlimited possibility of data transfer.

A new control system gives the user new possibilities regarding control, plant management and supervision, archiving and analysing of plant events important for timely undertaking of corrective actions.
KONČAR company, as the manufacturer of electric equipment for hydro power plants, has been constructing such plants worldwide and has a long lasting tradition in maintenance and refurbishment of such equipment and plants. Specialised teams of experts from different areas cover such activities related to refurbishment of electrical equipment, starting from diagnosis to putting of a power plant into operation and maintenance of the plant.

On the basis of our own experience and recent scientific achievements a methodology for assessment of the condition of equipment and plant during operation and overhauls has been developed.

Together with usage of the data from technical documentation and operation history, additional check ups, measurements and inspections are performed.

During all the stages of refurbishment, and especially during the stage of condition assessment and planning of the scope of revitalisation a close co-operation with user’s experts, who determine goals and decide on changes of rated parameters and operational characteristics, has being established.

All the companies, members of the KONČAR Group, from KONČAR - Power Plant and Electric Traction Engineering, as the company responsible for HPP refurbishment, to the equipment manufacturers and erection performers are ISO 9001 and ISO 14001 certified.
Recently refurbished hydro power plants, and those whose refurbishment is still in progress, are listed in the table below.

Among the data regarding generator power of those HPPs we have given the data of powers of preceding and refurbished units.

<table>
<thead>
<tr>
<th>Country</th>
<th>Power plant</th>
<th>Number of generators</th>
<th>Scope of refurbishment</th>
<th>Contract time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Croatia</td>
<td>Gojak</td>
<td>3</td>
<td>Older: 20, New: 20</td>
<td>2002-2003</td>
</tr>
<tr>
<td></td>
<td>Senj</td>
<td>3</td>
<td>Older: 80, New: 80</td>
<td>2000-2002</td>
</tr>
<tr>
<td>Albania</td>
<td>Ulza</td>
<td>4</td>
<td>Older: 7,5, New: 7,5</td>
<td>2001-2004</td>
</tr>
<tr>
<td></td>
<td>Shkopeti</td>
<td>2</td>
<td>Older: 15, New: 15</td>
<td>2002-2005</td>
</tr>
<tr>
<td>Macedonia</td>
<td>Tikveš</td>
<td>2</td>
<td>Older: 26, New: 31,8</td>
<td>2001-2004</td>
</tr>
<tr>
<td></td>
<td>Vrben</td>
<td>2</td>
<td>Older: 8, New: 9</td>
<td>2001-2004</td>
</tr>
<tr>
<td>Peru</td>
<td>Mantaro</td>
<td>7</td>
<td>Older: 120, New: 120</td>
<td>1998-1999</td>
</tr>
<tr>
<td>Slovenia</td>
<td>Moste</td>
<td>1</td>
<td>Older: 7,5, New: 9</td>
<td>2002-2003</td>
</tr>
<tr>
<td></td>
<td>Ožbalt</td>
<td>3</td>
<td>Older: 22, New: 30</td>
<td>2000-2004</td>
</tr>
<tr>
<td></td>
<td>Vuhred</td>
<td>3</td>
<td>Older: 22, New: 30</td>
<td>2000-2004</td>
</tr>
</tbody>
</table>

Up to now KONČAR has constructed and refurbished more than 150 HPPs in Croatia as well as abroad.