Project Focus, The international Journal of Hydropower&Dams, Issue Two, 2000

REHABILITATION OF A FRANCIS TURBINE OF POWERPLANT SCHWARZACH, AUSTRIA

M. Mione, G. Mazza, Fravit, Italy
G. Aigner, P. Hassler, Austrian Hydro Power AG, Austria
H. Wohlfarth, FV-Stell Engineering, Switzerland

The rehabilitation of the Francis turbine group 1 of Power Plant Schwarzach (Austria) is presented, taking into account the background problems linked to the liberalization of the european energy markt. The technical challenge has the goal to reduce the re-assembling time on site and increase the turbine life time.

The rehabilitation of the Francis turbine group 1 of Power Plant Schwarzach, Austrian Hydro Power AG, was performed 1998-1999 thanks to the collaboration beetween FV-Stell Engineering (Switzerland), FRAVIT (Italy) and Austrian Hydro Power (Austria).

The check of the turbine geometry (perpendicularity between shaft and spiral casing) by means of an on site rotating device and the possibility to correct any possible non-perpendicularity by milling on site are special services which have made it possible to pre-assemble the turbine in FRAVIT's workshop, thus reducing the assembly time on site from four to two months.

The coating with Tugsten Carbide of the runner, the guide blades and of all the most critical rings and labirinths had the aim to achieve a longer lifetime, which is now expected to be ten years in spite of five.

Power Plant Schwarzach (Austrian Hydro Power)
Power Plant Schwarzach, settled 1058/59, has a mean annual production of 482 million kWh (120MW) with 4 vertical shaft Francis turbines with the main data:

H = 142 m	net head
Q = 26,8 m3/s	flow each turbine
n = 375 t/min	speed
P = 34,41 MW	power each turbine

The wear due to water aggressiveness is of medium intensity, but enough to cause major problems on the runner, the blades and the several labirinth rings.

The installed capacity makes this plant strategic, so that it is important to reduce at a minimum all dead times due to maintenance. In this view, an effort was made to find the way to minimize the frequency of the periodic rehabilitation, as well as its duration. The experience made by FRAVIT in the rehabilitaiton of several Italian plants was merged with the effective requirements of Austrian Hydro Power, with the aim of achieving this goal.

Background rehabilitation strategies
Liberalization of the european energy market gives big influence to the power supply companies and the hydro power industry [1].
Decreasing income makes it necessary to save money anywhere and to reconstruct the strategies for rehabilitation. These new strategies are a big challenge for the industry in order to develop their working process using new technologies and giving longer life time by coating materials.

Machinery in hydro power plants have shown a very high availability during the past decades, because of an intensive rehabilitation. Intervals for rehabilitation thereby have been relatively short. New strategies have to consider three main goals:

- less cost
- minimum activities and
- operation with no big damages.

In order to reach these targets the experience of decades of operation combined with carefully developped new methods of repair can lead to the necessary success which is requested.
Special requirements have to be fullfilled:

- old powerplants are normally built in the pre-numerically controlled machining aera with its own inaccuracy, hindering prefabrication of spare parts etc. - new methods should avoid this disadvantage
- improvements in the design of new plants have to be realized even on the old parts if requested
- all new methods of repair and construction must lead to the same very long and increased life time of the parts.Trials are absolutly undesirable.

Technical and commercial premises
The well known and very high costs for dismantling of all the parts are demanding the assumed long life time cycles for the whole repaired equipment.

Therefore the following parameters:

- clearance between runner/housing in different gap positions
- minimum clearance between guide blades and wear-rings
- abrasion rates for the wear rings
- fully numerically controlled (CNC) production process from turning to grinding of the Tungsten Carbide coated surfaces in order to save the minimum clearances for the guide vane to wear ring gaps

are to be realized in perfect manner.
As well as the technical, the commercial conditions are mostly a premise for to get an order today.

- the total costs have to be reduced
- saving money means to do the job mainly by own staff, using special equipment too, if possible
- premounting in order to check accuracy of manufacturing or to detect failures are forbidden because of its high costs
- the life time of all parts should have similar amount.

Rehabilitation procedure

1. Dismantling of the main parts, transport to the manufacturer with the following steps:

- measuring and updating of the drawings
- non destuctive tests, i.e. magnetic particle inspection (MT) and liquid penetrant test (PT) corresponding the TQM (Total Quality Management) requirements of CCH70-3 [2]
- fixation of the final amount and procedure of repair.

2. On site measurements

Geometrical inspection of the whole position of the shaft and of the perpendicularity of the flanges of the spiral case to it. This operation is performed in the power plant with a special equipment designed by FRAVIT after dismantling of runner, blades and at least one cover. These measurements enable the definition of the exact relative geometry of the wear rings and the guide vane blades (s. Fig. 1).

By the way all measures of the parts such as runner diameters, ring gaps and guide vane parts have been fixed and reproduced on drawings. This can enable the User to have a complete and up-to-date documentation of the turbine.
The correction of the spiral casing by means of a portable milling machine (performed by FRAVIT several times in Italian plants) was in this case not necessary, as the deviations were very small.

3. Repairing works

Welding, turning, CNC-machining of bores and blades, grinding and coating have been performed according to procedures that have been followed respecting the ISO 9000 certification of the FRAVIT company with full documentation of each step of the working process (s. Fig. 2 and 3).

4. Coating

After the repair of all worn parts (i.e. Francis runner, guide blades, rings and covers) the coating with Tungsten Carbide of the in-water parts allows for achieving very hard surfaces, in order to maximize the life time of the Francis turbine [3].
The coating (CABOFLAM-H 654) was obtained with a special procedure consisting of introducing the carbides in the metallic layer by means of High Pressure Detonation (HP/HVOF). This method, developped with a continuous laboratory research, allows for coatings with no residual stress, thus achieving far better characteristics of hardness and resistance against fatigue than in the traditional detonation methods. The chemical analysis has also been optimised after several years of tests and researchs, with the aim of the best possible resistance against mechanical wear and corrosion.

Chemical analysis:

- Tungsten Carbide (WC) 86%
- Cobalt 10%
- Chrome 4%

Phisical properties:

- Microhardness (HV 300) 1100÷1300 HV
- Porosity < 1%
- Adhesion > 80 MPa

5. Preassembly

Preassembly of the guide vane group with turbine head cover and guide vane rings, including the new wear rings, has been made in order to check the very small gaps of the guide vane blades to its wear rings and to prevent any delay during the re-mounting on site (s. Fig. 4). In this way the targets of eliminating on site adjustments on the parts and at a time of reducing the assembly time have been achieved.

Moreover, since all pieces are coated (with a very high hardness) no intervention of on site adjustment, e.g. such as manual grinding, was possible anymore.
The pre-assembly has to take into account that, in old turbines, mainly because of concrete settlement of the spiral casing, there is no certainty that the shaft and the spiral casing are perfectly perpendicular. If this is not the case, the pre-assembly in the workshop does not give any reliable picture of the assembly on site.

6. Assembly in the power plant

By the personal of Austrian Hydro Power, under the supervision of a FRAVIT‘s technician.

Conclusions

Taking into account the new strategies and requirements linked to the liberalization of the european energy markt, the technical goal was reducing the re-assembling time on site and above all increasing the turbine life time.

The general results of the presented rehabilitation strategies can be summarized as follows:

- reduction in scheduled time more than 20 %
- no preventive mounting before coating process saves costs significantly
- coating with Tungsten Carbide (partly robotized working process) gives an increased life time of two times more than without coating the base material (martensitic stainless steel X 5 CrNi 13 4). This result should enable the increased period of maintenance of more than eight years.

Bibliogaphy

[1] **B. Denis,** "A new challenge for Hydropower in Europe: Rehabilitation", *Hydropower into the next century III, Gmunden (Austria), Conference proceedings,* 1999

[2] "Cahier des charges hydrauliques", *CCH70-3,* 1996

[3] **O.C. Brandt, S. Siegmann, R. Hitzek,** "HVOF-gespritzte Schichten in Wasserkraftanlagen: Herstellung, Prüfung und Erfahrungen ", *Proceedings of the United Thermal Spray Conference & Exposition, Düsseldorf (Germany)*, 1999

Fig. 1 – on site measurements of the turbine geometry

Fig. 3 – repairing of guide blades

Fig. 2 – CNC-machining of rings

Fig. 4 – pre-assembly in FRAVIT workshop (simulation of the actual conditions on site).

Peter Hassler, graduated as a doctor of technical sciences at the University Graz/Austria. Joined Austrian Hydro Power AG in 1984. The wide range of experience is given on overhaul and reconstruction of Pelton- Francis- and Kaplanturbines from feasability studies up to hydraulic model tests and operation. Analizing of various damages on different components of hydraulic equipment as well as measuring and control of efficiency of runners is a special field of experience. New rehabilitation strategies demand a main part of his time today.
Gerhard Aigner , education. technical high-school, electrical engineering. Joined Austrian Hydro Power AG in 1987 and has been responsible for three powerplants in the fields of operation and technical maintenance .
Austrian Hydro Power AG, Kohldorferstrasse 98, 9020 Klagenfurt, Austria

Mario Mione has been responsible for several developments in the field of high efficiency machining and welding and brought this experience to the hydropower sector as Chief Director of Fravit, which is a company specializing in the manufacture of forged Pelton runners.
Gianluca Mazza graduated as a doctor of engineering from the Politecnico di Milano, Italy, in 1995. After participating to the refurbishment of some Swiss powerplants, he joined Fravit in Italy, where he has been a project manager since 1997.
Fravit s.r.l., via Alle Fornaci 27, 23868 Valmadrera, Italy

Hans Wohlfarth, education technical high school, since 1962 has been working in the field of Hydropower, and is working at FV-Stell Engineering since 1990 in collaboration with Fravit as senior Sales Manager.
FV-Stell Engineering AG, Albulastrasse 24, 8048 Zürich, Switzerland