# RENOVATION, MODERNISATION AND UPRATING OF SMALL HYDRO-POWER STATIONS

**Dr. H.K. VERMA**
Distinguished Professor
Department of Electrical and Electronics Engineering
School of Engineering and Technology
SHARDA UNIVERSITY
Greater Noida, India
**Website: profhkverma.info**

## 1. INTRODUCTION

The early hydroelectric installations world over were small hydropower (SHP) stations. The world's first hydroelectric power (HP) station was installed in 1882 in Appleton, USA and India's first HP station was commissioned in 1897 in Sidrapong (Darjeeling), although its installed capacity was merely 130 kW. Amongst the other century-old HP stations still working in India are the 2000-kW station in Shivasamudram in Mysore (1902), 40 kW station in Chamba (1902), 450 kW station in Mohra (1905) and 3000 kW station in Galogi near Mussoorie (1907). These SHP stations were used primarily for lighting purposes in the nearby important towns.

A very large number of SHP stations in India are now old (30 to 40 years) or very old (more than 50 years). The normal life of a SHP station is 30 to 40 years, after which there may be frequent breakdowns, which can make the maintenance difficult and the operation uneconomical. Moreover, the electricity generation may reduce drastically and thus the water discharge may be partly or substantially wasted.

In such cases, the useful life of the power station can be extended by renovation, which may involve repair of the worn-out and damaged components, or more often their replacement. When renovation requires replacement of a component or system of the power station, the opportunity should be utilized for modernizing the power station in respect of that component/ system with the aim of enhancing the performance. At this stage, one should also examine the possibility of increasing the rating or capacity of the station. In short:

- ***Renovation aims at extending the life***
- ***Modernisation aims at enhancing the performance.***
- ***Uprating aims at increasing the station capacity***

## 2. RENOVATION OF SHP STATION

Renovation may be carried out either by repair of the worn out and damaged components, or by their replacement. The choice must take into account the residual life assessed of the component, the extent to which its useful life can be extended by repair, the shutdown times required for the repair and the replacement, useful life of the new (replaced) component, and difference between the costs of repair and the replacement. In many cases, repair may not be feasible or may be costlier than replacement. Moreover, replacement offers an opportunity to use the latest materials, designs and technologies.

Before taking up any extensive renovation, a detailed study of the working and health of various components and systems of the power station must be taken up. The study should include (a) detailed survey, (b) critical inspection, and (c) elaborate scientific testing.

## 3. MODERNISATION OF STATION

Certain components of the power station would have outlived their useful life, or their technology or design would have become obsolete, or their performance would have gone down considerably. Such components are ideally suited for replacement with components of the latest materials, designs and technologies. Some good examples are:

(a) A mechanical governor should be replaced with a digital electronic governor
(b) Electrodynamic (rotating) exciter with either brushless or static excitation system
(c) Electromechanical relays with microprocessor-based digital relays or digital management relays
(d) Electrodynamic energy meters with microprocessor-based trivector meters
(e) Electrodynamic indicating meters with digital panel meters.

Such replacements are not only readily available but they also give better performance and maintenance-free life as compared to original types/designs. Cost will also be an important deciding factor.

One may consider introducing automation and new features/concepts in the power station. For example, PLC based automation should replace manual controls of turbines and generators. Manual operation of intake gates should be changed to automated and remote operation. Computer based supervisory control and data acquisition (SCADA) may be incorporated. These features can improve the working of the plant by reducing delays in starting the units, eliminating human errors etc. and allow operation of the generating units with reduced safety margins. Even remote control of a cluster of SHP stations may be considered.

## 4. UPRATING OF STATION

The output capacity of the power station can be raised in more than one ways. For example, improved profile of the blades can improve turbine efficiency. Use of class F insulation in place of the old class B insulation in stator windings would permit operation at a higher winding temperature, that is, raise the generator rating. Improved core material can reduce iron losses and allow a high flux density in a generator, and thereby raise its efficiency and output rating. The units can be operated with reduced safety margins subject to their completely automated operation. Thus, a 10% to 30% increase in the output of the turbine-generator unit may be possible.

It has been observed in some power stations that the available water head and/or discharge have increased since the construction of the station. In such cases, it is possible to correspondingly increase the capacity of the station by replacing the generating units or adding one or more units in the power station. However, if the increase in discharge or head is marginal, the ratings of the existing machines can be increased by using improved materials and designs and by introducing automatic controls, instead of replacing or adding machines.

## 5. SCOPE OF RMU STUDY

The RMU study by the consultant should aim at the following:

i. The consultant should carry out survey, inspection and testing to access the condition of various components of the power station and its overall health.

ii. Make an assessment, wherever possible, of the residual life of the equipment, power house building and water conductor system.

iii. Should examine the problems being encountered in the operation and maintenance of the power station and identify the reasons for its poor performance.

iv. Should indicate the nature and scope of renovation and modernisation works involved, bring out various options in respect of renovation and modernisation, and discuss the scope and means of uprating.

v. The cost/benefit analysis of each option at (iv) above should be made.

vi. Societal implications in terms of higher and assured availability of electricity to the people in the region and effect on employment should be studied.

vii. Environmental implication, if any, should also be examined.

viii. A detailed project report (DPR) should be submitted at the end of the RMU study, which should include the details of the study and analysis as above and present a road–map for implementation of the project.

## 6. METHODOLOGY

The RMU study should be conducted in a systematic manner after a meticulous planning. The study comprises of the following steps in order:

i. Study of the available drawings and data of the station, operation and maintenance records and commissioning records of the power station.
ii. Survey and inspection of the power station.
iii. Testing of various components and systems of the power station.
iv. Techno-economic analysis.
v. Preparation of detailed project report (DPR).

## 7. STUDY OF DRAWINGS, DATA & RECORDS

The RMU studies should start with the study of the following drawings, data and records to the extent that they can be obtained:

i. Power house and project layout drawings
ii. Schematic, electrical and equipment drawings
iii. Technical data of main components
iv. Hydrological data
v. Testing and Commissioning records
vi. O&M records
vii. Past RMU studies, if any
viii. Perception of O&M engineers

# 8. SURVEY AND INSPECTION

## 8.1 Hot Survey

The second step in the study is to see in detail the working of the entire power station in hot (running) condition with the objective of identifying any deficiencies and problems. The "hot survey" must include all major parts and systems, namely

i. Canal and power channel
ii. Water conductor system
iii. Hydro-mechanical parts

## 8.2 Inspection

A close and critical inspection (visual examination) of all parts and systems in the power station to is required to identify deficiencies and problems in the power station. This also helps in deciding the need of cold survey, testing and any other investigations.

## 8.3 Cold Survey

Details of certain parts cannot be checked while the generating units are running. This can be done after shutting down the units and is called cold survey. For example, trash racks, gates and their grooves, draft tube and underwater parts of the turbine can be inspected only after dewatering and cleaning of these parts. Similarly, condition of the feeder channel, bypass channel and the tailrace channel and silt deposition in them may require closing of these water channels.

# 9. TESTING

## 9.1 Non-Destructive Mechanical Tests

Following are the basic non-destructive tests (NDTs) which must be conducted to identify mechanical defects in mechanical and hydro-mechanical parts:

i. Dye-penetration test: to identify surface cracks.
ii. Ultrasonic test: to identify internal cracks.

Some of the following special ND tests may also be taken up as and if necessary:

i. Magnetic particle test
ii. Metallographic test
iii. Hardness test
iv. Natural frequency test
v. Plate thickness test

## 9.2 Electrical Tests

### (a) Preliminary Electrical Tests

To begin with, the following preliminary tests are carried out to check the integrity and general health of the dielectrics of major electrical equipment, like generators, exciters, cables and transformers:

i. Insulation resistance and polarization index test.
ii. Partial discharge test

### (b) Detailed Electrical Tests

In case the above preliminary tests confirm that the insulation of the electrical equipment is alright, tan-delta and capacitance test is conducted.

Following tests are conducted further on the generators:

i. AC pole drop test
ii. Rotor impedance test
iii. DC resistance measurement of stator and rotor windings
iv. Excitation characteristic or open circuit test

DC resistance of the transformer windings may also be measured to verify against the values available in records.

Contact resistance measurement on circuit breakers is an important test. If necessary it also may be carried out on the busbar joints to check their integrity.

Calibrations of meters and transducers are checked. Secondary injection tests are carried out on the protective relays to check their health and accuracy. Earthing resistance of the earthing mat of the switchyard is measured to confirm its health.

### (c) Special Electrical Tests

Some or all of the following special tests may be conducted as necessary:

i. Earth resistivity test
ii. ELCID test
iii. High potential test
iv. Cable fault location
v. Battery/cell voltage test
vi. Charger current test

## 9.3 Non - Electrical Tests

The following non-electrical parameters of turbine-generator units are measured:

i. Bearing/Bracket vibrations
ii. Shaft vibrations
iii. Noise around machines
iv. Temperature rise of windings & bearings

## 9.4 Hydraulic Tests & Investigations

Following hydraulic measurements and investigations may be required:

i. Measurement of actual water discharge available
ii. Measurement of actual water head available
iii. Measurement of head losses in headrace, penstock, tailrace and draft tube.
iv. Silt assessment
v. Desilting and lining requirements for water channel

## 9.5 Structural Tests

Following tests are conducted on civil engineering structures in the power station:

i. Concrete strength measurements
    a) Indentation test
    b) Rebound test
    c) Ultrasonic pulse velocity test
ii. Crack/cavity detection
iii. Concrete-cover-on-bars measurement

## 9.6 Laboratory Tests

Some of the tests cannot be conducted in the field, but test samples can be taken to a laboratory for detailed analysis/examination. These tests may be as follows:

i. Dissolved-gas analysis
ii. Breakdown-voltage test on oil
iii. Material composition test
    a) Metallographic test
    b) Chemical analysis
    c) Electron spectroscopy
    d) Electron microscope scanning
    e) Electron probe analysis