Recent Renovation and Modernization Technologies for Existing Hydro Turbine

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ABSTRACT

In India most of the hydro power plant have passed there successful life of more than 25 to 30 years and are still operating with time these powerhouses are suffering frequent maintenance shutdown due to deterioration and damage in equipments, change in operating condition from the initial design stage. Renovation and modernization (R&M) of power plants in the present scenario of severe resource constraint is considered to be the best option for bridging the gap between the demand and supply of power as (R&M) schemes are cost effective and quicker than the setting up green field power plants. To this end, renovations of hydro turbines after many years of operation have been carried out for the purpose of life extension of units, performance improvements, and capacity up rating, availability improvement, and improved environment compliance. This paper describes the advanced technologies adopted in the renovations, including LVDT in servomotor, improved turbine efficiency, improved availability and simplified or no maintenance. Renovation and modernization case studies of life extension of Matatila power plant are introduced to illustrate how these technologies will be applied and what will be gain..

Key words: Hydro turbine, availability and efficiency

1 INTRODUCTION

The role of the hydroelectric power plant is increasing in importance because water power is a clean energy source amply available in nature furthermore, requirements for hydroelectric generation have been raised as a means of generating energy quickly in response to demands of electricity systems. It is very important to utilize existing old hydroelectric power plants effectively and efficiently, as well as to build new hydroelectric power plants.

Renovation of hydro plants calls for a systematic approach as there are a number of factors viz. hydraulic, mechanical, electrical and economic, which play a vital role in deciding the course of action. For techno. economic consideration, it is desirable to consider the upgrading along with Renovation & Modernization/ Life extension.

Recognizing the benefits of (R&M) programme, Govt. of India set up a National Committee in 1987 to formulate strategy on renovation and modernization of hydro power plants. Based on the recommendations of the National Committee and subsequent reviews, 55 hydro schemes were identified and its policy on hydropower development declared in 1998 has laid stress on need for renovation and modernization of hydro power plants.

In India most of the state electricity boards and Power utilities on account of their financial conditions are not in a position to invest in creation of new generating capacity. The economy in cost and time essentially results from the fact that apart from the availability of the existing infrastructure, only selective replacement of critical components such as turbine runner, generator winding with class F insulation, excitation system, governor etc. can lead to increase in efficiency, peak power and energy availability apart from giving a new lease on life to the power plant/ equipment. Modernization is a continuous process and can be a part of the renovation programme. The reliability of a power plant can certainly be improved by using modern equipments like shera pin detector, self lubricating bearings, LVDT, microprocessor based controls, electronic governors, high speed static relays, vibration, temperature, speed monitoring, silt content in water.

2 NECESSITY OF (R&M)

- The unplanned outages continued showing increasing trends in some machines.
- At some Power Houses the effect of silt erosion was predominant which necessitated the use of modern Technologies to retard the damage.
- The existing equipment at certain Power Houses was non-uniform. Therefore, there was a need to create Interchangeability of existing non-uniform to reduce larger downtimes for annual overhauls and maintenance of fewer spares and inventories.
- There was huge shortage of peaking power and possibilities existed for Up-gradation.

3. OBJECTIVES OF (R&M)

Technological advancements especially in improving the turbine efficiency, metallurgy, better insulation materials for electrical equipment and advanced numerical controls and protections made much better equipment available since the projects were originally constructed and it was found feasible to up-rate the machines further within the same space and enhance the peaking capacity. The main objectives of R&M of Hydro Plants are:

- To increase the capacity and energy with up-graded turbine runners for more effective utilization of reservoir waters.
- To ensure safe, reliable and economic electricity production by replacement of worn-out, deteriorated or obsolete electrical, mechanical, instrumentation, controls and protection system by state-of-the-art equipment.
- To ensure greater availability of Power Houses specially during peaking hours.

4 PROBLEM OCCURRING IN EXISTING POWER PLANT

Water Turbine: - Occurrence of excessive corrosion and/or wear on spiral case, guide vane, head cover, bottom ring and so on.

Table 1. Components and problems of hydro turbine

Components	Existing technologies	Problems	Recent Technologies
Hydro Turbine	Hydro Turbine wear, corrosion due to old age.	Occurrence of excessive corrosion or wear on spiral case, guide vane, head cover, bottom ring and so on.	Repair of Turbine with new technologies
Runner	No on line monitoring of cavitation and side gap between runner and inner head cover.	Occurrence of excessive corrosion and/or wear / cavitation	Application of high resistance material to cavitiation pitting & on line monitoring.
Guide Bearing	Guide Bearing without self lubrication.	Damage due to lack of forced circulation lubrication	Self Lubrication type to eliminate of the lubricating oil circulation system.
Inlet Valve.	Inlet Valve.	Occurrence of excessive wear / cavitation	Adoption of self lubricating bearing.
Pressure oil supply system (OPT)	Pressure oil supply system without manual cut off	Pressure gauges not worked	OPT with oil level meter. /computerized controlled out cut off.
Governor	Mechanical Governor	Occurrence of excessive wear / worn	Electro-hydraulic type/computerized controlled

5 STEPS OF RENOVATION

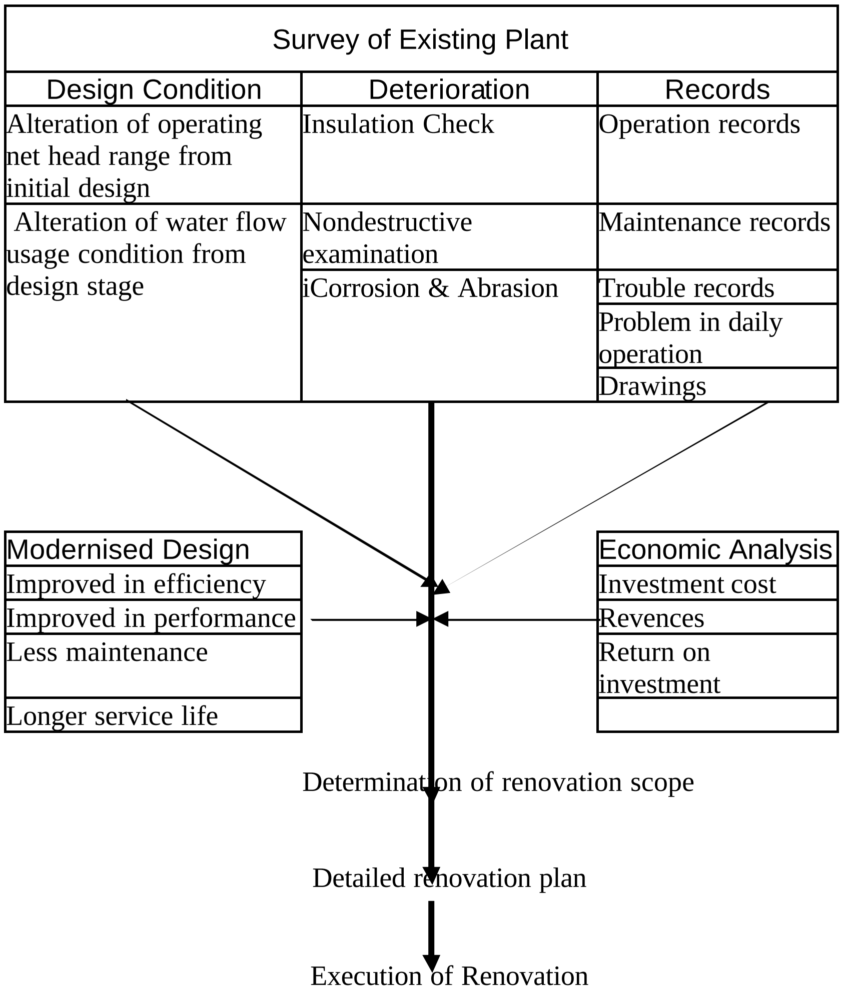

Figure – 01 Steps of Renovation

6 CASE STUDY

Matatila projects constructed between 1963 and 1965 and situated in Laltipur ,(UP). Matatila Dam on river Betwa with Power Stations of 3×10.2 MW with irrigation channel. Hear three units are installed with capacity of each unit 10.2 MW. The catchments area of the dam is 8000 sq. miles. full reservoir level of dam is 308.46 m, minimum drawn down level is 295.66 m, gross storage capacity of the dam is 638.63 million cubic meter and live storage capacity of the dam is 615.61 million cubic meter, the culturable command area is 428.36 thousand hectare and annual irrigation is 167 thousand hectare .the average annual evaporation losses from reservoir is approximate 88.38 million cubic meter. It was all about the basic information of the matatila hydel project matatila power stations are sources of low cost electrical energy (about 0.21 Rs. per kWh) and provide invaluable peaking power to the Northern Regional Grid of India.

To day in Matatila power plants still operating, there occurs deterioration, damage to or trouble with the equipment, alterations of conditions from the initial design stage, difficulty in maintenance, increasing maintenance costs and environmental pollution with the passage of time. These adverse circumstances result in a decrease in power revenue and an increase in maintenance costs. In considering the solution of this kind of trouble or inconvenience, it is very important for clients to conduct renovation.

Increase in generating electricity by applying a higher efficiency turbine or generator, or by modification of a turbine or generator design to meet the present rating range that differs from the initial design stage.

7 CALCULATION OF EFFICIENCY LOSS AND GENERATION LOSS

7.1 Standard efficiency of plant when it was installed

At full load (10.2 MW)			
?$_g$ (Generator efficiency)	?$_t$ (Turbine efficiency)	?$_p$ (Penstock efficiency)	?$_o$ (Overall efficiency)
96.45%	89.40%	99.00%	85.36%
At ¾ th load			
97.45%	91.30%	99.00%	88.09%
At ½ th load			
97.30%	91.20%	99.00%	87.85%
At ¼ th load			
93.50%	87.20%	99.00%	80.71%

7.2 Current efficiency of the plant

At full load (10.2 MW)			
?$_g$ (Generator efficiency)	?$_t$ (Turbine efficiency)	?$_p$ (Penstock efficiency)	?$_o$ (Overall efficiency)
92.00%	81.00%	95.00%	70.79%
At ¾ th load			
9250%	82.50%	95.00%	72.49%
At ½ th load			
92.50%	82.30%	95.00%	72.32%
At ¼ th load			
88.45%	77.19%	95.00%	64.86%

Efficiency loss= Standard efficiency – current efficiency= 85.50 – 70.11= 15.38%

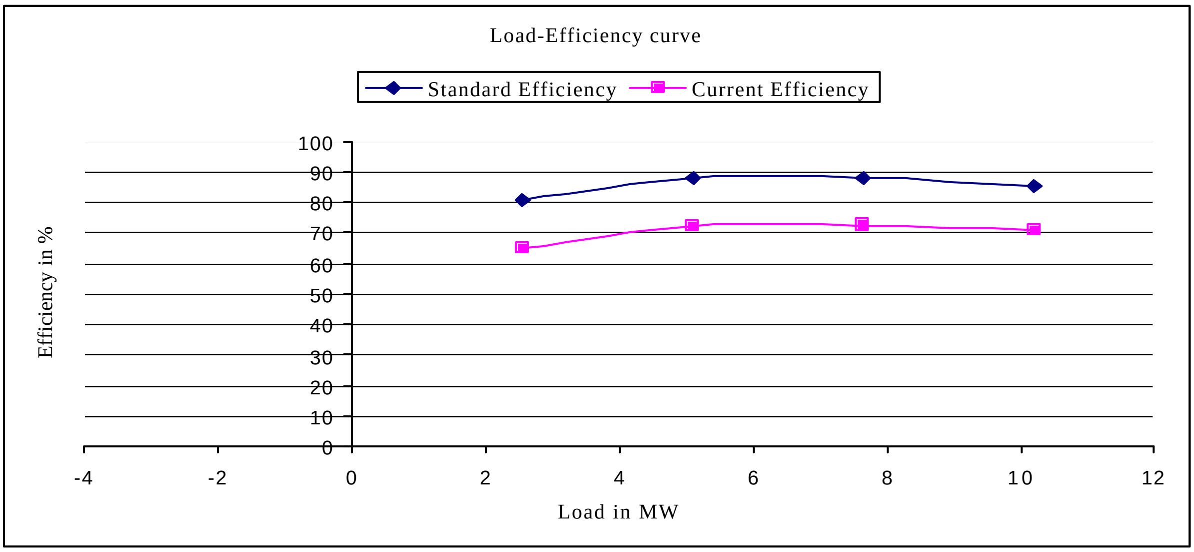

Chart 01 Curve between load & efficiency.

7.3 Availability of plant

Availability is based on the operation time, excluding down time, to loading time .hear the availability of the plant is being calculated in terms of hours of a year.

Availability = (operation time /loading time)= [(8760-3900)/8760] ×100= 55.47%

7.4 Generation losses due to shut down and maintenance:-

We have assume that tariff of electricity supplied per KWh is Rs.4.00
Generation capacity of one unit= 10.2×10^3 KWh
Then generation losses=$0.85\times10.2\times10^3\times4.00$ = Rs.34,680 per KWh

8 ADVANCED TECHNOLOGIES

8.1 LVDT for Servo Motor

Mounting the transducer external to the cylinder is the easiest implementation in Guide vane servomotor. The LVDT is mounted via clamps or pillow blocks in parallel with the cylinder. The coils are fixed on the cylinder housing, and the core assembly is free to move with the piston rod, providing the displacement measurement. The alternative is to mount the LVDT directly inside the cylinder, under pressures of 3,000 to 5,000 PSI. To accommodate these high pressures, we can either seal the unit against the pressure, or vent the housing and equalize the pressure. Figure 03 illustrates a vented LVDT mounted outside of a hydraulic cylinder. The piston rod has been gun-drilled to accommodate the LVDT housing, with the core assembly affixed inside the drill hole. As the piston moves in and out of the cylinder, the core moves relative to the coils, producing a voltage output proportional to the piston rod displacement. The leads can be brought out of the cylinder via a pressure fitting.

Alternatively, the LVDT can be sealed against pressure and manufactured with a flange at one end. This allows the unit to be inserted into the cylinder, butter minated external to the pressurized environment we compete with magnetostrictive and potentiometer transducers for this application. In displacement ranges under 20", we have a length, cost, and frequency response advantage over magnetostrictive units. The non-contact design of the core and coils in an LVDT provide longer life and better reliability than a linear potentiometer.

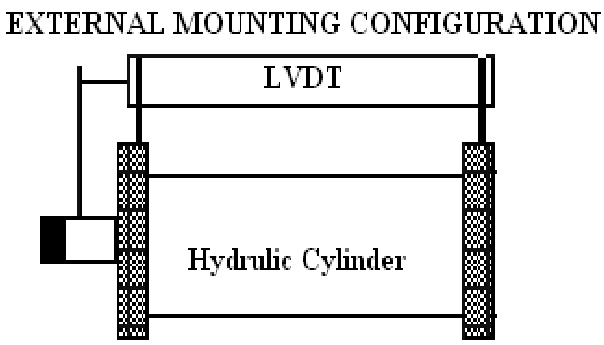

Figure -03 LVDT for servo motor

Figure - 04 Graphalloy bushing

8.2 Graphalloy Bushings

A graphite-metal alloy is a dry, self-lubricating alloy with a low coefficient of friction. Graphalloy bushings provide lifetime cost and operating advantages over other materials as shown in fig.04.

- Graphalloy bushings work where others won't. You can replace ball bearings, metal and plastic bushings, and ordinary hard carbon bushings.
- It bushings reduce maintenance and downtime.
- It is a self lubricating material and operates as a bearing without additional lubrication. These long-wearing bushings never need lubrication.
- Graphalloy bushings are available in over 100 grades with specific properties that meet a wide range of engineering solutions and specifications. The most used graphalloy materials are Babbitt, copper, bronze, nickel, and silver.
- Graphalloy provides design freedom, improves turbine efficiency and improves reliability.

Advantages:
Self Lubricating, No Grease or Oil, High Temperature Operates from -450º to 1500º F (-240º to 800º C),Low Coefficient of Friction, Chemical Resistant , Tolerant to Dust, No Oil Contamination & Reduced Downtime.

8.3 Runner Repair

Figure 5. Runner preheating

Figure 6 Runner cavitation

Newer runners and impellers are manufactured as one-piece castings, cast components welded together, fabricated components welded together, or a combination of cast and fabricated components welded together. In addition, areas of the runner may be weld over laid with cavitations resistant material.

Examination of the runner of a hydraulic turbine or the impeller of a pump often discloses pitted areas in various stages of development. Pitted areas may also be found on turbine or pump water passage surfaces where water velocities are high. This damage is generally termed cavitations erosion or impingement erosion. Because of various physical conditions present in the water flow system, a cycle of cavitations is induced as follows:

Extreme low-pressure areas are produced by flow irregularities. Pockets or "cavities" of vapor form. Pressure and flow conditions change abruptly. The pockets or "cavities" collapse causing high shock pressures. Where the collapse occurs adjacent to a metal surface, the resultant impact tears out bits of the metal.

"Runner modifications require a through analyses and understanding of the cause of the cavitations pitting. Basically, three types of modifications may be necessary to reduce the damage:

- Leading edge modification,
- Trailing edge modification
- Addition of anti-cavitations fins (on propeller and Kaplan turbines)
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It is important that a well devised plan be made for any runner modifications, involving if necessary, changes made in small steps with more frequent inspection.

Repair Methods:-
Welding is the most common and, to date, the most successful method of repairing cavitations damage on hydraulic turbines. The various steps for repair by welding are as follows:

Pre dimension check, preheating of cavitation area shoen in figure 5 and 6, TIG welding, Grinding of welding area, weld inspection and dye penetration test and Final dimensional checks.

8.4 Shear Pin Detector

Shear pin detector shown in figure 7 for fast identification of a broken shear pin. A shear pin is a mechanical fuse that breaks when too much effort is applied on a wicket gate. It protects the wicket gates and related mechanism against major damage when its blocked by debris during closure. When it happens, it is important to quickly identify which shear pin is broken The breaking detector to the rescue:- the breaking detector for shear pin is a unique piece with LED light on the top that fits in to the shear pin. Each detector is connected and to an alarm. When a shear pin breaks, the light of its breaking detector turn on and the alarm is triggered. On average, a turbine has about 20-wicket gates each protected by a shear pin and to be equipped with a breaking detector.

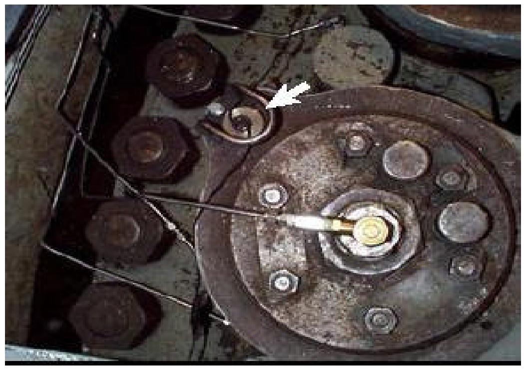

Fig.7 shear pin detector in guide vane arm

9 RESULT AND DISCUSSION

The availability of the plant for one year is 55.47% .the curve shown in figure no. 01 shows that graph between load & efficiency. Due to old age the efficiency of the plant was decreases approximate 15.38% and the generation losses per KWh is Rs 34680 for one unit. If we will not take any step towards applied recent technologies and renovation and modernization then definitely it will be tripe the whole plant as well as generation losses.

10 CONCLUSION

In the present scenario of severe resource crunch, capacity addition through renovation, modernization, of matatila power plant is considered to be the best option as R&M schemes are cost effective and have lesser generation period because the Indian economies is not so strong to reinstall the whole plant. This paper should be targeted towards maintaining low cost generation as every Kwh of missed hydroelectric opportunity, builds pressures to generate Power through other resources, which are generally non-renewable and expensive. Advance technology for hydraulic turbines have been developed for life extension and upgrade of again hydraulic turbine plants and adopted successfully in the renovation of all the three units. cost effective renovate solution to maximize the value of again hydraulic turbine generator plant assets will continue to be provided based on these experience.

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