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RENOVATION WITH CONFIRMATION TEST FOR VERTICAL FRANCIS TURBINE

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ABSTRACT

This paper presents confirmation test and renovation of 4x9 MW vertical Francis turbine of Umiam hydro Power station situated at Shillong, Meghalaya State of India. For this purpose before renovation of plant, test conducted for measurement of various signatures like pressure, temperature, speed, vibration etc. which increase due to old age. The results show that after confirmation test and renovation the generator output is always improved for the parameters like guide vane servomotor stroke, vibration, shaft run out and noise at turbine pit entrance. The result also provides information that the overall efficiency of the plant is increased after renovation.

Keywords: synchronize, renovation, confirmation test.

INTRODUCTION

The use of hydropower is increasing day by day as a source of electric power. Waterpower is clean and renewable energy source and amply available in nature. In India most of the hydro power plant have passed there successful life of more than 25 years and are still operating [1]. 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. Increase in maintenance cost and decreases in generation are making these powerhouses inefficient. In considering the solution of this kind of trouble or inconvenience, it is very important for client to conduct renovation of powerhouse that will offer the benefit [7]. Renovation and modernization of old 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. 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. Major hydro turbine manufactures have continued to push forward the development of advanced technologies to satisfy demand from utilities by providing renovate design that optimizes the above criteria. Before renovation or disassembly of turbine the test conduct is known as Confirmation Test.

This test was applied on the 4X9 MW vertical Francis Turbine of Umiam hydro Power station situated at Shillong, Meghalaya State of India. Various equipments were used such as vibration meter, watt meter, noise meter, dial gauge for checking shaft run out etc. These instruments were used to record the initial readings such as vibration, noise, pressure, temperature, generator voltage, generator current, guide vane servomotor stroke, shaft run out, draft tube pressure, spiral casing pressure, water level of reservoir and tailrace before disassembly.

The machine is controlled from control room and these readings are being taken at various locations in powerhouse i.e., at 11kV control room, generator floor, turbine floor, turbine pit floor. The electric bells were used in each of these areas to synchronise the timings of recording of the measuring instruments. The operator from the control room was monitoring the measurements by initiating the ringing of the bell.

After recording operating conditions, the static dimensions of all assemblies of the machine were recorded carefully. After that, machine is completely dismantled and each and every component is put to through visual inspection and there life and condition is estimated by conducting various non destructive test like dye penetration test, magnetic particle test etc. Dimensional checks were carried out to ascertain that components are with in tolerance. Similarly electrical test were carried out on electrical system and there healthiness were checked [2-4].

Hydraulic path being the most critical in turbine efficiency, which were thoroughly repaired [6]. Major repair were carried out in turbine assemblies. Water and oil pipe lines were totally replaced with new pipe lines

After renovation again all operating test were conducted, all the initial condition of testing equipment will be the same and same parameters will be recorded as temperature, pressure, noise, vibration, generator voltage and current shaft run out and tail race water level.

In this research paper confirmation test and renovation of 4x9 MW vertical Francis turbine of Umiam hydro Power station is conducted for the year 2001 and various parameters are recorded to prepare results which shows the variation of generator output.

Description

The test is carried out to establish wear and tear in the machine and to calculate turbine and generator efficiency and performance. The different technical data is collected from 4x9 MW vertical Francis turbine of Umiam

Power House for year 2001 and it is given in Tables 1 and 2. The condition of water path is studied to see the damage due to corrosion and cavitation [5]. It is important to measure the efficiency of turbine so that better hydraulic path can be designed with appropriate runner to achieve better efficiencies. The cost of renovation and modernization is recovered in very short duration due to increased power out put and reduced shutdown period. The following parameter shall be measured to study the feasibility of renovation and modernization for the machine under consideration shown in Tables no. 1 and 2.

Instruments required for test

The parameter for study is given in Table-3. The mechanical and electrical instruments which are used in the testing are given in Table-4.

Table-1. Output test before renovation.

Signature		Unit	1	2	3	4	5	6	7	8
Generator output		(kW)	0	1212	3564	4800	5904	6840	7920	8976
G.V. servo stroke		(mm)	12	42	88	107	122	135	149	171
GENERATOR	Voltage	(kV)	10.17	10.15	10.16	10.08	9.85	9.90	10.03	10.22
	Current (R)	(A)	0	60	192	258	330	390	444	498
TURBINE	Casing pressure	(kg/cm^2)	15.0	15.0	15.0	14.9	14.8	14.7	14.7	14.5
AFT RUNOUT	Turbine bearing	(mm)	0.07	0.08	0.09	0.10	0.09	0.08	0.07	0.07
VIBRATION	Generator upper bracket	(V/Hμ-p-p)	8/5	7/5	6/6	6/6	6/5	5/5	5/5	5/6
	Turbine head cover	(V/Hμ-p-p)	4/4	4/4	3/3	3/2	2/2	4/10	2/2	2/2
NOISE	Turbine pit entrance	(dB"A")	97	97	98	98	97	98	97	97
WATER LEVEL	Headrace water level	(EL.m)	969.31	969.31	969.31	969.31	969.31	969.31	969.31	969.31
	Static head	(m)	159.152	159.152	159.152	159.152	159.152	159.152	159.152	159.152

Table-2. Output test after renovation.

Signature		Unit	0	1	2	3	4	5	6	7	8
Generator output		(kW)	2	1024	2005	3006	4017	4974	6065	6924	7850
G.V. servo stroke		(mm)	6	26	43	60	75	89	105	118	130
GENERATOR	Voltage	(kV)	10091	10087	10083	10093	10082	10083	10082	10085	10083
	Current (r)	(A)	7.4	60.2	115.7	173.1	230.8	285.9	348.6	397.9	451
TURB INE	Casing pressure	(kg/cm^2)	16.2	16.2	16.1	16.1	16.1	16.0	16.0	15.8	15.8
SHAFT RUN OUT	Turbine bearing	(X.01mm)	0.015	0.02	0.02	0.02	0.025	0.025	0.02	0.02	0.02
VIBRATION	Generator upper bracket	(V/H)μ-p-p	10/10	10/10	10/10.5	10.5/10.5	10.5/10.5	10.5/10.5	11/11	11/11	11/11
	Turbine head cover	(V/H) μ-p-p	1/.9	1.1/.9	1.1/.8	1.5/1.2	1.7/1.5	1.6/1.4	1.6/1.8	1.7/2.4	1.5/1.5
NOISE	Turbine pit entrance	(dB “A”)	96	93.4	92.4	93	95	95	97.9	99.3	97.4
WATER LEVEL	Headrace water level	(EL.m)	978.49	978.49	978.9	978.49	978.49	978.9	978.49	978.49	978.9
	Static head	m	168.91	168.88	168.81	168.73	168.67	168.57	168.51	168.48	168.41

Table-3. Parameter to study the feasibility of renovation and modernization for the machine under consideration.

Turbine	Generator	Auxiliaries
Head race and tail race water level	Generator out put (MW)	Cooling water system
Water discharge	Generator voltage (KV)	Drainage and dewatering system
Condition of water path	Generator current (A)	Compressed air system
Turbine efficiency	Reactive power (power factor)	Air conditioning system
Guide bearing temperatures	Meggar value of stator insulation	Draft tube gate
Guide vane servo motor stroke (gate position)	Thrust and guide bearing temperatures	EOT (Electric overhead traveling) crane
Spiral casing pressure	Hot and cold air temperatures	
Draft tube pressure	Cooling water temperatures	
Shaft run out and vibration		
Vibration at head cover		
Noise.		

Table-4. Instruments required for test.

Electrical	Mechanical
3 phase wattmeter- 1A, 110 V	Magnet stand
Oscilloscope	Dial gauge
Ammeter 1A	Scale, measuring tapes, etc
Voltmeter 110 V	Vibration meter set
Multimeter	Noise meter

Preparation for the test

The measurement of Generator parameter like MW, V, A, power factor shall be taken at rated voltage through calibrated current transformer's and potential transformer's in control cubicle. The parameter like bearing temperature, cooling water temperature and air temperature in generator are to be carefully recorded at various load settings. Vibration meter shall be installed in the turbine pit for measuring the vibration at runner shaft and head cover. Dial gauge shall be installed at turbine guide bearing; thrust bearing and upper guide bearing for measuring shaft run out. Two dial gauges at 90 degree shall be located at each of these bearings. The measurement for spiral casing pressure and draft tube pressure shall be made. The readings for the same shall be taken from the meters on the existing turbine control panel. Noise measurement shall be made at turbine at turbine generator floor. Since the machine is controlled from control room and these readings are being taken at different locations i.e. at 11kV room/ control room, turbine pit turbine floor, bells are proposed to be located in each of these areas to synchronise the timings of recording of the same. The operator from the control room will initiate the ringing of the bell.

RESULTS AND DISCUSSIONS

Figure-1 show the curve between guide vane servomotor and Generator out put before and after disassembly of hydro turbine. In the both case the guide vane servomotor stroke rises as for constant head the power output from generator is directly proportion to discharge. But the guide vane servomotor stroke for any constant power output is lower in case of after renovation of hydro plant because overall efficiency of hydro power plant is increased. After renovation curve shows that the same out put can be obtained at less GV servomotor open. So we can say that saving a more amount of water.

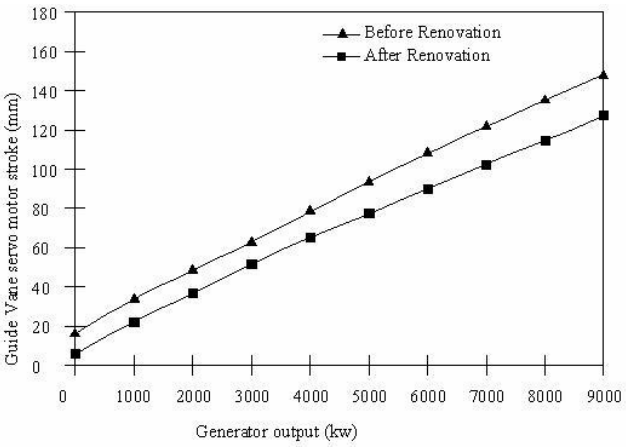

Figure-1. Curve between GV servo motor and generator output.

Figure-2 shows the curve between vibration of turbine entrance pit and generator output from this Figure it is clear that the vibration of turbine pit is low after renovation of plant because the wear and tear of different parts are reduced due to worn out parts.

This Figure also shows that with the increase of the generator output the fluctuation in the variation of vibration is very slight in case of after renovation of plant but the fluctuation variation of vibration with increase in generator output is high incase of before renovation of plant

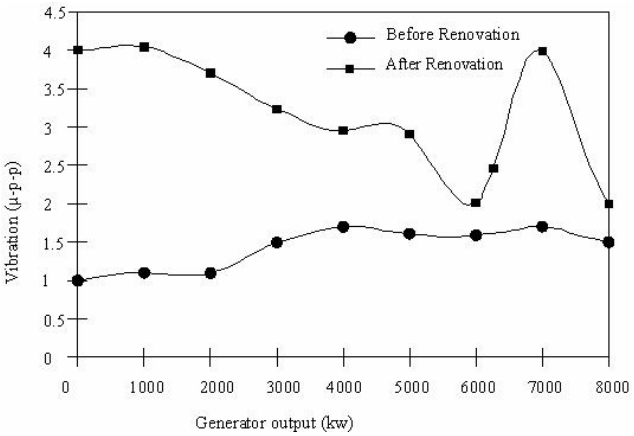

Figure-2. Curve between vibration and generator output.

Figure-3 shows the curve between shaft run out and generator out put. This Figure shows that shaft run out is more in case of before renovation of plant because misalignment of shaft and gap between shaft and bearing is varying. After renovation shaft aligned and gap bearing are fixed. Hence the shaft run out is varying continually with generator output while in case of before renovation it is more.

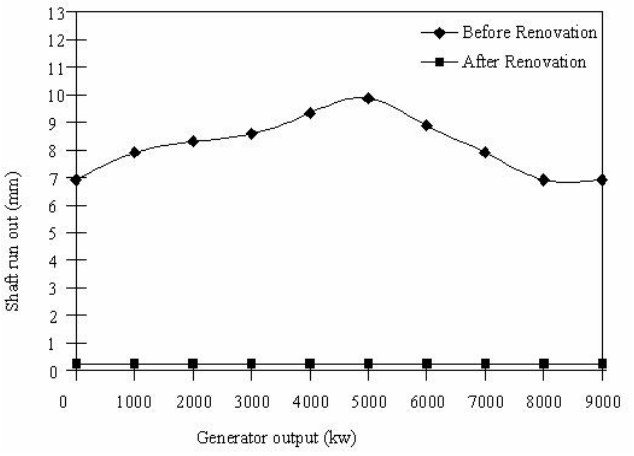

Figure-3. Curve between shaft run out and generator output.

Figure-4 shows curve between noise and generator output. Noise was taken from in the turbine pit and draft tube access way. The noise indication after renovation is almost constant with varying load condition.

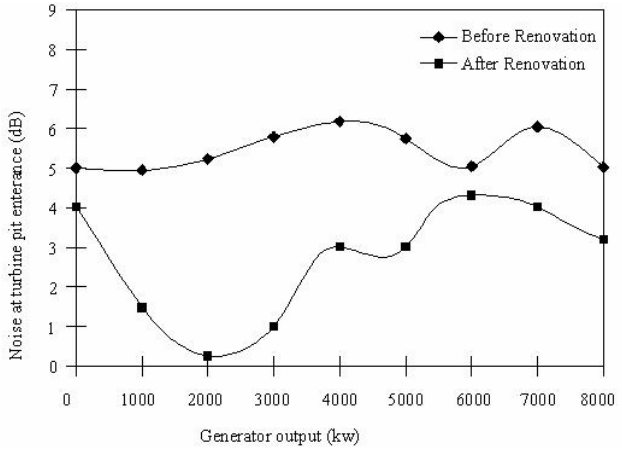

Figure-4. Curve between noise and generator output.

Figure-5 shows curve between plant life and overall efficiency of power plant. At the time of installation of plant efficiency was 98 per cent; the efficiency was decreased up to 59 per cent when increasing the life of the plant up to forty two years. After renovation again efficiency and life of plant increased.

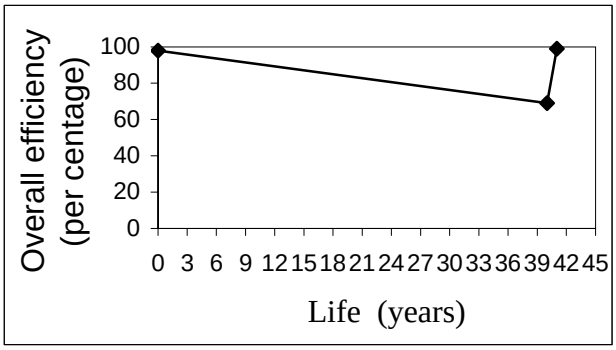

Figure-5. Curve between plant life and overall efficiency of power plant.

CONCLUSIONS

In this work, we have analysed testing data of hydro turbine by confirmation test which gives the information about before and after condition of turbine and generator signatures. These signatures are very helpful for prediction of overall life of hydropower plants and gives satisfactory result to the customer. Data recorded are studied for performance curves, temperature rise and vibration and it is noted that most of the time of the year the hydro machine run either below their rated output or run above the rated output, and in both cases the efficiency of the machine is lower which a direct loss in useful power generated.

Nomenclature

V	Voltage
A	Ampere
MW	Megawatt
kW	Kilowatt
kV	Kilovolt
Kvar	Kilovolt ampere
(V/H) μ-p-p	Vertical/Horizontal micron peak to peak
	dB "A" Decibel in Angstrom
EL.m	Elevation in meter

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