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Commercial Operation of 2.82 mw Pakpattan Hydropower Plant in Punjab Pakistan

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Abstract

The 2.82 MW Pakpattan Hydropower Project (PHP) lies on Pakpattan Canal, achieved commercial operation on December 2016. Construction of the power plant began in May 28, 2012 and was completed at a cost of US $10.64 million in December 30, 2016. It is capable of generating enough electricity to power approximately 35,000 homes in Punjab Province and will offset more than 2500t of greenhouse gases annually. The hydroelectric facility successfully completed the 72-hour testing period required to achieve the Commercial Operation Date (COD). This paper highlights details of testing required to achieve commercial operation of the project.

Keywords: Commercial operation • Hydropower • Canal • Grid

Introduction

Project description

The Pakpattan Hydropower Project with a plant capacity of 2.82 MW has been constructed as a run of the river hydropower project in the power canal in bypass arrangement at R.D. 114+800 of Pakpattan Canal. The site is located approximately 12 KM from the district town of Pakpattan in Punjab province. Pakpattan is connected to National Highway (Lahore – Multan) at Okara through Deepalpur and at Sahiwal through Arifwala. Access to the Project area is gained from Pakpattan through paved road up to R.D. 112+350 on left side of Pakpattan Canal, then crossing the V.R. Bridge at RD 112+350 to Powerhouse Location at R.D. 114+800 along the right bank of canal. [1]

The hydropower project mainly consists of combination of two falls to utilize the head for energy output. A power canal (in a bypass arrangement) situated at right side of Pakpattan has been constructed between the two fall structures and the power house is constructed approximately midway (at RD 114+800 of Pakpattan Canal in the power canal. The power canal has been designed to carry a maximum discharge of 112.57 cubic meters per second (3976 cusecs) [2]. The gated spillway is located adjacent to the Powerhouse Table 1. An access road is constructed to reach the powerhouse area on the right bank of the Pakpattan Canal as per the conditions [3]. Project Index map is shown in Figure 1. A completed view of Pakpattan hydropower plant is shown in Figure 2.

Methods

Electrical and mechanical works

The major E&M Works are as under:

Gated spillway: The spillway includes four [4] radial gates, hydraulically operated by hoist cylinders, two for each gate. The hydraulic hoist system includes pressure accumulators pumps, oil sump tanks, control valves and piping housed in the local control room located on a deck over piers, downstream of the gates. A service road is constructed on the upstream side of the gates which gives access to the spillway from the adjacent powerhouse.

Two sets of stop logs are provided for inspection and repairs of gates while the spillway is in operation. A mobile crane (25t) is provided with a telescopic boom for handling the stop logs, and a truck trailer to transport the stoplogs from the storage yard.

Power plant: The power plant includes two horizontal shafts, double regulated, pit type Kaplan Turbines coupled to the generator through a speed increaser (Gear Box). Base Data of the above equipment is given below in Table 2.

Gear box: The gear box details are given in Table 3 below

Generator: The generator details are given in Table 4 below.

Station Auxiliaries and other Equipment:

The power plant has the following station auxiliaries to help the T-G units to run safely and reliably.

- Powerhouse bridge crane (25t/5t)
- Lube oil system for turbine and generator.
- Lube oil system for gear box.
- Powerhouse drainage and turbine dewatering system.
- Cooling water system for turbine, generator and gear box.
- Compressed air system and pipework.
- Firefighting water system and pipework.
- Ventilation and air conditioning system.
- Generator transformers and auxiliary transformers.

Table 1. Technical details of spillway gates.

Type of Gates	Radial Gates Hydraulically Operated
No. of Gates	4 No.s
Dimensions(W × H)(mm)	8112 × 2792
Gates opening time	0.5 m/min
Gates closing time	0.5 m/min
Hydraulic Hoist lift force	2 x 150 kN
Gates sill level/elevation	165.93 masl.
Spillway Discharge Capacity	112.57 m^3/s

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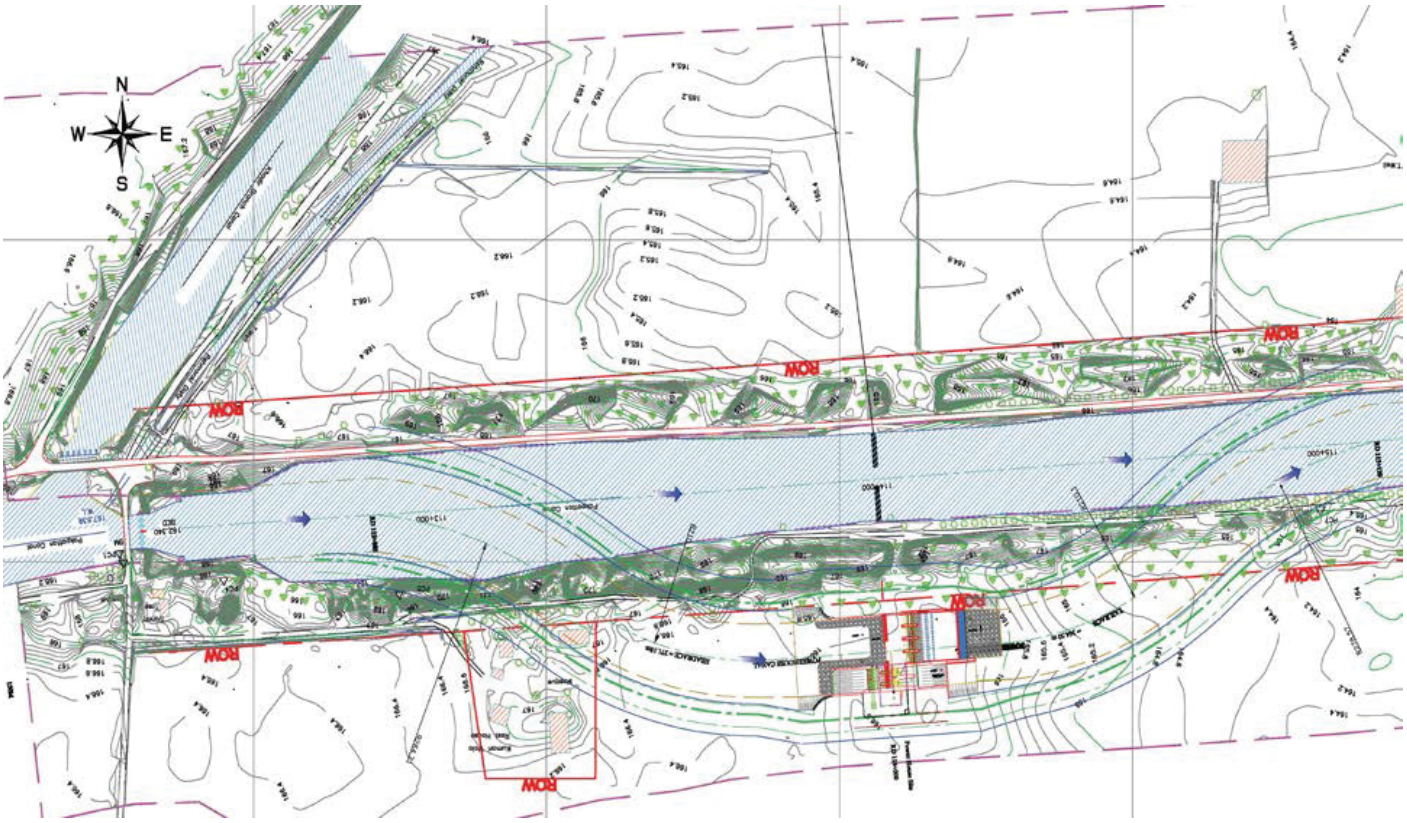

Figure 1. Lay out plan of Pakpattan Hydro Power Project (PHP).

Figure 2. A view of completed Pakpattan hydropower project.

Table 3. Gear box details.

Type of Gear Box	Involute Cylindrical Planetary type
Max Input to Gear Box	1800 KW
Input Speed	173.6 rpm
Output Speed	750 rpm
Speed Ratio	1:4.32
Gear Box Efficiency	98.5%

Table 4. Generator details.

Generator Details	Parameters
Rated Power	1.76 MVA
Rated Current	161.5 A
Maximum Continuous Rating(mcr)	1.76 MVA
Nominal Speed	750 rpm
Nominal Voltage/Frequency	6.3 KV/50Hz
Generator Efficiency	96.03%
Power Factor	Cos ϕ(0.8)

- Cables and control panels for the power plant equipment.
- HV/LV switchgear and control panels
- Standby diesel generator.
- Draft tube roller gates and hydraulic hoist system.
- Power intake stop logs.
- Power intake trash racks and trash rack cleaning machine.
- Spillway radial gates and hydraulic hoist and pipework.
- Spillway stop logs.

Commissioning and tests:

- Upon completion of erection of the above equipment all items of plant were tested and adjusted for normal operation. The details of tests performed at plant are given in Table 5 below.
- The station auxiliaries were tested individually before flooding the turbines.
- After flooding the turbines, the following tests were conducted.

Pre-commissioning tests of power plant:

i. During assembly of turbine, check the guide vane clearances with inner and outer casing, inter gate clearances and runner blade clearances with runner chamber

ii. Install the gear box and generator with bearings on their foundation.

iii. Fix flexible couplings between turbine shaft and gear box and between gear box/ generator shaft and check the alignment of shafts for turbine/ gear box/generator by slow rotation of gear box manually and adjust as required.

iv. Install and test governor and its hydraulic system, including governor hydraulic control panel, oil pumps, pressure accumulator, and all related pipework.

v. Install and test gear box lube oil system and related pipework.

vi. Install and test lube oil system and pipework for turbine and generator.

vii. Install and test powerhouse drainage and turbine dewatering system.

viii. Install and test cooling water system and pipework for turbine, generator and gear box.

ix. Install and test compressed air system and pipework.

x. Install and test firefighting water system and pipework.

Table 5. Details of tests performed.

Sr. No	Test Description	Date of Tests
1	No Load Trial Run	March 2-4, 2016
2	Over Speed Test	March 2-3, 2016
3	Machine Synchronized with Grid	
	Unit No. 1	May 1,2016
	Unit No. 2	May 2, 2016
4	On load Test Run at 25%, 50%, 75% and 100% of rated load at rated head	May 2-4, 2016
5	Load Rejection Tests.	May 4, 2016
		Oct 15, 2016
6	72 Hours Continuous Test Run at Full Load	Oct 3-9, 2016
	Repeat 72 Hours Continuous Test Run at Full Load	Dec 16-26,2016
7	Performance Guarantee Tests	Nov 19-22, 2016

xi. Install and test ventilation and air conditioning system.

xii. Install and test generator transformers.

xiii. Install all cables and control panels for the power plant equipment and complete terminations and test.

xiv. Install and test HV/LV switchgear and control panels

xv. Install and test standby diesel generator.

xvi. Install and test draft tube roller gates and hydraulic hoist system and pipework.

xvii. Install and test power intake stoplogs.

xviii. Install and test power intake trash racks and trash rack cleaning machine.

xix. Install and test spillway radial gates and hydraulic hoist and pipework.

xx. Install and test spillway stoplogs.

Commissioning tests

Before flooding the canal, conduct the following tests:

i. Check the operation of trash rack cleaning machine

ii. Check the power intake stoplogs for smooth operation while lowering and raising in the slots by the electric hoist.

iii. Operate the draft tube roller gates with hydraulic hoists and check for smooth operation.

iv. Check turbine parts (runner, wicket gates, and shaft seal) and waterway from inside and clean the area.

v. Check the operation of runner blades and guide vanes by hydraulic system.

vi. Close the man-hole of draft tube.

Flood the Canal upstream and downstream of the power-house, keeping the power intake stoplogs and the draft tube roller gates closed:

i. Pressurize Compressed air system and pressurize air strip at shaft seal.

ii. Open the filling valves of draft tube gates using the lifting beam and flood the turbine from inside and pressure by TW.

iii. Check for any leakage from the turbine body joints, draft tube man-hole and the inflatable shaft seal.

iv. Lift the draft tube gates to open position by the hydraulic hoist.

v. Lift the power intake stoplogs to open the turbine inlet, using the electric hoist and mobile crane.

Operate and test the pumps and filters of the following:

i. Unit cooling water system

ii. Drainage and dewatering system.

iii. Firefighting water system.

No load trial run:

In the starting process, the following items should be checked or recorded. Check if there is a colliding phenomenon between rotating parts and fixed portion:

- Monitor the operating condition of oil and cooling water system;
- Monitor and record the temperature of each bearing;
- Check the leakage situation at each part;
- Record the guide vane opening at starting run and that at 50% and 100% of rated speed, and upstream and downstream levels corresponding to the gate openings;
- Monitor and record the vibration or oscillation values at various positions.

Over Speed test:

- Increase the speed of the machine manually and check that it trips at the specified limit (about 140% of normal speed.)

On load test run:

- The load shall be applied gradually to 25%, 50%,75% and 100% of rated output. The unit should steadily work for some time (normally one to two hours) at various loads. The temperature of each bearing and the oscillation and vibration of certain positions should be checked and recorded during that period.

Load Rejection Test:

- The dynamic feature of governor, sensibility of over-speed protecting device, and speed rise and water pressure rise of the unit shall be tested during the rejection test.
- The relevant rejection test shall be performed subsequently after each on-load test at 25%, 50%, 75% and 100% of rated output is finished.

72 hours on-load continuous test:

- After all of the test for each system (including governor, generator, exciter and control etc.) are finished, the 72 hours on-load continuous trial-run test shall be performed to check performances of unit for continuous run at full load.
- In the full load continuous run, the temperature, vibration and swing at various parts shall meet the requirements, and the operation shall be in order.

Index test:

- According to IEC standards, set two different pressure positions to connect a pressure differential transducer.
- On the basis of formula QIX=K*$\triangle$px, the index discharge Q can be calculated, then according to the formula N=ρgQhη, calculate the index efficiency (η).
- At selected water head, first appoint a runner blade, then change guide vane opening to make a N-η curve, then change a runner blade angle and repeat the process, so we can obtain several N-η curves, then an envelope curve can be made. It's a combination operating condition curve at specified water head. Repeat last process, we can obtain the combination operating condition curves to optimize the operation condition of the unit.

Performance guarantee tests:

- Turbine and governor
- Generator
- Transformers
- Runner cavitation guarantees.
- Inspect the runner after about- six (6) months of turbine operation.

Conclusion

All the tests indicated in above sections have successfully been completed. The Completion Certificate has been issued to the Contractor. The plant is now in operation and dispatching energy to the national Grid.

References

1. Hydraulic Design of Reservoir Outlet Works,(1980)
2. Feasibility study Reports of low head hydropower stations in Punjab, (2006)
3. Mahu, Mazhar Hussain. "Development of low head hydropower projects on canals in Punjab Pakistan." Centenary Celebration. 719 (2012):251-266.
4. Mahu, Mazhar Hussain. "Water Power from Canal falls in Punjab Pakistan." Pakistan Engineering Congress Quarterly Publication, (2016).

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