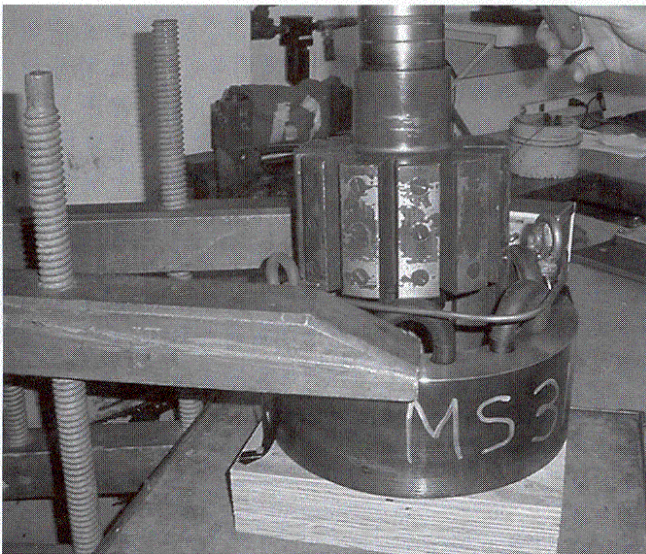


Sticky Wickets

Working to Solve Pelton Governor Instability At John Day Dam

For 14 years, the U.S. Army Corps of Engineers experienced intermittent governor stability problems with three of the 16 units at its 2,160-MW John Day Dam on the Columbia River between Washington and Oregon. The problem usually appeared after a unit had been shut down for a few days for routine maintenance. Symptoms included hunting and difficulty synchronizing. However, after a few hours of operation, the governor behaved normally.

Corps mechanics and electricians undertook numerous investigations to isolate and resolve the problem, to no avail. They then decided to test the output voltage of the permanent magnet generator (PMG) of one of the three governors. It was found to be low, suggesting that the PMG needed to be remagnetized. American Governor Company in Langhorne, Pa., designed a special apparatus to remagnetize the PMG — which was of the Pelton design — and performed this operation on the PMGs of two John Day governors. Following remagnetization, both governors operated normally.



This rotor from the permanent magnet generator (PMG) of a Pelton governor from 2,160-MW John Day Dam is being remagnetized using direct current voltage. Remagnetizing the PMG temporarily solved a 14-year problem of governor instability on this unit.

Understanding PMGs

Mechanical governors on medium to large hydroelectric units typically use a PMG to sense the rotational speed of the turbine-generator. The PMG is a three-phase, self-excited motor mounted atop the generator. The PMG's rotor is mechanically connected to the generator shaft, and the stator is wired to a complementary three-phase motor in the governor cabinet. As the turbine starts rotating, voltage from the stator is immediately supplied to the governor's flyball motor, locking it in synchronism with the unit. In addition to its simplicity, the PMG provides a highly accurate speed signal that is immune to generator or system disturbances, except those resulting from a change in unit speed.

PMGs with the Pelton design differ significantly from those with the Woodward design. The Pelton rotor features individual vertical pole pieces, and the number of pole pieces differs between the stator and rotor. This design allows the Pelton PMG rotor to be separated from the stator without losing magnetism, simplifying routine bearing replacement. With the Woodward design, the number of pole pieces in the rotor and stator are the same, allowing remagnetization in place. However, the rotor of a Woodward PMG can never be separated from the stator without suffering a loss of magnetism.

Even though the rotor of a Pelton PMG can be separated from the stator without adverse effects, age, sharp blows, or rough treatment can degrade rotor magnetism. Over the course of many years and many

overhauls, Pelton rotors can gradually de-magnetize. This can be corrected by periodic remagnetization; however, specialized equipment is required. Pelton offered this service, but in the decades since the manufacturer went out of business, the availability of this service has become more difficult to arrange.

Discovering the problem

Each of the 16 units at John Day undergoes scheduled maintenance twice a year. The unit usually is out of service four days, for completion of a variety of turbine and generator maintenance tasks. In January 2004, after one such maintenance outage, the Unit 4 governor exhibited moderate to severe instability during start up. Speed control was so poor, operators had to resort to using the gate limit to get the unit to synchronize. Once the unit had been on-line for a few hours, the problem disappeared, as evidenced by the unit coming off the gate limit and being controllable again using the speed adjustment controls. Unit 4 was critical to plant operation, so it was returned to service without further analysis.

In March 2004, after technicians finished a maintenance outage on Unit 3, the same start-up stability problem that was observed with Unit 4 appeared on this unit. Also, some time prior to this, another unit in the plant had showed the same symptoms. Concerned that more and more units would exhibit the problem, the Corps concentrated on finding and resolving the root cause.

The fundamental question: "Is it a mechanical or an electrical problem?" Mechanics disassembled the flyball assembly and pilot valve. They cleaned and inspected both assemblies for friction and slop, replaced parts, and reassembled them. Everything seemed normal. Electrical technicians bench-tested the flyball drive motor, checking motor insulation and resistance. Everything seemed normal. Most puzzling was why the problem appeared *only* after the unit had been down for a few days, and

why the problem went away on its own.

During the troublesome start up of Unit 4, mechanics had observed that the flyballs were spinning erratically, speeding up and slowing down independent of unit rotational speed. They ruled out excessive friction as the cause because the ballhead assembly had just been overhauled, including replacement of all bearings. Electricians noted that the ballhead motor also had just been tested and found to operate normally. These factors led to speculation that the problem was in the PMG itself.

Electricians measured the PMG output voltage and found it to be about 10 percent below normal. However, they noted that a few other Pelton governors at John Day were operating normally with similarly low PMG voltages. Because none of the PMGs at John Day had been remagnetized since their original installation in the mid-1960s, the electricians agreed to send the PMG from Unit 3 to be remagnetized.

Designing a solution

The Corps made inquiries among the companies still supporting Pelton me-

chanical governors, and arrangements were made for American Governor to perform the work. The Corps removed the PMG from Unit 3 and shipped it to American Governor's repair facility in Wisconsin. However, the Corps needed to quickly restore Unit 3 to service because it is required for fish passage attraction water. Taking advantage of a separate turbine outage on Unit 13, the Corps relocated the PMG from that unit to Unit 3 and returned the unit to service.

At its repair facility, American Governor mounted the Unit 3 PMG on its PMG test stand and determined that output voltage was 14 percent below nominal. While this result was within Woodward tolerances, the documentation provided for the Pelton PMG explicitly cautioned against PMG output voltage more than 10 percent below nominal.

American Governor concluded that this PMG would indeed need to be remagnetized. But there was a problem. Woodward PMGs are remagnetized using alternating current (AC), whereas the Pelton design requires direct current (DC). American Governor worked with a magnetization expert to design a cus-

tom fixture and apparatus to supply short bursts of high-current DC. After several bursts, the PMG output voltage was restored to within acceptable limits. American Governor re-assembled the PMG and shipped it back to John Day. Because Unit 3 was already in operation, the Corps decided to reinstall the PMG during the next available scheduled outage.

Encouraging results, more work ahead

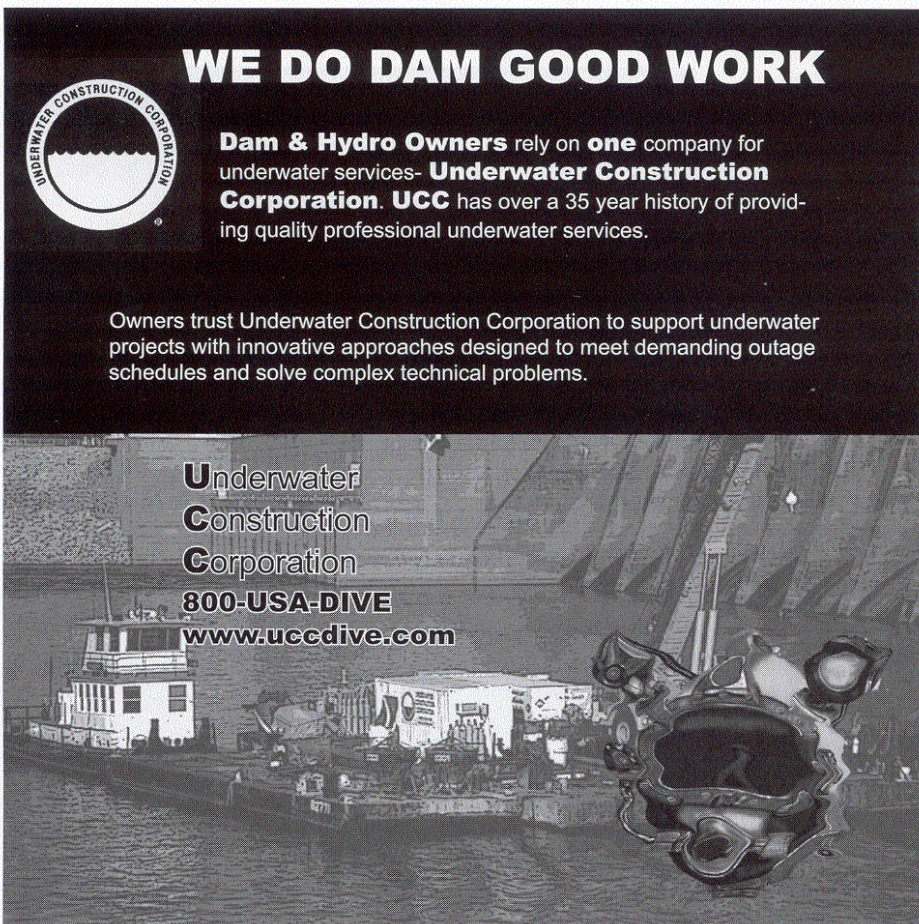
In the fall of 2004, Unit 3 was again off-line for a normal maintenance outage, and plant personnel reinstalled the remagnetized PMG. The unit had been down for four days, so if the PMG remagnetization was not the solution, the unit would experience start-up instability. When the unit was re-started, it experienced no governor instability. The unit controlled speed well and synchronized easily.

Based on this successful result, in early 2005 the Corps sent the PMG from Unit 4 to American Governor to be remagnetized. At the same time, the Corps initiated a program to track PMG voltage on all units at John Day.

When this PMG was returned and installed, Unit 4 started with no governor instability and has operated normally ever since.

However, in January 2006, the start-up problem returned to Unit 3, and mechanics and electricians are again wrestling with the question: "Is it a mechanical or an electrical problem?" American Governor is working with Corps technicians to find the answers and may provide a field-operable PMG simulator to isolate and test the response of the mechanical elements of the governor.

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