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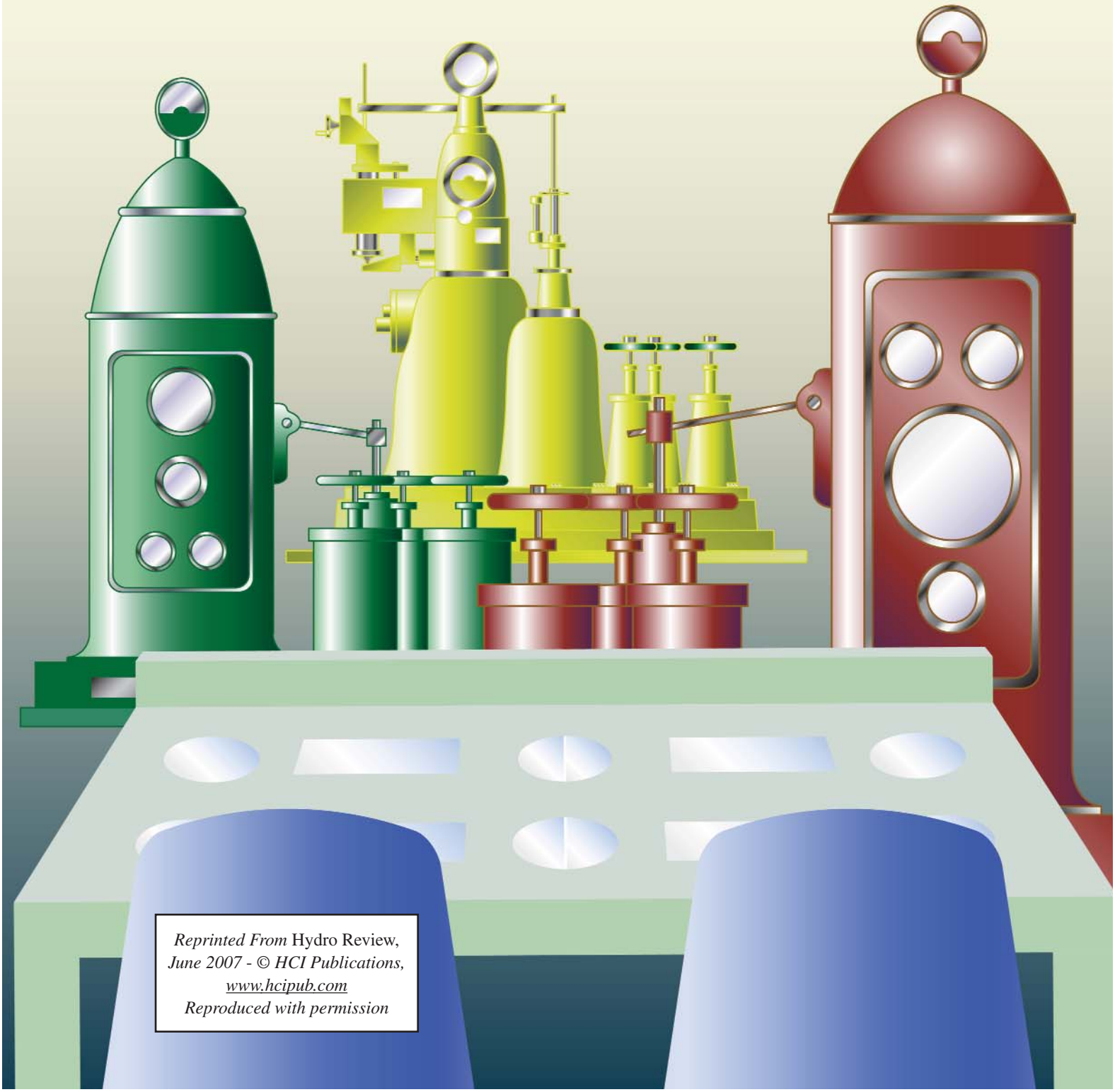
Monitoring Mechanical Governors

WaterpowerXV Preview



Monitoring the Health of Mechanical Governors

At hydro plants owned by Pacific Gas and Electric Company, more than two-thirds of the units feature mechanical governors. Instead of a traditional time-based approach to maintaining these governors, the utility uses a test-based program. Personnel perform yearly calibrations to determine whether more work is needed — an approach that saves significant staff time and maintenance dollars.

By Michael S. Mato and Gerald G. Runyan

Pacific Gas and Electric Company (PG&E) operates a hydroelectric system consisting of 68 powerhouses with a total capacity of 3,896 MW, spread over 94,000 square miles in California. Nearly 70 percent of the turbine-generator units at these facilities are equipped with mechanical governors.

Until 2000, PG&E followed traditional maintenance methods for these governors. Every year, maintenance staff disassembled the units, cleaned and inspected components, and reassembled each governor. However, owing to attrition and early retirements, skilled governor mechanics were in short supply. Getting the governors reassembled and working properly could take two or three days.

In 2000, PG&E instituted a maintenance program that lets site technicians quickly test mechanical governor performance and determine whether the governor needs to be overhauled. This approach, which the utility calls Governor Health Monitoring, bases the decision to overhaul a governor on observed performance, not elapsed time. On-site governor training is an integral part of the program, to ensure technicians understand the function of all the governor components and how they work together. PG&E has applied the program's test procedures on a variety of Pelton, Allis-Chalmers, and Woodward mechanical governors with excellent results.

PG&E maintenance staff now perform a governor calibration once a year. This calibration consists of off- and on-line tests. Off-line testing ensures each governor is in good mechanical condition and is free of problems such as binding or slop in the governor mechanisms. After completing the off-line calibration, PG&E personnel perform on-line governor tests. These tests enable governor stability to be tuned and adjusted for optimum response. Most governor problems can be found during this calibration. When personnel identify a problem, they pinpoint the specific area, disassemble the governor, and perform a repair.

By calibrating and testing the governors on a regular basis, site technicians become more familiar with the operation of their governors. Before implementing this program, outages for governor testing and maintenance lasted three days. Now the units are back on line in less than a day.

Mike Mato, a hydro generation specialist at Pacific Gas and Electric Company, directs the utility's hydro governor maintenance work. Jerry Runyan, now senior governor specialist with American Governor Company, was senior governor specialist for Stevens Point Consulting. The authors collaborated to develop new methods for assessing governor condition, tuning for optimum performance, and determining when maintenance is needed.

Circumstances leading to the test-based maintenance program

Governor manufacturers began converting to digital controls in the 1980s. By 1995, it was difficult to get replacement parts and field service for mechanical governors. Prices for parts had escalated dramatically, and lead times to receive parts often were six months or longer. Manufacturers warned that support for older governors would cease in a few years, if it had not already.

The situation was not much better on the service side. PG&E site staff had been reduced due to the competitive pressures of the soon-to-be-deregulated power market in California. When operators complained of difficulty synchronizing due to governor instability, or slow loading times when on line, PG&E relied on consultants to troubleshoot these governor problems. However, this was not an ideal situation. Younger Woodward service engineers sometimes knew less about a 50-year-old Woodward governor than did PG&E's mechanics. The consultant PG&E used for its Pelton governors was aging and could no longer travel to their remote sites. An alternative means of governor support had to be found.

Although PG&E did not conduct a formal cost-benefit analysis of digital governors compared to mechanical governors, the utility was reluctant to replace all existing mechanical governors with digital ones owing to the short shelf life of controls software.

In 1999, PG&E hired consultant Gerald G. Runyan to troubleshoot one of its Pelton governors. Runyan had worked for Woodward Governor Company and was the utility's preferred Woodward service engineer. He was under contract to calibrate and tune PG&E's Woodward governors. Runyan discovered that the primary governor concepts were the same between the brands; just the nomenclature and physical implementation differed. During his first assignment troubleshooting a Pelton governor, Runyan got a very troublesome governor working better than PG&E staff had

ever seen it run. At that time, he also informed PG&E about a new company, American Governor Company, that offered replacement parts for older Woodward governors. A typical overhaul parts kit cost less than $5,000.

With affordable overhaul parts and expert service available, PG&E decided it would only replace mechanical governors with digital governors if the mechanical governors were completely unsupported or if control requirements changed, as happened at the 9.7-MW Chili Bar project on the American River. As part of the new operating license for Chili Bar, precise downstream flow control under varying head conditions and strictly controlled ramping of downstream river flows were required. These advanced control modes are beyond the capability of the mechanical governor and mechanical bypass valve control systems, so PG&E installed digital governors at Chili Bar.

Another potential problem with mechanical governors for PG&E was meeting a governor response requirement set by the Western Electricity Coordinating Council (WECC) — the largest of the ten regional councils of the North American Electric Reliability Council (NERC). In 2003, WECC expanded unit performance testing to include governor response. Units greater than 10 MW must demonstrate they are operating with 5 percent droop. However, PG&E found that, once calibrated, its older Woodward and Pelton mechanical governors responded to system disturbances just as well as the digital governors. And, PG&E found that its test-based governor maintenance program provided all the test data needed to satisfy WECC requirements.

Elements of a test-based governor maintenance program

The authors worked together to develop a series of off-line and on-line procedures for testing governor performance. The foundation of optimal governor performance is proper mechanical calibration, which is done off-line and with the unit dewatered. Some of the procedures performed include: calibration of the gate positioning mechanisms over the full range of operation, calibration of the speed droop mechanism, and initial testing and calibration of the governor dashpot. Other specialized tests and measurements also are done at this time.

Off-line calibration takes about four hours using small hand tools. It ensures each governor is in good mechanical condition and is free of problems such as binding or slop. If personnel find problems that cannot immediately be repaired using spare parts on-hand, they flag the unit for overhaul. Lead time to receive spare parts varies from immediately to about eight weeks, and PG&E can schedule the outage at its convenience. The off-line calibration also reveals whether there is excessive slop in the wicket gate linkages, which can adversely affect governor control.

Once the off-line calibration is complete, personnel start the unit and perform on-line calibration and stability tests. The goal of these tests is to optimally tune the governor so the unit synchronizes quickly and is responsive to frequency disruptions on-line. Some of the components tested, adjusted, and/or verified during on-line testing are the speed droop mechanism, dashpot and dashpot bypass, and permanent magnet generator (PMG). Personnel test governor stability by introducing a speed/frequency disturbance and measuring the governor response. Testing and adjustment continue until the expected governor response is achieved. If governor performance is less than expected, an outage is scheduled to repair or replace problem components.

During on-line calibration of the mechanical governors, Pacific Gas and Electric Company personnel test stability by introducing a speed/frequency disturbance using the gate limit and watching how the governor responds.

Importance of training

Training is an integral part of PG&E's new governor maintenance program. The utility believes training is critical to educate hydro maintenance and opera-

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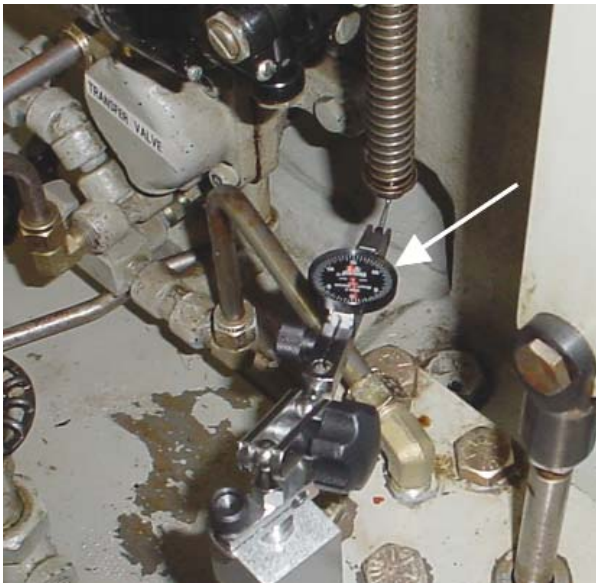

During on-line calibration of the mechanical governors at Pacific Gas and Electric Company's hydroelectric plants, a dial indicator (see arrow) helps determine droop. Performing yearly calibrations allows the utility to overhaul governors only when needed, instead of every year.

tions personnel and to ensure proper knowledge transfer for the operation, repair, and calibration of its governors.

In 2001, PG&E implemented a plan to provide governor training at all 14 of its regional maintenance shops. American Governor provides two- to three-day classes approximately once every five years. To enhance knowledge retention, the training features hands-on activities on PG&E governors, as well as classroom sessions on governor fundamentals. Working directly on their governors enables technicians to gain an understanding and familiarity with their particular governor type and model. With well-trained staff and the simplified approach to testing governor performance before overhauling, PG&E can once again effectively maintain its mechanical governors.

Pacific Gas and Electric Company personnel use ballhead drive simulators to perform on-line calibration of mechanical governors when other work being done on the turbine or generator prevents the unit from operating.

Importance of oil cleanliness

As a result of this new calibration and testing program, PG&E finds that units can run longer before needing an overhaul. However; oil cleanliness is critical to extending the life of the governors. In the past, time between overhauls was about three years, versus five to seven years with the new calibration program and clean oil.

Poor oil quality causes accelerated wear of the moving parts of a mechanical governor, which results in more frequent overhauls (perhaps as often as every three years, which can negate many of the benefits gained from the calibration program). To keep the oil clean, PG&E personnel are cleaning the governor sumps and pressure tanks. The utility then is adding kidney loop filtration systems supplied by a local hydraulics company on all its governor sumps. The kidney loop system continuously filters the oil, keeping it clean and extending the time between overhauls. Previously, PG&E used a few filter carts that were moved between power plants as requested by site personnel. This was a time-consuming job, and personnel primarily used the filter cart to clean the turbine lubricating oil. Filtering the governor sump oil could get overlooked.

Once a year, PG&E sends a sample of governor oil from each plant to the company that supplied the filtration systems to gauge water content and contaminants. If testing notes a significant deterioration in oil quality, PG&E replaces the governor oil.

New technology for governor testing

PG&E sought a way to simulate on-line operation of the governor when the turbine-generating unit is at rest and dewatered. This happens once a year, when other work is being done on the turbine or generator that prevents the unit from operating. In 2005, PG&E began purchasing ballhead drive simulators from American Governor. This portable simulator is wired to the governor ballhead and mimics the speed signal from the PMG. Primarily used to test and measure governor response to on-line step changes, it also can be used to test start-up and overspeed performance. The only governor performance attributes that cannot be tested in this way are:

— Stability settings, which are affected by turbine-generator inertia and water conduit configuration; and

— PMG performance, which can be degraded by loose couplings or low voltage.

Summary

Mechanical governors have been the workhorses of many hydro plants, and thousands remain in service today. With proper maintenance, these governors can continue to provide excellent frequency control for decades to come. When combined with good oil cleanliness and periodic training of governor maintenance staff, a program of test-based governor maintenance results in better performance and less downtime. This approach also provides the data PG&E needs to satisfy WECC requirements for governor testing. PG&E finds, in most cases, it can avoid the significant cost of digital conversion by retaining and properly maintaining its mechanical governors. ■

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