NORTHWEST HYDROELECTRIC ASSOCIATION

2019 SMALL HYDRO AND TECHNICAL WORKSHOP

BEND, OREGON

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UNDOCUMENTED PROCESSES PLUS TIME;

A DANGEROUS COMBINATION?
• **BRIEF TIMELINE & PROJECT HISTORY**

• **TURBINE COMMISSIONED IN 1984**
  – Gilkes scope of supply included the turbine case, runner, and inlet pipework up to the connection to the inlet valves
  – Developer scope included the supply of the inlet valves, generator, turbine controls and protection system, governing system, switchgear, and balance of plant auxiliaries

• **PLANT HAS RUN RELIABLY SINCE COMMISSIONING**

• **CLIENT IS EXTREMELY PLEASED WITH THE PERFORMANCE OF THEIR ASSET**
ONE DARK AND STORMY NIGHT THE PLANT HAD A SEEMINGLY ROUTINE ISSUE...

- Turbine tripped offline due to a line fault in the middle of the night (of course it did!)
- Generator went into a momentary overspeed condition
- Deflectors immediately engaged to divert the water away from the runner, removing the generator axial & radial thrust loads
- Electric actuators for the spear/needle valves should have begun to close, but they didn’t – Hmmm
- Lube oil unit stopped supplying oil to the bearings – Oh, Oh
- Generator coasted down to a stop without lubrication damaging the drive end bearing (400rpm generator with plenty of inertia)
THE ROOT CAUSE?

• DC BATTERY BACKUP UP SYSTEM HAD FAILED

• WHY?
  — Batteries hadn’t been regularly monitored and nobody was aware they were completely discharged
  — Batteries need to be cycled on a regular basis for them to remain in optimum condition
  — Inconsistencies in plant operation and maintenance procedures, coupled with no recording or activity log contributed to the issue

CLIENT REQUESTED GILKES’ ASSISTANCE WITH THE DRIVE END BEARING REPAIR, AS WELL AS A SOLUTION TO ENHANCE THE BACKUP PROTECTION AND GENERAL PLANT CONTROL
• Discussions with the owner, plant operator, and maintenance staff began
• Gilkes engineers witnessed multiple starts and stops of the machine
• Some interesting things were observed, forming the basis of the proposed plant modifications
• The scope of supply was determined, agreed upon, and the Gilkes team got to work on delivering the solution
  — New control section to fully automate the plant and have a ‘one button’ start and remote start capability
  — New digital governing package replacing the original mechanical governor to provide improved deflector control, speed control, frequency control, etc.
  — A toothed wheel and speed sensor for the generator
  — New hydraulic control module (HCM/HPU) to replace the original unit
  — Replacement hydraulic actuator sized to match the new HCM/HPU
  — A UPS (uninterruptable power supply) unit to ensure that a repeat of the DC backup failure wouldn’t again occur
• The equipment was delivered to site and the commissioning team deployed to implement and execute the solution

• And then things got interesting...
Control Section

– Client wanted to keep the existing 3-cabinet enclosure
– Limited wiring schematics were available which helped
– Gilkes designed a replacement door, back, and side panels to fit inside the existing control section
– Door, back, and side panels were manufactured and FAT in shop utilizing PLC simulation techniques
– Client’s crews did an amazing job tracing and terminating existing wiring with new relays, etc.
– Installation and commissioning at site was a huge success
The mechanical governing system was upgraded to digital
A toothed wheel with speed sensor was installed.
A new HCM/HPU was installed
An uninterruptable power supply (UPS) was installed
Issues discovered during commissioning

• The power section had no wiring diagrams or electrical schematics
• Upon further inspection to create as-builds, many undocumented modifications had been made
• Fundamental protections had been disabled over the years to allow for “easier startup” and to reduce/eliminate “spurious trips”
• Two generator stator RTD’s had failed, reading open circuit when resistance was measured
• Electric actuators had badly worn stem nuts resulting in delays in actuator movement
• The generator neutral earthing transformer was entirely disconnected from the relevant protection relay
• An inspection of the Loss of Excitation relay revealed the mechanism had seized, preventing it from tripping
• One of two trip outputs on the Generator Differential Protection relay had been disconnected
• The coil on the Generator Lockout Relay was completely disconnected, disabling a number of important protections such as;
  • Ground fault detection
  • Loss of excitation
  • Generator differential protection
  • Thermal trips

• And then...
Disabling this protection with a worst-case scenario ground fault, could have resulted in the generator and turbine case being ‘live’
Successful conclusions to the project

• Plant is now fully automated, has one-button start and remote start capability
• Staff can now trust that important protections are operational and have been thoroughly tested
• The control system now starts the unit, synchronizes to the grid, and regulates the intake level without any manual operator input required
• The replacement HCM/HPU and actuator precisely control the generator speed, resulting in faster grid synchronization
• Rapid deflector closing in trip situations limits overspeed to very low levels
• A worst-case scenario of full power complete loss of mains was successfully simulated
• The UPS system safely shuts down the system without any station service
Key takeaways for project owners, operators, and maintenance staff

• Are all of the plant modifications documented and recorded?
• Are there documented operation and maintenance schedules in place? Are they routinely followed, verified, and signed off?
• It’s great to rely on and trust the experienced plant operator but...
• Owners and operators should continually ask questions as to the safe operation and maintenance of the plant
• New operators shouldn’t be afraid to ask questions or request help when being groomed by an existing operator
• As turbine and W2W experts, we’re available to perform plant assessments and suggest modifications for the health and longevity of your plant
THANK YOU!

QUESTIONS?

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