The "twitchy" turbine.

By

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George was walking along a dam crest with Tom, the manager of a series of powerplants on a large river system. They were conducting the annual dam safety inspection, looking at the condition of the rip-rap. Another group was walking along the dam toe, looking for seepage and wet spots. George casually asked Tom how the system was working, and Tom replied that everything was fine, except for their new powerplant at Slate Canal which was "twitchy". George asked what he meant by "twitchy", and Tom replied that whenever there was a minor system disturbance, the single unit would drop off the line on a fault.

Further questioning elucidated the fact that the unit had been operating for just under a year, and that during this time they had had several minor frequency deviations of less than one quarter cycle due to lightning strikes, wind storms overturning trees and other distribution disturbances. On every frequency deviation, the 40MW Slate unit dropped off the line a few minutes after the frequency had returned to normal. The unit controls and governor had been inspected in detail after the second incident, and all parameters were found to be correctly set. This was puzzling to George, since he had worked on several of their powerplants, and was familiar with the system. George asked what was the reason for the disconnect, and Tom indicated that he would ask for the SCADA report.

A few days later Tom advised that the unit had always tripped on low governor oil. George thought about the circumstances for a few minutes, and indicated that he had a similar problem on a much smaller and remote system a few years ago. It involved a new Kaplan turbine, (HRW July 2001, page 36) where the Kaplan blade timing had been incorrectly set, but this could not be the reason on Tom's system, since all the turbines were Francis units. Tom then replied that the Slate Canal unit was their only Kaplan!

With this new information, George asked what the timing of the Kaplan blade movement was, and what the governor wicket gate open-close times were. This was not known, so George advised that he suspected that the Kaplan blade timing had been set at close to the same time for the wicket gates, and that this combination usually resulted in hunting of the blades and wicket gates, causing the governor oil to be rapidly used up, and consequently the unit could trip off line on low governor oil. The incident could be triggered by a small system load change, calling for a new wicket gate opening. Before leaving the site, George asked Tom to call him with the blade-gate timings.

A few months later, Tom called to advise that the wicket gates were set to open in 15 seconds, close in 10 seconds, and that the Kaplan blade timing was about 13 seconds. George advised Tom to change the blade timing to 4 times the longest wicket gate time, or to 60 seconds. Tom mentioned that a committee had been established to look into the problem, and he would advise them of George's suggestion.

About a year later Tom emailed with the information that the blade timing had been changed as suggested, and that they had now operated for several months with no further "twitchy" incidents.

Lesson learned.

For some reason, Kaplan blade timings are rarely mentioned in commissioning data, so the turbine erectors usually set the time at somewhere between the wicket gate times. It required several days of looking through commissioning records to determine the Slate blade time, and then it was not certain, since it had not been verified by the plant operators. Re-setting of the time had to wait until the next annual dewatering for maintenance.

In a Kaplan unit gate-blade hunting occurs when the gate-blade timings are close. This happens when there is a call for a new gate opening (say larger), the governor moves the gates to a new larger opening, the blades also move open to a more efficient operating point, causing the wicket gate opening to overshoot the correct setting. The governor tries to correct with a smaller opening on the wicket gates, and hunting starts.

By slowing down the blade movement, the Kaplan operates temporarily as a propeller with the wicket gates rapidly moving to the new larger opening. The blades slowly move open to the new more efficient operating point, and the governor has time to slowly close the wicket gates, avoiding hunting.

Always check to ensure that Kaplan blade times are about 4 to 6 times the effective wicket gate movement time. The effective time is measured in the dry, and is taken as twice the time recorded for the wicket gates to move from 75% open to 25% open when closing from a full open position. Refer to "The Guide to Hydropower Mechanical Design", chapter 4, page 18 for a brief discussion of Kaplan blade timing.