New Method for Improving On-Line Loading Rates on Mechanical Governors

By Gerald G. Runyan

Abstract

Properly tuned and calibrated, mechanical governors provide excellent frequency control, passing all NERC/FERC test regimens. Even so, some utilities believe they must convert their mechanical governors to digital in order to achieve fast on-line loading rates. This is no longer the case. This paper describes a relatively simple electrical modification that enables mechanical cabinet actuator governors to achieve very high loading rates without compromising on-line stability.

Introduction

In today's hydro market place hydro turbine/generators that supply 10 megawatts or more of generation must demonstrate that the governor controlling the turbine/generator must be stable (Help Control System Grid Frequency) and yet respond quickly to load changes requested by the independent system operator.

Most modern mechanical hydraulic governors were equipped with a solenoid operated dashpot by-pass needle valve assembly. This by-pass dashpot needle valve is a second needle valve whose orifice is physically in parallel with the main governor needle valve orifice. The solenoid operated dashpot by-pass needle valve assembly was typically operated in an "and" circuit arrangement where a wicket gate position switch (33-X) was wired in series with an auxiliary generator breaker switch (52-X). When the unit was started and synchronized to the grid the auxiliary generator breaker switch would be closed and after the governor was given a signal to increase the generation on the generator the gates would begin to open. When the gates were opened to the setting of the wicket gate position switch the solenoid operated dashpot by-pass needle valve assembly would be energized and the by-pass needle valve would allow the governor to be loaded very quickly. If there was enough by-pass needle valve opening the wicket gates could be opened almost as fast as the gate timing would allow.

Figure 1 Dashpot with Solenoid Bypass
(solenoid bypass assembly shown at right)

The problem that occurs when a solenoid operated dashpot by-pass needle valve assembly is improperly adjusted is the governor will go unstable if there is a system frequency disturbance. Generally the auxiliary generator breaker is still closed therefore the governor solenoid operated dashpot by-pass needle valve assembly is still energized and there is not enough dashpot reset time to keep the governor stable.

There is some confusion sometimes in powerhouses when the solenoid operated dashpot by-pass needle valve assembly is energized. Some utilities say the compensation is in yet others say it is out. It should be understood that whenever the solenoid operated dashpot by-pass needle assembly is energized the governor compensation (Dashpot Reset Time) has been reduced and can be reduced to the point where the governor can become unstable under some conditions.

The purpose of this paper will attempt to point out how to adjust the solenoid operated dashpot by-pass needle valve assembly to allow the unit to load quickly, but still remain stable if there is a system frequency disturbance. This will be to offer several solutions. One will be to adjust the setting of the solenoid operated dashpot by-pass needle valve assembly properly or by the addition of a time delay to drop out relay or a limit switch.

Background on Dashpot Operation

The small governor dashpot plunger of the dashpot must be examined to understand the problem with slow loading units when the generator has been synchronized to the grid. The dashpot is comprised of two plungers hydraulically connected together (see Figure 2). The large dashpot plunger movement is directly proportional to wicket gate movement. The amount the large plunger moves in relation to a wicket gate movement is controlled by the governor temporary speed droop adjustment. The large dashpot plunger movement is then hydraulically transmitted to the small dashpot plunger. The small dashpot plunger is smaller in diameter than the large plunger and therefore moves farther than the large plunger each time the large plunger moves. The small dashpot plunger via a linkage is connected directly to the governor pilot valve. The small dashpot plunger signal is the feedback element in the governor that provides the compensation, both temporary speed droop and dashpot reset time, for the governor. Therefore each time the gates move in the open direction to load the generator there is a signal from the large dashpot plunger to the small dashpot plunger which tends to re-center the governor pilot valve.

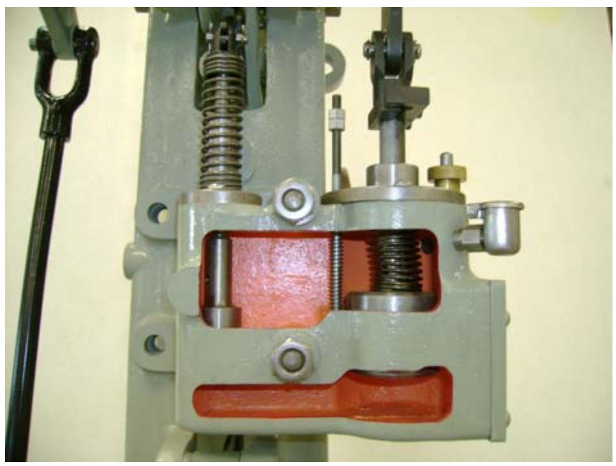

Figure 2 Dashpot Cutaway
(showing small and large plungers)

After the generator has been synchronized to the grid the governor speed adjustment control is the device used to load or unload the generator. This speed adjustment signal by design must be small in magnitude. Therefore every time the gates begin to open when being loaded by the governor speed adjustment control the small dashpot plunger signal re-centers the governor pilot valve. The opposite is true when load is being removed from the generator. This is why it takes a long time to load or unload the generator after it has been connected to the grid when a solenoid operated dashpot by-pass needle valve assembly is not used.

A logical question is: how can the governor control the unit speed quickly at speed no load before the generator is synchronized to the grid. The answer is in the construction of the small dashpot plunger. The small dashpot plunger has by-pass flats on the top of the plunger and also on the bottom of the plunger. During rapid gate movements, for example on a load rejection, the small dashpot plunger moves to the bypass position but moves no farther. The reason for this is that the normal dashpot action has to be removed so that normal gate timing is not interfered with. The same logic holds true on startup. The gates are allowed to open quickly without being impeded by action of the small dashpot plunger. As previously discussed when the governor speed adjustment control is operated to load or unload the generator the speed adjustment signal is small and does not cause the small dashpot plunger to be moved far enough to go the by-pass position. The reason why the solenoid operated dashpot bypass assembly was developed was to allow generators to be loaded and unloaded faster.

There are many articles written about optimum governor tuning and this paper will not endeavor to discuss those at this time. Generally most utilities adjust the governor so that the turbine is stable enough to allow the auto synchronizer to parallel the generator to the grid. The loading of the unit is then dependent on the setting of the solenoid operated dashpot bypass needle valve.

There are not many publications written to instruct on the proper setting of the solenoid operated dashpot needle valve. The author has found many utilities arbitrarily set the solenoid operated dashpot by-pass needle valve to one and one half turns open because one step of an instruction sheet from a governor manufacturer said as part of the test procedure to set the bypass needle valve to one and one half turns open. Also they were tested in the governor shop and were shipped with 1 ½ turns open. When a governor dashpot bypass needle valve is adjusted for one and a half turns open the governor will be unstable should there be a grid disturbance.

The author has conducted tests and found out that most turbine/generators 10 megawatts or larger have a dashpot reset time which falls between 7 to 10 seconds. The author suggests that the dashpot reset time should be adjusted as close to the seven second reset time as possible.

A mechanical governor with a seven second dashpot reset time, a normal temporary speed droop adjustment from 30 to 40 percent, and a typical speed droop of 5 percent, will have a governor response time from 215 to 245 seconds. This is 3.5 to 4 minutes for any given load change.

This long time for loading generators causes problems with automatic SCADA systems in that the SCADA system never gets satisfied and causes the load of the unit to continually swing about the set point.

Basic Dashpot Bypass Setting

The author has found that a good rule of thumb is to adjust the solenoid operated dashpot needle to be the same as the main dashpot needle valve. This will reduce the loading time to be approximately ½ of the value of just using the main dashpot needle valve. One utility performed islanded system tests using this criterion. The tests allowed the islanded system to very stable and yet the loading rates of the generators were still acceptable.

Alternate Method for Faster Loading

If the basic setting (same as main dashpot needle) does not provide acceptable on-line loading rates, the following is suggested. Adjust the dashpot bypass needle to one turn open. Wire a time-delay-to-drop-out relay in series with the command contact that operates the governor speed adjustment motor after the generator has been connected to the grid. This time delay relay will energize the dashpot bypass solenoid needle valve once the command signal is received. Since the dashpot bypass is only active during load changes, the bypass needle valve can be opened one or one and a half turns open to permit a faster loading rate. The time delay drop out relay will be adjusted to allow the dashpot bypass needle valve to stay bypassed long enough until the generator has picked up the requested load. During grid disturbances the solenoid operated needle valve will not be energized, so the governor will remain stable and will be able to help bring grid frequency back to normal.

Safeguard Against Instability

If one and one half turns is required on the setting of the by-pass needle valve then the following is suggested. A limit switch should be added to the main distributing valve that detects when the relay valve is saturated in the opening or closing direction. If the relay valve gets saturated, which occurs when the governor is apt to be unstable, the solenoid operated dashpot by-pass solenoid will be de-energized. There should be a manual reset if this occurs or the governor might go unstable again.

Summary

In summary this approach will allow the utility to achieve the faster on-line loading rates and yet remain stable should there be a system frequency excursion. Care should be used to determine how much bypass needle valve opening is acceptable for stable operation. There are some foreign made governors that have a different type of dashpot construction and these governors must be evaluated on a unit by unit basis.

Author Biography

Gerald (Jerry) Runyan is a Senior Governor Specialist and Trainer with American Governor Company. The majority of Jerry's hydro governor expertise comes from his 42 years at Woodward Governor Company. He served Woodward in many areas: Manufacturing, Field Service, Commissioning, Design, Engineering, Training and Marketing. He is experienced with all types of Woodward governors - from mechanical to digital - and has conducted over 100 training classes. Jerry is also fluent in Pelton, Allis-Chalmers, and Voith governor calibration and tuning.