Plant Vogtle Units 3 & 4 construction site with Vogtle Units 1 & 2 in the background. Photo: Southern Co.

Digital field devices make headway and deliver results in NPPs

Digital field devices in the form of valve positioners have been in widespread use for a number of years in the broader process industries. In fact, industry estimates point to more than 1.5 million units currently installed around the world. Adoption rates in the nuclear industry have been slower than the process industries in general due to concerns about the potential for unique "digital" failure modes that might impact the overall reliability of the reactor, as reliability and safety are key drivers for this type of power plant. That is beginning to change, as more and more nuclear plant operators are beginning to use these devices, and several factors have contributed to that positive trend.

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The industry, with the help of the Electric Power Research Institute (EPRI) has developed guidelines that involve a very detailed auditing process of the hardware, firmware, and software associated with these devices. Essentially, an audit team takes a very hard look at operating experience, in-house testing, and quality control, along with an in-depth review of the operation of the device itself. If the device passes this screening, a nuclear end-user can have reasonable assurance that the device will be at least as reliable as the analog device it is replacing, so that overall plant reliability is maintained. In fact, in reviewing the performance of the Fisher® FIELDVUE™ digital valve controller pictured, it's generally been found that they are much more reliable than equivalent analog models.

The approach is summarized in EPRI document TR106439. These guidelines were originally meant to provide for the commercial dedication of these devices for use in safety related applications, but many end-users have decided that they needed this same type of assurance even for commercial BOP (balance of plant) type applications. One of the first applications where these devices have been employed is FW REG (Feedwater

Figure 1: Fisher Fieldvue Digital Valve Controller mounted on a standard Air-operated control valve.

Regulation) service. While that is not typically a safety related application, it is one that is very important to the function of the plant, so it makes sense to insure that the device being used is very reliable and the EPRI process helps to insure that it is. With that in mind, many end-users ask that the devices be checked against the EPRI guidelines before they'll use them in critical applications.

In addition to the development of the EPRI guidelines, Institute of Nuclear Power Operations (INPO) studies on reliability over the last 10 years have pointed to the feedwater regulation and feedwater heater systems as representing a high percentage of reported maintenance issues in the fleet in North America. Further studies have uncovered that analog positioner reliability and performance were contributing to these broader maintenance issues. The industry needed to address this and turned to these digital devices to help solve reliability and process performance issues.

The reasons for taking a serious look at digital devices to help solve these problems were 3-fold. First, as has already been discussed, the digital devices were inherently more reliable than analogs, assuming that they passed the EPRI screening process. Secondly, in the case of the Fisher digital valve controller, it is much faster and more stable than analog positioners due to the high flow rates and the ability to custom tune the device to the control valve and system that it is being used on. Many of the maintenance issues noted by INPO were actually caused by excessive cycling in the process systems that wore everything out. Faster, more stable positioners can be used to tune this cycling out, so that the control valve, and everything in the system, lasts longer. Thirdly, digital devices feature the ability to check out positioner, valve, and system performance on line while the system is operating, looking for early warning signs of impending problems. Predictive maintenance like this can be much more cost effective than more traditional preventive maintenance methods, and greatly reduces the chances of having to take the system off line to correct problems. More uptime means more revenue; and more revenue makes the plants more successful.

Operating experience in the plants

With that as background, we talked to a number of plants who are now using these devices in key applications and asked them to give some feedback in those 3 areas:

- Was overall reliability improved?
- Did they see improvements in process performance-reduction in cycling?
- And are they employing the on-line diagnostic capability to transition to a predictive maintenance approach?

We'll now review the experience for each of those plants contacted.

Ginna Station, Rochester, NY

Ginna is a 610 MW PWR. This plant is using or will use Fisher FIELDVUE digital valve controllers (DVC's) on several key applications. The first was their 2 feedwater regulation (FW REG) valves. They were having maintenance issues on these valves, especially with the old analog positioners, and decided to upgrade to digital in 2006. They saw a big improvement in reliability and process control, but had some issues with the position feedback mechanism on the new DVC's. Fortunately, they were able to use the on-line diagnostic capability of the devices to self-check themselves every two weeks looking for any signs of deterioration on the feedback potentiometer, which kept this from becoming a more serious issue. They are currently in the process of upgrading to a new feedback approach that is non-contact and linkage-less, which will eliminate any concerns over the feedback mechanism going forward. Overall, they've been very happy with their experiences with this technology on one of the most important BOP applications in the plant.

Figure 2: Remote mount DVC electronic units shown on panels.

Figure 3: New non-contact feedback sensors mounted on feedwater bypass valves.

Based upon the INPO findings mentioned above, and their positive experience on the FW REG valves, they next turned to the Moisture Separator (MSR) and Heater Drain system to look for opportunities for improvement. This system had been operating poorly for many years at the plant due to outdated control schemes. The system was seeing a lot of cycling that was wearing out packing, valve stems, actuators and accessories, not to mention the additional strain the cycling was putting on other equipment in the system. Essentially they had to maintain the 24 valves on this system every 18 months to insure proper operation. They attacked the upgrade here in several phases, featuring new Fisher valve assemblies, lower friction ENVIRO-SEAL™ valve packing, digital upgrades to the level control sensors and controllers, along with digital positioners on the valves. They then tuned the positioners to perfectly match the system dynamics. The results have been dramatic. The systems have stabilized and the cycling has essentially been eliminated. The MSR's and FW heaters are actually working as designed to improve overall plant efficiency, and with stable operation the valves are lasting much longer without having to be maintained. The projected preventive maintenance intervals (PM's) have been extended from the original 18 months mentioned above out to 6-8 years! The plant is also beginning to do on-line diagnostics on these valves to insure that they get early warning signals on developing problems, which takes them into the predictive maintenance realm which delivers even more savings.

The next step for this plant is to install the same digital positioner technology on the atmospheric relief valves to increase their overall reliability. They also plan to continue to leverage the on-line diagnostic capability on all the DVC's installed to date to further enhance their predictive approach to valve maintenance.

Vogtle 1&2, Waynesboro, GA

Vogtle is a twin unit site, with 2 1200 MW PWR's in operation. They also started with a digital upgrade on their Main FW REG and bypass valves due to problems with the old analog positioners. Their approach was somewhat unique in that it featured the use of remote mount Fisher DVC's, which enabled the electronic portion of the device to be panel mounted away from the relatively high temperatures that they were seeing on the valves.

At this plant the valves are in a room that tends to be pretty warm (110°F / 43°C) and the temperature near the valve stem can approach 250°F / 121°C as a result. This can be very hard on the elastomers and electronics in the device, so the remote mount was used to keep that part of the device away from those very high temperatures. (See figures 2, 3, 4). Note that they utilized a dual redundant set up on these valves, so that they could move to a back up DVC if the first one failed for any reason. This was part of their defense in depth approach on these highly critical valves.

With this change, they saw much more stable operation of the valves, but also had some issues with the feedback mechanism. This was traced to relatively high flow-induced vibration that seems to be unique to this application. They moved to an alternate 3rd party feedback device that got them through re-fueling cycles, but due to general concerns about its performance, they set up a regular monitoring program using the on-line diagnostics capability of the device. They

Figure 4: New feedback sensors mounted on main feedwater regulation valves-dual redundant system.

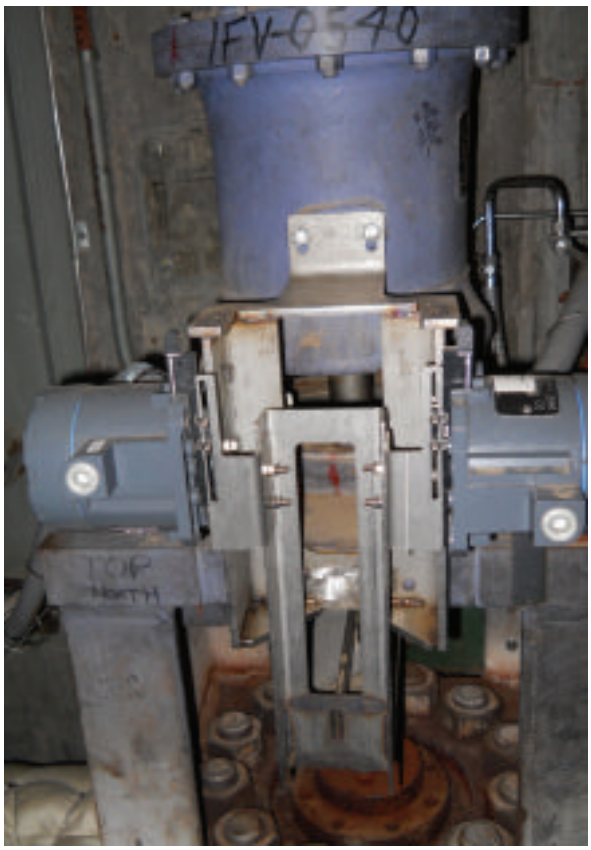

Figure 5: New feedback sensors on main FW reg valves-close up.

routinely used what is called a "one button sweep" to quickly evaluate the operation of the DVC and valve and insure that everything was working properly. (See box 'Performance Diagnostics'). They do the one-button sweeps once a week.

In conjunction with the digital upgrade on the valves, Vogtle has also implemented a digital controls update using an Ovation™ system installed by Westinghouse. Once the whole digital upgrade was in place, they saw a tremendous improvement in steam generator level control. Before the upgrade, they could see swings of up to 3%. After it was done, the level remains stable to within 0.5%, which means much fewer headaches for the operators. They have just upgraded in September to the new FIELDVUE DVC6205, which is a remote mount hall effect feedback mechanism that has no linkages, and is non-contact. This will solve the feedback mechanism issues that they had been dealing with. In addition to the FW system, they have DVC's installed on Feedpump temperature control and Main steam bypass valves. They continue to look for more opportunities to leverage this technology, and are rapidly moving towards predictive maintenance on many of their key valve applications.

Conclusion

While the adoption rate has been understandably slower for nuclear than the other process industries, momentum is beginning to pick up. In fact, based upon positive experiences with the technology to date, EDF (Électricité de France) in France just placed an order for 900 Fisher FIELDVUE DVC's for the French Nuclear fleet. With the industry's penchant for reliable operation tied to safety, and limited accessibility to key valves during operation, this technology is a perfect fit for Nuclear. As word gets out on the successful installation of these early adopters, we believe that the rate of digital installations will accelerate and the nuclear industry will see a step change in valve performance and resulting process performance. This will drive increased revenues for the plants, and the transition to predictive maintenance will further drive down O&M (operating & maintenance) costs, making the existing plants much more attractive as an on-going source of power for grids all over the world.

Performance Diagnostics (PD):

Performance Diagnostics (PD) gives the FIELDVUE DVC end user the opportunity to un-intrusively monitor and capture multiple real-time in-process field variables at the control valve assembly. This diagnostic "Suite" has several different tests that capture the real-time data via on-board sensors built into the DVC such as travel deviations, pressure deviations in both supply and output pressure(s), and internal component adjustments and operation. This collected data gives the end user remote insight to the overall health of the valve assembly as well as actual friction experienced at the valve during operations without interfering with the process. Many of these tests can be ran continuously or limited to a user specified length of time. Several tests can also be automated via the FIELDVUE DVC's support ValveLink software to execute at a specified time.

Ease of interpretation:

The "One Button Sweep" test within the PD Suite is a 20 second snap shot of multiple parameters important to proper operation of the valve assembly such as travel, supply, air consumption, and internal component integrity. Each of these parameters are graphed and evaluated with an easy to read "Traffic Light" system of Red, Green, and Yellow indicators along with recommendations to correct discovered issues before they become serious operational concerns. There is also a "Triggered" feature within the PD Suite that when enabled will monitor operation conditions within a user defined window. If the operation parameters violate the window's thresholds the DVC will record up to 15 minutes of data for 4 channels and store it onboard the device. A "Diagnostic Data Available" alert notifies operations that the DVC has captured data contained in its memory buffer which can be remotely extracted to be reviewed. The same "Traffic Light" system of Red, Green, and Yellow indicators is given along with probable causes and recommended corrective actions.