6.8 Diagnostics and Predictive Valve Maintenance

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Types of Predictive Maintenance:
- a) Performance tests
- b) Valve characterization and signatures
- c) Valve response tests

Types of Diagnostic Systems:
- a) Field testing using specially mounted sensors
- b) Smart positioners with integral sensors
- c) Host system tools that measure response
- d) Partial stroke test for safety-related valves

Special Features:
- a) Actuator pressures, temperature, and position measurements
- b) Fully integrated with smart positioners, or field installed for individual tests
- c) Specially prepared valves for regular testing

Cost:
- Premium for $300–$1000 for smart positioner,
  $50–200 per test for field-mounted test systems

Partial List of Valve Diagnostics Suppliers:
- ABB Inc. (www.abb.com/us/instrumentation)
- Dresser Flow Control, Masoneilan Operations (www.masoneilan.com)
- Fisher Controls International (www.fisher.com)
- Flowserve, Flow Control Div. (www.flowserve.com)
- Honeywell Industry Solutions (www.iac.honeywell.com)
- Invensys Flow Control (www.invensysflowcontrol.com)
- Metso Automation (www.jamesbury.com)
- Samson Controls Inc. (www.samson-usa.com)
- Siemens Energy and Automation (www.sea.siemens.com)
- Smar International Corp. (www.smar.com)
- Yamatke Corp (www.ycv.com)
- Yokogawa Corporation of America (www.yca.com)

INTRODUCTION

There is currently a major change in the approach taken to equipment maintenance due to longer times between turnarounds and a reduction in the available personnel. Valves are typically one of the higher maintenance pieces of equipment in a process. This is because, unlike measurement instrumentation that only monitors the process, valves are dynamic devices, and in order for them to function properly, their main components, such as their actuators, packings, positioners, and I/P converters, all need to be operational. If any of these components fail, the result is that the process can no longer be remotely controlled. For this reason, control valve testing should evaluate the condition of all of these components.

Valve diagnostics and predictive maintenance is relatively new. In the past, the approach to maintenance was to schedule the periodic rebuilding of critical valves based on the time that the valve has been in service and not on the basis of actual need. This type of preventative maintenance method has several drawbacks. One is that by using this approach, a lot of unnecessary maintenance is done. Secondly, if critical failures occur between maintenance intervals, they are overlooked. Finally, sometimes the act of maintenance itself causes problems in valves that had no problem before.

DIAGNOSTICS

Instrumentation Used

Diagnostic information can be obtained from smart positioners, local portable sensors, and the evaluation of process control signals. As discussed in more detail in Section 6.12, smart positioners are relatively inexpensive and easy to use. For these reasons, they are used most commonly.

The local sensors utilized in diagnosing the control valves are usually integrally mounted on the valve. In safety-related control valve systems (as discussed further in Section 6.10),
specialized positioners are used to provide partial stroke tests, which can verify the operational status of the valve without interrupting the process.

When diagnosing existing installations, the testing is often performed by analyzing the past performance and records of the process instrumentation. When time permits, portable sensors can be installed in the field to monitor the performance of the valves and to provide the required data for diagnostic tests.

Intermediate signal control boxes can also be used, primarily in safety-related systems. These can partially stroke on/off safety and shut-off valves (Section 6.10) by briefly interrupting the signal to a solenoid. This way, the system can verify that the valve is operational, because it is beginning to operate. In order not to adversely affect the operating process, once the valve begins to respond, the solenoid is quickly re-energized. This way, the valve is tested without a need to shut down the process while testing.

Diagnostic Methods

Standards such as ISA-75.13-1996, “Method of Evaluating the Performance of Positioners with Analog Input Signals and Pneumatic Output,” or “ANSI/ISA-75.25.01-2000,” “Test Procedure for Control Valve Response Measurement from Step Inputs,” are useful in evaluating the performance capabilities of control valves. These standards describe the performance tests required to determine HRL hysteresis, repeatability, and linearity (HRL) of control valves.

These tests provide very useful information on the performance of both the positioner and the valve actuator, but they do not provide much information that would be useful in predictive maintenance.

Many smart positioners have built-in diagnostics that can provide usage information and current status that is very useful in troubleshooting existing problems. Most of these positioners do not provide on-board predictive diagnostic information. In order to perform predictive diagnostic tests, the positioner usually has to be accessed through a digital interface and its data downloaded into a PC for analysis.

Many new host control systems can pass the information directly to a diagnostic PC over a network connection. Some positioners also have internal data historians that provide detailed information on the valve command, actual position, and actuator pressures that provide a level of detail not normally available in host historians for diagnosing transient problems.

Characteristics Tests

Another category of tests are the characteristic or signature tests, which are well suited for predictive diagnostics. They can be generated by a smart positioner or obtained by using a portable test rig.

Valve signatures are obtained by ramping the valve through a range of travel and capturing information concerning the position command, the valve travel, and the actuator pressure(s). This information can be analyzed independently, or over time to observe changes in the characteristics of the control valve.

For example, a signature can be the friction in a valve over a range of travel. Changes or abnormalities in the friction plot over the range of travel provide direct information related to seating problems or galling that may be occurring in the valve trim. A full travel signature can provide information on the travel calibration of pneumatic actuators or help to locate leaking or worn seals and fittings.

New software tools are also available for the historical analysis of valve command signals and of the corresponding process response. This method of analysis is nonintrusive and can be applied with both smart and traditional positioners.

Many of the analysis packages can access the required data directly from a historian in the DCS. This method of analysis involves the comparing of the controlled process measurement with the command signal received by the control valve. If the controlled process measurement is sensitive enough to respond to small changes in the valve opening, then this measurement can be correlated with the control signal received by the valve and, thereby, determine if there is sticking or lagging and quantify the magnitude of the problem. The main limitation with this type of analysis is that it provides an indication of the existence of a problem, but does not provide detailed information.

Some equipment suppliers now offer diagnostic services on a contractual basis. In providing these services, the suppliers utilize large databases that they have compiled over time, using various types of valve designs in a wide variety of process services. These services often include a review of the existing installation to see if other valve designs might not be better suited for the applications at hand.

Valve Signatures

A valve signature is obtained by running a reproducible test on a control valve. During such a test, a repeatable signal is sent to the control valve, and the response to that signal is captured and then analyzed to see if the control valve operates correctly.

The valve should be removed from the process and placed on a test stand while running the complete signature test. This is because during the test, the valve is forced to travel over a wide range, and if this was not done off-line, it could cause harm to equipment, personnel, or the process. For the signature of an emergency shutdown valve, refer to Figure 6.8a.

However, a partial stroke signature can sometimes be obtained on-line. If a valve signature is obtained near the end of the valve stem travel, or even beyond the end of travel, it still can be of some value. For example, if the behavior of a normally closed valve is tested with a control signal range of –5 to 0%, one can obtain diagnostic data on the response...
of the pilot valve in the positioner without opening the valve (moving the valve stem) at all.

Similarly, limited signatures can be obtained, when control valves are in operation, by changing their control signals within a small range (1–2% of travel) around the required opening of the value.

**Valve Signature Types** There are four types of valve signatures. These are obtained by detecting the valve’s response to steps, ramps, partial strokes, or internal operation. The step and ramp signatures can be performed in either the opening or closing directions. Figure 6.8b shows the ramp test signature of a control valve with a double-acting actuator, and Figure 6.8c shows the same signature for a valve provided with a spring-loaded, single-acting actuator.

When performing a ramp test, first the starting and ending valve positions are entered. The ramp rate and the sampling time is usually also entered. The data gathered at each sample point includes the value of the control command signal, the valve position, and actuator pressure.

In order to obtain a step signature, first the step size is defined by setting the starting and ending valve positions, and then the recording time period is set, where time zero is the time at which the step command is issued. The data gathered at each sample point include elapsed time and the values of the control command, valve position, and actuator pressure.
Control Valve Selection and Sizing

pressure. The result is a graph that shows the response of the valve to a step in its control signal including the approach and stabilization of the valve at the new position.

A partial stroke test is similar to a step test, but it is based on a temporary and small change in the control signal. Instead of reaching and maintaining an end position, the test only lasts long enough for the valve to begin to move or sometimes not even that, but only begins to apply the necessary pressure to begin to move the valve stem before resuming normal operation.

Internal operation signatures are primarily positioner diagnostic tools, because they test the operation of the pneumatic relay.

Analyzing Valve Signatures

Most valve manufacturers provide information and guidance for interpreting the above-described signature tests. Interpretation of valve signatures considers two different factors: One is the characteristics of type of valve used, the second is the past history of valve performance.

In terms of valve characteristics, the control signal and valve travel relationship is a function of the type of valve used. Similarly, the minimum and maximum stem friction values depend on the type of packing used by the particular valve design (see Section 6.5 on packing designs). Other characteristics include the balancing pressure range of double-acting actuators and positioners, which, if it is outside the design range, is an indication of problems in the actuator. Also, there usually are inflection points in the valve signature, which indicate the particular seating and linkage characteristics of the valve.

The second basis for evaluating the signature of a valve is by making a historical comparison with past performance. The reference signatures can best be obtained when the valve is in good working order. Once a set of baseline signatures for each valve have been obtained, subsequent signatures can be directly compared against that baseline reference signature, which was taken under the same conditions as the existing ones. The differences between the reference and actual signatures can point to possible problem areas.

The Instrumentation, Systems, and Automation Society (ISA) committee “SP 75.26.01, Valve Diagnostic Data Acquisition and Reporting” is in the process of developing a standard for the methodology to be used in acquiring valve signatures. Their scope includes the defining of the test procedures to be used and the obtaining of reports that can be transferred from one diagnostic system to another.

CONCLUSIONS

The analyzing of valve diagnostic information is a new and evolving field. The diagnostic needs of a plant can depend on its age, on the type of control system being used, and also on the experience and attitude of the operating staff. Today, a variety of diagnostic services are offered by valve manufacturers, instrument suppliers, and service companies. With the passage of time, standardization is expected both in the methods of obtaining and in the interpretation of valve signature tests.

Bibliography


