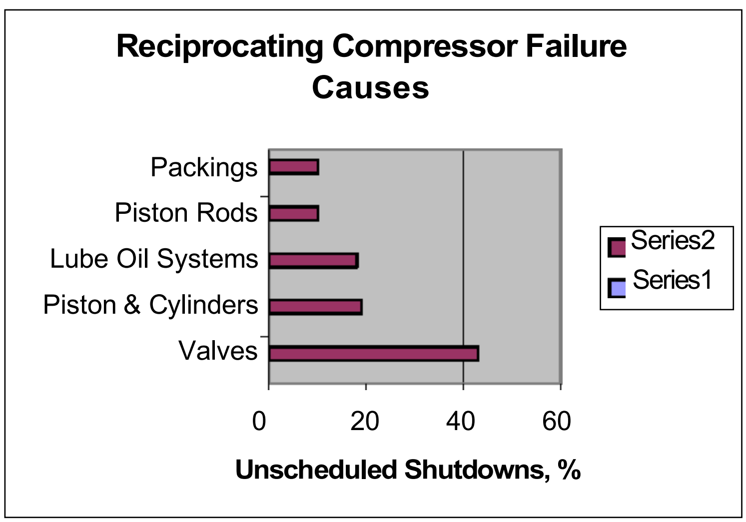
Reciprocating Compressor Condition Monitoring

Reciprocating compressors are the most common type of compressor. They are used for compression of light gases and are essential for high-pressure processes. They are extremely flexible and can work under variable operating conditions while maintaining high efficiency. However, they can have high maintenance costs and consequently low availability if they are inadequately operated, controlled and maintained. Recent investigations showed maintenance costs of around 45.00 US$ per horsepower per year (~60.00 $/kW/a) for reciprocating compression equipment as opposed to some 10.00 US$ per horsepower per year (~13.00$/kW/a) for turbocompressors.

Despite the application of advanced technologies in the development and manufacture of wearing parts, such as valves, piston rings and packings, these components continue to be the main causes of reciprocating compressor failures and unscheduled outages. See Figure 1.

Monitoring of reciprocating compressors should follow the same basic rules we outlined in a previous column[2] where we discussed the importance of operator rounds covering our compression equipment.

In the context of reciprocating compressors, and particularly with respect to valve condition monitoring, operator attention has been invaluable: When compressor valves fail allowing gas to leak by, there is always an increase in temperature.



Usually this temperature rise will affect the whole cylinder, but it occurs predominantly at or in the vicinity of the failing or failed valve. Operators find leaking valves by checking the temperatures of each valve cover as part of their rounds. Another practice is to have technicians periodically check all valves after a sudden increase in overall discharge temperature for a given cylinder. Various instruments have been used to assess cylinder valve condition such as ultrasonic leak detectors and thermographic cameras. However, these methods require much time from skilled analysts. Additionally, these approaches have certain limitations: First, valve temperatures vary with load and process conditions. Second, low ratio cylinders may not exhibit any discernible valve temperature rise until the valve is in significant distress. Gas composition may also have an impact on the degree of valve temperature rise caused by valve failure. Small temperature changes associated with some gases and low pressure ratios may cause a very small increase in temperature on the valve cover until the valve has major problems.

In order to improve valve diagnostics, and in view of decreased manning levels in the plants, many facilities have resorted to on-line valve temperature surveillance systems as part of an overall modern automatic reciprocating compressor monitoring concept.

This system will typically measure temperatures on the inside of each valve cover and compare them to the temperatures of other similar valves. By comparing, for instance, all suction valve temperatures on the same cylinder, errors due to a temperature rise associated with a change in process conditions are eliminated. If the process parameters change, then all the suction valve temperatures should increase or decrease simultaneously. The same is true for discharge valves. The system determines the average valve temperatures of like valves and initiates alarms based on any meaningful deviation from the average. The benefits of using a valve temperature monitor include the ability to:

- Detect defective valves. Defective valves result in reduced capacity and efficiency, as well as damage to the cylinder liner due to valve parts falling into the cylinder, or damage to the cylinder liner from ineffective lubrication caused by high temperatures. In addition, the imbalance between head and crank ends of the cylinder due to leakage may result in insufficient rod reversal and consequential damage to the wrist pin and crosshead assembly.

- Determine if gas leakage is occurring due to damaged or worn piston rings.

Automated monitoring and diagnostics therefore, is an approach that can reduce operating and maintenance costs by the early identification of faults that may lead to deterioration of performance, efficiency and production, and to failures that potentially pose safety issues and may cause lengthy unplanned maintenance outages.

The ideal reciprocating compressor monitoring system should be designed to meet several distinct objectives:

1. It should continuously surveil compressor and driver to protect against conventional mechanical failures by monitoring mechanical components. This is accomplished by the use of crankcase vibration sensors, bearing thermocouples and piston rod drop detection devices. Some types of process upset should also be detected by measuring inlet and discharge temperatures of each compressor stage. Similarly, calculated piston rod loads must be continuously monitored and timely alarms issued well before a protective safety valve is activated.

2. The system should continuously monitor the thermodynamic behavior of the compressor by analyzing cylinder performance. A list of probable causes of deviations from normal operation should then be presented together with recommendations for corrective actions. It should do so by utilizing a mathematical model that continuously calculates expected values from real-time temperature and pressure inputs.

3. A desirable monitoring system should be able to warn plant personnel of operating conditions leading to failure, such as excessive gas temperatures, regardless of compressor loads.

4. It should also predict deteriorating mechanical condition, inform the operations department about changes in compressor performance and provide data for stewardship of energy consumption.

5. In addition, the system should provide technical services personnel with the data required for failure analysis as well as the information needed to further improve system design. The system should be designed to minimize false alarms and to allow for easy future system expansion.

Suitable modular advanced diagnostic systems for reciprocating compressors attempting to meet the above objectives are currently offered by at least three reputable vendors. □□□

1. **References:** U. Sela, *Reciprocating compressor condition monitoring*, HYDROCARBON PROCESSING, Feb.2000
2. Practical Machinery Management for Process Plants: Volume 5; *Maximizing Machinery Uptime*, H.P. Bloch and F.K. Geitner, ISBN 13:978-0-7506-7725-7, 2006, www.books.elsevier.com

Author: Fred K. Geitner (fredgeitner@gmail.com), resides in Brights Grove ON, Canada. He advises process plants worldwide on machinery maintenance cost reduction and reliability improvement.