Improving Reciprocating Compressor Reliability

In a previous column, we discussed monitoring activities around reciprocating compressors. Monitoring is considered the first line of defense against machinery breakdowns and forced outages. While monitoring compression machinery will not prevent failures from occurring it mitigates their consequences by early fault detection and possibly preventive planned shutdowns.

In the following we shall attempt to discuss reciprocating compressor reliability issues in order of their significance – see Figure 1. Increased component reliability will lead to fewer forced outages and consequently to higher availability.

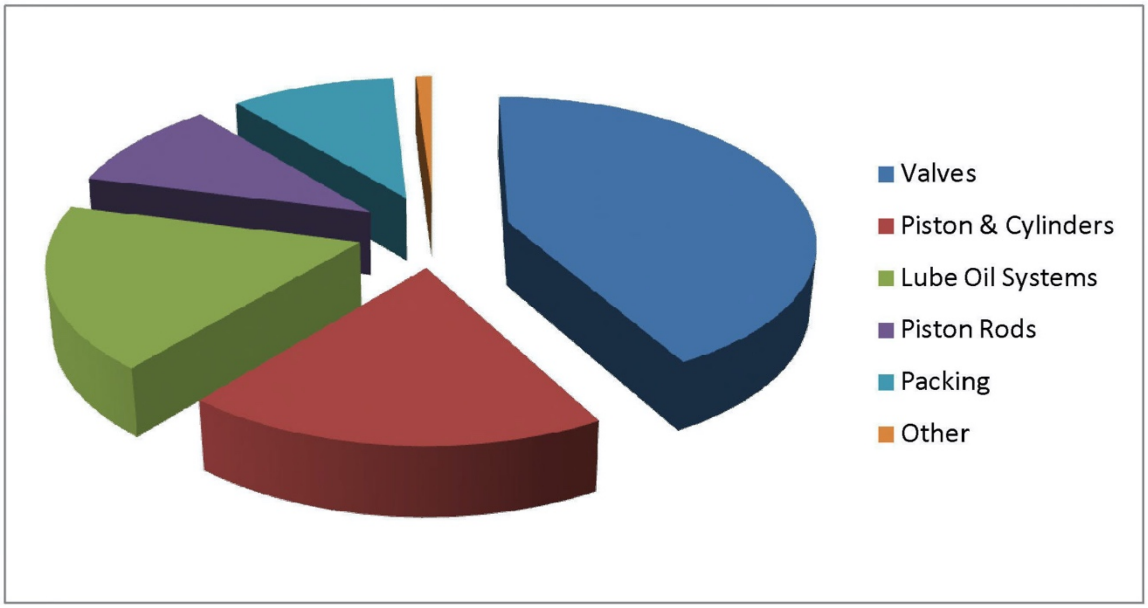

Figure 1. Causes of reciprocating compressor forced shutdowns.[1]

Compressor Valves. Most owners and operators of reciprocating compressors have managed to upgrade their compressor valves driven partially by in-house reliability enhancement programs but also by good salesmanship of valve and valve component vendors. Usually compressor operators have been well advised to change from metallic to thermoplastic ring material. Where valve rings have failed due to exposure to high temperatures good success has been achieved by choosing a different thermoplastic in order to extend the temperature range of the rings.

Whenever valve failures continued to plague them compressor owners have resorted to reverse engineering in cooperation with valve OEMs (Original Equipment Manufacturers). In order to optimize the design, OEMs use simulations contained in digital proprietary programs. The mathematical models are able to determine:

[1] Hydrocarbon processing experience

- Ring displacement or the distance travelled by moving valve elements
- Spring stiffness
- Flow
- Pressure drop
- Compressor cycles

The dynamic aspects of the design are related to the mechanical behavior and consequent fatigue failures. A thorough simulation is therefore required to optimize the characteristics of the valve by using computational fluid dynamics (CFD) evaluations. In order to have an adequate validation of the simulation programs, special coefficients have to be identified such as the flow coefficient[2] for example.

Piston Rods, Piston Rings, Rider Rings (Wear Bands), and Packing. Piston rod fractures are most often related to operational oversights in that operators and mechanics do not understand rod loads[3]. Operators need to be guided by a simple graph or computer display showing real time rod loads and their limits at various operating pressures.

In order to extend service life of their piston, rider and particularly packing rings successful operators have identified the material of construction of these components. Once this information was available they embarked on a stepwise life improvement of those parts. Establishing well kept record systems in form of computerized maintenance management systems (CMMS) was of utmost importance. They helped capture and evaluate life data on all compressor components.

During a recent visit in a hydrogen compression facility with a fleet of reciprocating compressors we found PTFE[4] filled packing ring materials invented around 1950. We recommended the owner set out on a controlled program of introducing new materials for piston rings, rider rings and packing rings once he acquired a stand-by compressor to cover unforeseen events as the new components were to be tried out. The first thing to do in an improvement program, again, is the identification of currently used piston rod materials and piston rod coatings as the latter influence the life expectancy of packing rings: If the material does not meet OEM standards, it must be upgraded and a suitable rod coating introduced with a finish[5] to be defined with the help of the packing ring supplier's engineering department.

Additionally, we stressed the need for running-in newly installed wear components such as the packing rings mentioned above. A large body of evidence suggests a temperature increase during the initial hours of unloaded operation. During this time thermoplastics release their lubricant

[2] *CompressorTechTwo*, October 2009, p.58-62
[3] See Pipeline & Gas Technology June 2003
[4] Fluorocarbon - polytetrafluorethylene - Teflon™
[5] One possible specification: The portion of the piston rod which operates in the packing shall be coated with Union Carbide D Gun (or equal), plasma sprayed Tungsten Carbide or equal to a thickness of 0.005 inches. Where filled PTFE packing is used, the surface finish of this coating shall be 3 to 5 μ inches rms.

compounds by coating mating parts. A four to six-hour run-in seems appropriate.

New wear materials for reciprocating compressors are PEEK[6] – mostly used as valve ring material – PPS[7], PI[8] , and PAI[9]. These "high performance" thermoplastics, in their pure form, do not have the ability to run dry. However, they become very resistant to wear once they are modified by additions of lubricating substances like PTFE - 10 to 15% by weight, graphite and molybdenum disulfide. If the compressor OEM cannot help extend component life, operators should try companies in the wear materials business as well as their current packing ring suppliers.

Lubrication. Lubrication makes sliding and rotating of compressor components possible. Probably fewer than 20% of all reciprocating compressors cylinders are designed for non-lubricated operation because of process demands for oil-free gas such as oxygen, high pressure air or downstream facilities sensitive to oil contamination. While thermoplastic components as mentioned above are used on non-lubricated cylinders, compressor owners have also applyed them successfully to increase compressor availability by providing a very small, carefully metered supply of an appropriate lubricant to cylinder and packing boxes by retrofitting divider block systems. This is often referred to as "mini-lubrication". A typical case where more is not better, is admitting too much oil into cylinders and packing boxes thus preventing rings from getting a chance to deposit PTFE onto the cylinder walls and rod surfaces. Excessive lubricating oil would tend to wash out the PTFE coating.

Operational problems related to lubrication can arise sometimes in form of condensation on the cylinder walls by allowing the temperature of the cylinder jacket coolant to decrease below the process gas inlet temperature. This will cause dilution of the thin lubrication film and ultimately result in accelerated wear of piston and packing rings.

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Literature: H.P. Bloch, *A Practical Guide to Compressor Technology,* 2nd Edition, 2006 John Wiley and Sons, Inc., ISBN-13: 978-0471727934, ISBN-10: 9780471727934

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[6] Polyetheretherketone
[7] Polyphenylensulfide
[8] Polymide
[9] Polyamidimide