



CPI installed this divider block lubrication system on a reciprocating compressor.

RECIPROCATING COMPRESSOR OIL SYSTEMS NEED FINE TUNING

Under- or over-lubrication frequently causes mechanical problems

By Lee Alexander

In recent years the compression industry has witnessed much improvement in the area of materials technology, specifically with polytetrafluoroethylene (PTFE) mixed with various fillers.

These advanced PTFE based products have extended the wear characteristics and the reliability of piston, rider and packing rings.

Through improved modeling simulation, Compressor Products International (CPI) has developed a better

Lee Alexander is Technical Director for Compressor Products International (CPI) in the Americas. He has a master's degree in engineering from University College London. Alexander joined CPI in 2008 and is based in Houston, Texas. He has a background in developing innovative monitoring and lubrication technology, performance analysis and wear component applications for reciprocating compressors.

understanding of the flow characteristics of reciprocating compressor valves and thus their life.

All of these advancements easily can be diminished when one important aspect of reciprocating compressor operation is over looked — the lubrication system.

In many instances of poor reliability, reciprocating compressor wear components and valves are first looked at as the culprits and the root cause of the reduced reliability. This is often not the case.

When CPI's engineering team is asked to support our field service team we often find that the lubrication system simply has been adjusted above or below recommended levels.

The compressor needs to be viewed as a system and the interaction between all components is essential.

The compressor lubrication system has four basic functions: it serves as a

coolant, washes away particle matter and helps sealing, prevents corrosion and reduces friction.

The importance of a correctly engineered lubrication system depends upon several aspects: the compressor specifications, the gas application and the type of oil.

For reciprocating compressors two basic types of lubrication systems are used to deliver the correct levels of lubrication oil to the injection points: pump-to-point lubrication systems and divider block systems.

Either of these lubrication systems can be direct drive, where lubrication gearbox crank rotation is derived from the compressor. This is advantageous for variable speed compressors as the quantity of oil automatically adjusts to the compressor speed.

Alternatively, the lubrication system can be independently driven from a motor. This is advantageous for pre-



This reciprocating compressor packing case shows signs of excessive lubrication.

lubrication before compressor start up.

In a pump-to-point system, a lubricator gearbox holds a pump which is responsible for delivering oil to each individual injection point of the compressor. As a result, these lubricators are much larger to hold a higher number of pumps.

The pump-to-point system has several advantages. The gearbox cam speeds are much slower resulting in less wear. The individual flow rates are easily adjustable without affecting other pump outputs. And the individual pump unit failures do not affect other pump units.

Pump-to-point has disadvantages too. It is difficult and costly to monitor each individual pump output accurately. It is difficult and costly to add pressure gauges on the outlet of each pump assembly. And sight glass drip rates are not a perfect measurement of actual pump output.

A divider block system consists of a single block or multiple blocks that are each a single line hydraulic circuit. Each block has a minimum of three elements with a total of six outputs. Each block receives the lubricant at the inlet and divides it between the individual lube injection points on the compressor or engine.

Secondary divider blocks, located on or near the compressor cylinders, can be supplied with lubricant from a master divider block to further divide the lubricant between the various lube points. Precise delivery rates to each cylinder, packing or engine lube point are achieved by the use of various sized pistons.

The divider block system has three major advantages.

Only one divider block element needs to be monitored to assure proper operation of the entire lubrication system. A no-flow device can shut the compressor down if insufficient oil is delivered to the compressor.

Output monitored at the divider

block is a true measurement of the quantity of lubricant delivered to the compressor.

Only one or two pumps are responsible for the pressure and output of every lube point.

A disadvantage of the divider block system is that camshaft speeds are higher with less gearing, resulting in more potential wear and tear on drive train components.

Also, balancing valves must be used when pressure differentials between lube points exceed 800 to 1200 psi (55 to 83 bar). And the divider block system must be completely re-designed in order to change individual flow rates.

Although both systems have their pros and cons, the most critical aspect of their design is controlling the quantity of oil that is delivered to both the running surfaces at the packing case and the cylinder liner.

Under normal circumstances, oil should be applied evenly to a film thickness of about 0.002 in. (0.05 mm) on the surfaces that will see a mating counter surface.

At the simplest level, the base quantities of oil are calculated based on the following compressor parameters: cylinder diameter, rod diameter, stroke and speed (rpm).

Additional factors need to be applied to these base rate calculations depending on the compressor application: cylinder discharge pressure, molecular weight of gas, and water content in the gas.

All of these factors affect the viscosity of the oil and the ability to be able to lubricate effectively. Once the correct amount of oil has been calculated, this needs to be split between the injection points.

For a long time, the quantity of oil was split equally between the injection points of the cylinder and packing case. More recently there has been a practice of applying an increased

amount of oil to the upper or top cylinder lubrication point and the higher pressure side of the packing case.

When this methodology is applied, typically two thirds of the total quantity is applied to the top of the cylinder and to the high pressure side of the packing case.

Delivering the correct amount and grade of oil to the proper points for rod packing and piston ring lubrication is a prerequisite for compressor reliability. If too little oil is applied, it can result in increased temperature and accelerated wear of PTFE-based products if they have been designed for lubricated service.

If excessive wear occurs, it can lead to secondary damage including scuffing or scoring to more expensive cylinder components such as the piston rod and cylinder liner.

Excessive lubrication is equally, if not more, damaging to reciprocating compressor sealing component reliability. Too much lubrication oil in the cylinders can lead to valve sticktion.

The oil between the valve sealing elements and the seat can cause delayed opening of the valves. The delay in the opening allows the pressure to increase within the cylinder.

The higher pressure differential across the valve causes it to open with a higher than normal impact velocity and increased stress to all the sealing elements.

Hydraulic locking is caused when there is excessive lubrication oil in the packing case and the packing ring sets do not have enough side clearance in the cups. This in turn causes increased heat and in the worst case, the packing rings sets can extrude down the piston rod.

It is a common practice to run "break in" lubrication rates for new or overhauled compressors for a period of 200 hr after start up. This "break in" period prevents excessive temperature at start up, allows conformity of piston and packing rings to mating surfaces and allows debris to be carried away.

It is very often the case that compressor operators do not scale back the lubrication rates to normal levels. This is even more prevalent if a large fleet of compressors is maintained or the compressors are in remote locations.

Lubrication oil is one of the highest costs associated with the operation of compressors. For the average compressor operator, oil usage can average 25 to 30% of running costs. Managing these costs in today's economy is more important as excessive lubrication erodes profitability.



CPI field service technicians make a preventative maintenance call.

The cost of over-lubrication for the period of a year for a typical four cylinder natural gas compressor is approaching US\$15,000 per unit, based on some standard OEM industry lubrication rate formulas.

Although this is the worst case, it highlights the fact that when operating a large fleet of compressors there is significant cost reduction to be gained through a lubrication system that is engineered for the compressor application.

There is an added cost of this additional lubrication oil in the form of coalescing filters to remove the lubrication oil from the gas stream. Reducing the lubrication oil rates to correct levels preserves the life of the filters, again increasing the probability of an operation.

A lubrication system with moving components can see wear and lead to under lubrication of the compressor. The two major sources of wear in the lubrication system, and inherent under lubrication, stem from the lubricator positive displacement pump and divider block element piston.

When the pump starts to wear its output decreases and the quantity of oil delivered into the system is reduced. For a pump-to-point system this decreases the quantity of oil for a single injection point.

In the case of a divider block system it decreases all the injection points associated with that pump but to each to a lesser extent. When a divider block element wears the oil will be distributed to the line of least resistance. This

can cause a lubrication injection point of a higher pressure to be under lubricated and a lower pressure injection point to be over lubricated.

Regular preventative maintenance (PM) schedules are the key to a correctly working lubrication system. Ensuring that each pump is outputting the correct lubrication level and that the lubrication is being delivered to the injection point is paramount.

CPI's lubrication group field service teams check all system components for correct operation — including filters that can reduce the life of components if they allow particulate and debris to enter the system.

The CPI lubrication teams use a number of devices and procedures that make testing the system components easier. They include using a purge gun to determine if divider block elements can hold pressure.

In between maintenance, a number of devices can ensure that correct levels of lubrication are being applied, including visual and electronics devices that monitor the quantities of oil.

In summary, to get maximum reliability from sealing and wear components, the correct quantities of lubricating oil need to be applied to the compressor.

The ideal level of lubrication oil depends on the compressor specification, gas application and type of oil used. Under- or over-lubrication can significantly affect the performance of cylinder end components.

An effective PM schedule — which can be provided by CPI's engineering or field service teams — can ensure lubrication oil levels do not deviate from the ideal quantities and do not impact a compressor's operation. ©