Friction is defined, for purposes of this discussion, as the resistance to motion of two moving objects or surfaces that touch. This resistance is the force that creates heat and wear of two moving objects that are touching, such as the rod and packing, the cylinder bore, and the rings and rider bands. By supplying a thin film of lubricant to these “wear” parts, friction and the wear of the components is reduced. This will result in increased life and reliability of the components, reducing downtime of the unit.

In a gas compressor, there are two states of lubrication: hydrodynamic and boundary layer. Hydrodynamic lubrication is when the two surfaces are completely separated by the oil, which is considered an excessive amount of oil. Boundary layer lubrication would not be a complete separation of surfaces and the surfaces would partially rub against each other and result in a higher frictional component than desired, resulting in excess wear of the two surfaces.

As examples, four scenarios are presented. The first case is one with no lubrication, resulting in the highest friction and wear. As the two surfaces move across each other, the friction and wear are at its highest. The second case presents boundary layer lubrication, which would be a partial layer of oil film, about 50%, which would separate the two surfaces slightly; however, the two surfaces would have some contact. The friction and wear have been reduced, but the lowest friction possible has not been attained. Third, hydrodynamic lubrication is an excess of oil that separates the surfaces completely; however, the excess oil creates fluid friction, raising the heat and wear rate of the two surfaces. The excess oil also creates additional issues in the discharge valves and downstream processes and parts. The fourth case reveals an amount of oil somewhere between boundary layer and hydrodynamic lubrication, which is a 100% coverage of the parts with a thin film of oil. This amount of oil will reduce the frictional component, heat, and minimize wear. With a great deal of engineering and testing, the optimum amount of oil can be calculated to apply to the wear components, to achieve the longest lasting and greatest reliability of these components.

The purpose of an automatic lubrication system is to supply the proper amount of lubrication, at the proper location, at the proper time, by applying small amounts of lubrication on a continual basis, to achieve “full film” lubrication.

PUMP TO POINT

The original automatic lubrication system, called “pump to point,” was invented in the late 1800s and has a single pump for every individual lube point on the unit, i.e., if there are 10 lube points, there must be 10 lube pumps and 10 pump adjustments. The flow rate is measured by counting the drops of oil dripping through the sight glass of the pump. The adjustment is very time-consuming and inaccurate, because a drop of oil will change volume as the temperature and viscosity changes. In addition, in many cases, the gearbox that drives the pumps is also the oil reservoir. As the gearbox components (cams, gears, bearings, etc.) wear, and as the gearbox breathes in contamination, the pump will suck in the contamination and wear out the pump and lubricated parts prematurely. When the wear reaches a certain point, the pump will begin to bypass back into the reservoir; however, there is no way to see this, so a reduction in oil flow to the lubrication point will occur without any way to see it is happening. An improved pump design, which allows an external oil supply, such as a day tank or a compressor/engine crankcase sump, to be supplied by gravity or pressurized feed, allows for cleaner, filtered oil to supply the lubrication system, which results in longer pump life and longer compressor wear component life. This design also allows the use of a high-quality gear oil in the gearbox, which increases the life of the gearbox drive components. Also, if the pump does begin to bypass due to piston wear, the gearbox will begin to fill up and overflow, which alerts an operator of a problem.

You may be asking yourself why this is brought up. Sometimes, you need to see where you’ve been to see where you need to go. In the case of lubrication systems, it is good to see where we started, which is still on many compressors, and compare it to where we are now, to justify upgrading to the newer, state-of-the-art system.
COUNTING DROPS

When counting drops during the adjustment of the pumps, an average drop size of 0.002 cu.in. (0.033 mL) is used, which equals about 14,400 drops per pint of oil. One pint per day would equal approximately 10.0 drops per minute. However, depending on oil temperature and viscosity, one pint of oil could equal anywhere between 10,000 and 16,000 drops per day, which results in a very inaccurate way to adjust the flow rate of the pumps.

SERIES PROGRESSIVE DIVIDER BLOCK SYSTEMS

The series progressive divider block system, invented in the 1930s, requires only one pump to supply the entire lubrication system and, therefore, requires only one pump adjustment for the entire system.

The divider block is a “series progressive” system, made up of multiple moving pistons, which very precisely meter the volume of oil to multiple lubrication points in a proportional manner, resulting in each lubrication point receiving the proper amount of lubrication on a somewhat continuous basis. The lubrication system can supply from one lubrication point to more than 100 lubrication points from a single lubricator pump. Because of the “series progressive” mechanism, the movement of a piston can be monitored with a visual or electronic indicator and the actual lubrication point going into the system can be calculated. This monitoring capability can also be used to send an alarm or shutdown signal from the lubrication system monitor, programmable logic controller (PLC), distributed control system (DCS), etc., if there is a reduction of lubricant supply, which can alert an operator or shut down of the unit. An alarm or shutdown output signal can also be programmed, based on watching the piston move and timing this movement. If the pistons slow down to a predetermined rate, which equates to a reduction in lubrication volume to the lube points, or if the pistons stop moving completely for some reason, an alarm or shutdown output signal can be transmitted to alert an operator or shut down of the unit.

It is important to note that the monitoring of the piston movement for calculating flow rates assumes that the pistons do not “bypass” the lubricant when operating. Since the pistons are metal and moving in a metal bore, in some cases, several million times per year, they must be inspected on a periodic basis to assure the pistons are not bypassing. The inspection procedure consists of blocking each divider block outlet, one outlet at a time, and pumping lubricant through the divider block. The divider block must “lock up” and hold a predetermined pressure for a set amount of time. Each outlet must be tested in this manner. If any piston does not hold pressure, the entire divider block assembly must be replaced.

The divider block assemblies can have between three and 10 pistons in each assembly, and each piston can feed one or two lube points. A system can consist of a single divider block assembly with outlets feeding lube points, or it can have multiple divider block assemblies consisting of a “master” and “secondaries.” Each outlet of the master block assembly would feed a secondary divider block assembly and the secondary divider block outlets would feed the individual lube points. Because the divider block assemblies are a “series progressive system,” and the piston movement engages the movement of the next piston, only one of the pistons in the master divider block assembly needs to be monitored. If any one piston stops moving, the entire divider block stops moving and the chain reaction, in turn, causes the entire lubrication system to stop moving, which stops the entire lubrication system from pumping lubricant to the unit.

Each divider block section is labeled with numbers and letters that designate the exact output of each piston and how many lubrication points each piston feeds. The numbers (and outputs) are as follows: 6 (0.006 cu.in. [0.0098 mL]), 9 (0.009 cu.in. [0.147 mL]), 12 (0.012 cu.in. [0.197 mL]), 15 (0.015 cu.in. [0.246 mL]), 18 (0.018 cu.in. [0.295 mL]), 21 (0.021 cu.in. [0.344 mL]), 24 (0.024 cu.in. [0.393 mL]), and 30 (0.030 cu.in. [0.492 mL]), which is the volume of lubricant pumped when the piston moves in one direction. The piston pumps the same amount of lubricant when it moves in the other direction. The letters are “S” (piston feeds a single lube point) and “T” (the piston feeds two lube points) per cycle. A cycle is when all the pistons in a divider block assembly move in both directions one time. In some cases, two pistons must be combined to feed a single lubrication point, which is accomplished by using a “crossover bar.”

The actual volume of oil the divider block assembly dispenses, and cycle times, can be calculated using the following formulas. (NOTE: The “6” in the numerator is a constant used in converting thousands of cu.in. to pints per day, and using divider block total, not cycle total for the calculation. Cycle total is 2X block total.)
Since the divider blocks are designed to feed specific lube points with a precise volume of lubricant, it is important to note that any changes in the divider block configuration, numbers, or letters will result in incorrect amounts of lubricant being distributed to the lubrication points, and in some cases will result in the lubrication system failing to operate. In addition, changes will result, in most cases, in premature wear of the lubricated components.

TROUBLESHOOTING
Each divider block outlet has a second “alternate outlet” in the front of each divider block section, which is internally “Tee’d” together with the outlet and used for a pressure indicator pin, which monitors the pressure in the lubrication line. If a lubrication point or line becomes plugged, increased backpressure will “pop out” an indicator pin creating a “road map” showing where the blockage is located. This feature decreases the troubleshooting time required to find and fix a problem in the lubrication system.

FILTRATION
Another important aspect of the automatic lubrication system is the filtration requirements. The components of the system are not dirt-tolerant; therefore, proper filtration must be maintained. It is recommended that the lubricant be filtered to a 10-µm level or better. This is accomplished using a low-pressure, non-bypassprefilter between the lubricant supply and the system pump, and an additional, non-bypass, high-pressure filter between the system pump and the divider block assemblies. Optional delta-P gauges are recommended to monitor the condition of the filter elements to eliminate unscheduled shutdowns of the lubrication system, due to plugged filter elements.

Many of the lubrication pumps have a maximum supply pressure of 25 psi (1.72 bar) to operate properly. To accomplish this in a pressurized lubricant supply, it is recommended that a pressure regulator set at 15 to 20 psi (1.03 to 1.38 bar) in the supply line is used.

AIR IN THE SYSTEM
The pumps and divider blocks will not operate properly if air or gas is introduced into the lubrication system. To prevent air from entering the system from the supply, it is recommended using an “air trap” to remove any entrained air in the lubricant supply. Gas can enter the divider block system when check valves leak. Check valves must be maintained to assure they seal tightly. It is recommended that the check valves be installed in a manner that keeps a “head of oil” on the check valve outlet to isolate any contamination present in the compressor cylinder and packing lubrication points from reaching the check valve sealing area. This can be accomplished by orienting the check valve with the flow in the upward direction, or by using a “check valve protector,” which keeps a head of oil on the outlet of the check valve in any orientation. Best practices suggest using a double ball “terminal check valve” at each lube point and an additional single ball “outlet check valve” at each outlet of the divider block assemblies.

SUMMARY
An automatic lubrication system is a very precise mechanism that supplies lubrication in small amounts, on a somewhat continuous basis, to each lubrication point of an engine and compressor. It is capable of complete monitoring, alarming, and shutdown of the lubrication system and the unit it is lubricating. Since it is a very “tight clearance” mechanical system, it must be properly maintained to operate reliably. Due to the extremely tight fit and tolerance of the divider block pistons, the moving components must be replaced on a periodic basis to assure proper lubrication rates to each lubrication point. ☮

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Cycle Time Formula: \( \frac{\text{Divider Block Total} \times 6}{\text{Pints Per Day}} \) = Cycle Time in Seconds

Pints Per Day Formula: \( \frac{\text{Divider Block Total} \times 6}{\text{Cycle Time in Seconds}} \) = Pints Per Day

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