Improving air system efficiency

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Part 3: The piping system is a critical but often overlooked part of the design of a compressed air system.

The piping portion of the compressed air system serves a number of purposes. The most obvious is to transport the air from the supply side of the system to the downstream equipment. It also provides limited storage capacity and controls velocity to and from various process parts of the system.

There are many different piping materials that can be used, as well as many approaches to assembling them. There are also numerous types and styles of valves that can be used within the air system. Different piping configurations can also be used to suit a broad range of needs. One thing is for sure: there are rarely straightforward answers regarding piping and piping systems.

Types of piping and assembly methods

There are many piping materials available for compressed air systems. The most common are:

- **black iron**
- *** carbon steel**
- *** galvanized steel**
- *** copper**
- *** plastic (PVC and CPVC)**
- *** ABS, and**
- *** stainless steel.**

There are also many different connecting or assembly approaches. (Naturally, some of them will only work with specific types of pipe materials.) The most common are:

- **butt weld**
- *** slip-on weld**
- *** threaded**
- *** socket weld**
- *** sweat fit**
- *** chemical weld**
- *** flared and threaded, and**
- *** grooved and clamped.**

Remember that the goal of the designer in compressed air piping is to construct a safe and efficient system which is easy to work with and flexible for the future. When selecting material, remember that each has a rating for pressure and temperature. Determine the highest operating or

working temperature and pressure for the location in the system that the material will be installed at. Codes may dictate the test requirements for your area or application. Most burst tests are 1.52 rated working pressure.

From the compressor to the aftercooler, the temperature could range from 175° to 425° F, and the air could be thoroughly saturated with water vapor. If Schedule 40 black iron pipe is used for a discharge line between a compressor and the aftercooler, a substantial amount of iron oxide will build up in the pipe due to corrosion. It has to come out somewhere - probably the separator drain line. This means that the drain-line size must be generous, a Y-strainer installed with a trash-out valve, and the the trap will have to be frequently serviced. Choosing carbon steel, stainless, or galvanized for this application will eliminate significant pipe contamination, and will require no extraordinary approach toward piping or maintenance.

In many overhead piping configurations, plastic and ABS-based materials - if approved for compressed air service - are light and easy to assemble. They resist corrosion and are cost effective. This material is particularly good for inlet piping where the inlet is located outside, remote from the compressor. It also works well in many underground installations. Some local codes will not allow this type of piping in the overhead systems because of potential byproducts in the event of a fire. Expansion joints must be provided in these types of pipe, as they will expand and contract due to both interior and ambient temperature changes. With some materials, as much as 1Ú4-in. of expansion must be provided per 10-ft length per 10° total temperature change from rated temperature. It is important not to clamp down on this piping with hangers or make 90° turns without provision for expansion and contraction.

The compressor room

In many smaller systems, copper Schedule L pipe with K fittings may be the best choice. Valves can be wafer- or butterfly-style installed between flanges in the copper pipe. ACR copper can also be an excellent choice of materials over stainless steel where cleanliness and low porosity are desirable, such as system dew points below -40° F. With line sizes over 3 in., copper is no longer economical.

In larger systems, galvanized and carbon steel offer relative cleanliness, but are harder to work with than several other choices. One particular assembly method grooves carbon steel or black iron, which offers the ability to prefabricate large piping systems.

Inlet piping differs considerably from discharge pressurized piping. It is most important that the piping material be clean and not capable of developing contaminants such as rust or oxides. It is also important to assemble piping in such a way that there are no parts that can dislodge and go into the compressor. It is a good practice to install a cone strainer in the final flange before the inlet with the cone facing against the inlet flow.

Another common problem is remoting the inlet to the outside. Although there are many reasons to install the inlet outside, it can be difficult to service. When this is done, it is particularly important to properly instrument the inlet so it will alert maintenance personnel or operators to the need for maintenance. But a better approach would be an inlet filter, set up for on-compressor mounting with remote connections. When this is done, a pre-cleaner should be installed on the remote inlet to capture the larger inlet contaminants.

Shut-off and special-duty in-line valves There are many types of valves available for compressed air service. The following are the more common types: globe, gate, ball, wafer, butterfly, plug, slow-acting, relieving, wedge, needle, petcocks, and notched ball.

There are a tremendous number of globe and gate valves installed in compressed air service. However, they would be my last choice for shut-off valves in the piping system. They have the highest pressure drop of any of those listed for line service, and they cost two to three times as much. Plug valves have minimum pressure drop for shut-off service, but can also be expensive.

Ball, wafer, and butterfly valves are superior for in-line shut-off service in the compressed air system. I would suggest full-flow ball valves for 1Ú2 to 2 in. piping. In larger piping, I suggest either the compression-type wafer or butterfly valves. The butterfly valve has a bolt pattern in the valve body which mates to the adjacent flanges. The wafer valve usually has a grooved ring seat in the valve body for an O-ring, which is compressed between the mating flanges when they are bolted together.

The other six valves are used primarily for point-of-use applications, along with ball valves. Slow-acting valves are a most interesting choice for higher flow applications. They can be spring-loaded, and pneumatically, mechanically, or electrically actuated. When actuated, they can take 10 sec or more to fully open. This not only ramps in the flow (which reduces surge), but also protects downstream components from being slammed as the pressure goes from atmosphere to full line. This can be a thoughtful selection on any large-volume point-of-use installation.

The relieving or auto drain valve is designed to relieve the downstream pressure when in the shut-off position. These are primarily used in subheaders down to the point-of-use and are offered in ball- and plug-type valves. Other types of valves trap pressurized air in the downstream piping, hose, etc. when they are shut off. Another advantage for these types of valves at the point of use is that when partially open they blow air and make substantial noise, allowing for easy troubleshooting. Wedge valves, notched ball valves, and needle valves are used for manual flow control in process or metered recovery applications.

Other issues

One of the common problems regarding valves and all smaller, frequently used parts in the air system is the large number of stocked sizes for use in the air system. There are 16 sizes available that are 8-in. or smaller. The number of sizes should be minimized to 1Ú2, 1, and 2 in. in smaller valves and 3, 4, 6, 8, 10, and 12 in. wherever possible with larger valves. This will limit inventory and reduce pressure drop in the system.

Another issue to keep in mind is the compatibility of valve components with the contaminants and conditions of the air which might be in a specific part of the system. When acid and caustic gases (common in industrial applications at a low volume - 1 to 5 ppm) combine with water in coolers in the compression process or in dryers, liquid acid will form, which must be dealt with in the piping and drainage systems. Once past the compressor, many of these use water as a carrier. Getting the water out will effectively deal with much of the problem.

Consider the types of contaminants that are present, and select appropriate components. Particular attention should be given to seals and internal valve components. Some lubricants can be very aggressive with rubber components, such as low nitryl Buna-N. A common material compatible with most compressed air contamination is Viton.

Pipe hangers and support

Hangers in the system should not be fastened tight on the piping. Roller-type hangers work best with air piping sized 4-in. or larger. Larger pipe hangers are also available with spring isolation between the truss contact and the hanger rod. This minimizes the transfer of negative vibration and resonance to the building structural members and downstream equipment. Some longer stroke reciprocating compressors will require inlet and discharge axis support from vibration and pulsation effects on piping for short runs to and from the compressor. You should also consider the use of flexible connectors, particularly on reciprocating type compressors. The focus should be on the direction of the piston travel in the unit. Pulsation or vibration isolation should be perpendicular to the opposing forces.

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