How to Control Liquid Ring Vacuum Pumps

BY JOE ALIASSO

Liquid ring vacuum pumps are versatile machines because they can handle "wet" loads and can operate down to around 1" HgA. They require proper operation and monitoring, however. This article will address several monitoring and troubleshooting situations involving liquid ring vacuum pumps (Figure 1).

A check valve will prevent a backflow of gases at start-up or shut-down of the system. When choosing a check valve, a low pressure drop type should be considered to minimize pressure loss in the system. A butterfly style check valve normally has the lowest pressure drop.

Typically for pressures of 100 mmHgA and less, some sort of anti-cavitation or suction pressure control is needed. The simplest type is a manual bleed valve such as a globe valve. If automatic opening and closing is required, then an inexpensive spring operated diaphragm valve can be used. In this design, the suction pressure opposes the spring. When the vacuum in the sensing line pulls the diaphragm down, air will be bled in to restore the pressure. Barometric pressure will affect the setpoint range, so periodic adjustment may be required. By bleeding air in on reduced load conditions, this device will prevent the pump from cavitating, but it will not accurately control suction pressure.

For accurate control of suction pressure, an absolute pressure transmitter, a pressure controller and a recycle valve (typically a pneumatic diaphragm operated globe valve) should be considered. This combination will maintain a constant suction pressure by recycling non-condensables from the separator discharge to the vacuum pump suction.

It is a good idea to have a vacuum gauge, typically a bourdon tube type, on the vacuum pump suction. Although this is not the most accurate device, it will roughly indicate the vacuum level at which the pump is operating. When testing or troubleshooting the system, a more accurate device should be used - a u-tube manometer or a calibrated electronic pressure transmitter, for example.

The liquid ring pump discharges vapor and seal liquid into the separator tank. By centrifugal action and the force of gravity, the vapor and liquid are separated, with the vapor exiting the top and the liquid discharging at the bottom of the separator tank. In a recirculated seal fluid arrangement seal liquid is cooled and then recirculated to the pump. A level gauge should always be installed on the separator tank. Visible indication of the contents of a closed vessel is good engineering practice.

Level gauges typically used are the tubular glass type and the reflex glass type. A tubular glass gauge can be used for water or other non-hazardous fluids. If the fluid in the separator tank is flammable or hazardous, then a reflex gauge should be used over a tubular glass type. This will provide better protection from breakage, which would result in fluid in the tank leaking out.

The liquid ring pump usually handles a "wet" or condensable load. Vapors will condense in the pump and be discharged into the separator. This will produce excess fluid in the separator. The simplest way to maintain a constant level in the separator is to have an overflow connection on the separator tank. This will drain excess fluid. If make-up is needed, then usually a manual valve is installed. If automatic make-up is required, a float operated valve can be used. This, along with the overflow connection, will maintain a constant level in the separator. If remote monitoring and automatic control is required, then level switches and automatic on/off valves can be used. Another option is to use a displacer type level controller or transmitter connected to automatic throttling valves.

It is a good idea on recirculated seal liquid systems to have manual drain and fill/make-up valves. The fill/make-up valve is used during initial filling of the liquid ring pump system and also during normal operation for any make-up required.

Now that the level is maintained, the amount of flow to the vacuum pump needs to be controlled and/or monitored. On recirculated seal fluid arrangements with recirculation pumps, a globe valve or orifice is required to regulate flow to the pump. A compound gauge, bourdon tube type, is useful when trying to regulate the flow. The pump manufacturer will recommend the seal liquid pressure that should be observed on the compound gauge for proper flow of the seal liquid. On recirculated seal fluid arrangements without recirculation pumps, only a manual shutoff valve (usually a ball or gate valve) is required for maintenance. This will keep the pressure drop to a minimum. A compound gauge would not be needed since the liquid ring pump will pull the amount of fluid it needs to satisfy itself. No regulation or pressure reading is normally required.

The vacuum pump requires a certain amount of seal liquid to operate at the design pressure. Not enough liquid may result in insufficient vacuum, reduced capacity or possible cavitation of the pump. To alert the user if seal liquid flow is low, a flow switch can be installed. The paddle/vane type is the most common. This has a large pressure drop associated with it. On recirculated systems with no recirculation pumps, pressure drop needs to be kept to a minimum for proper flow of the seal fluid. A thermal dispersion flow switch with low pressure drop can be used for monitoring the seal fluid flow in this instance.

Sight flow indicators or rotameters can also be used for visual assurance of flow. The rotameter can be used to regulate flow and indicate the quantity of flow. (Note that on recirculated systems without a recirculation pump, a rotameter should not be used due to the pressure drop associated with it.)

A seal liquid cooler (heat exchanger) is needed to remove the heat of compression, friction and condensation. Different types of exchangers can be used.

For example, plate and frame heat exchangers are economical and best suited for the close temperature approach required; shell and tubes are the conventional heat exchanger; and a coiled heat exchanger is compact, saves space and has better heat transfer characteristics vs. a shell and tube style.

If a liquid cooled heat exchanger is not possible, then an air cooled model can be considered.

The temperature of the seal fluid directly affects the vacuum at which the pump can operate. A good troubleshooting device to have installed on the system is a bi-metal thermometer. This will indicate the temperature of the seal fluid so it can be compared to design. If remote monitoring or shutdown is required, then a temperature transmitter, RTD or thermocouple can be installed.

Liquid ring pumps require a shaft seal flush. Packing glands, single mechanical seals and double mechanical seals all require a clean source of flush fluid to cool and lubricate the shaft seals. For packing glands, the flush fluid enters the stuffing box and is dispersed across the glands. The packing will have some dripping associated with it, which means it is being properly lubricated and cooled. For single mechanical seals, the flush fluid lubricates and cools the seal faces, and on many liquid ring pumps, the flush fluid will be discharged directly inside the pump, mixing with the liquid ring. For this reason the flush fluid and liquid ring fluid should be compatible. (Normally they are the same fluid). The flush fluid on double mechanical seals enters the cavity between the mechanical seals and then leaves it through a separate connection. There is no mixing or contact of the mechanical seal flush fluid and the liquid ring fluid for double seals unless there is a leak. This is why water is normally used as the mechanical seal flush fluid. Many flush plans are available. API (American Petroleum Institute) publishes some of these.

Y-type strainers can be used to remove large particles. However, periodic inspection will be needed to insure that the strainer is not clogged. On systems without a recirculation pump installed, a y-type strainer should only be used on the make-up fluid line to filter out any particles. If it were to become clogged on the seal fluid line, then it would starve the pump of seal liquid and could cause damage. If the process is dirty, then a strainer ahead of the vacuum pump system should be installed.

With proper indicating, regulating and monitoring accessories installed, the liquid ring pump system will operate trouble free for years. This has been a general over-view of the types of controls typically used or required for proper operation and monitoring of a liquid ring vacuum pump system.

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