Vacuum technology

Control your vacuum to your needs

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It is of utmost importance, that at any time the minimum required absolute vacuum level for a given process application is available. In many occasions, insufficient vacuum may negatively affect product quality. Common methods to install, to control and to maintain an acceptable absolute vacuum level are frequency drive, cascade regulation, throttle valve, by-pass and supplementary gas inlet regulation.

Variable frequency drive regulation

In variable frequency vacuum regulation, the capacity of the vacuum pump is accommodated to varying vacuum demand, with minimum pressure variation. A liquid ring pump with variable frequency drive can be used in vessel evacuation of batch processes where the load volume is high at start-up and diminishes as the vessel is emptied. At the end of the cycle, the usual intent is to hold as deep vacuum absolute as possible for a given period of time. At this end point, the initial vacuum pump speed is in fact to high. When there is no load anymore, the majority of the load to the water ring pump at this point is the vaporized service liquid, which can finally result in cavitation. That cavitation can be avoided by slowing down the pump speed to a minimum level enough to hold the desired vacuum, which allows to save power and to prevent wear on the pump. Other advantages of Electronic Variable Frequency Drives are over-heating, over-loading prevention, and voltage protection. Vacuum control by means of frequency drive (variable speed drive) regulation can also be applied with dry vacuum pumps (Skelton, 1998).

Cascade regulation

For better flow and vacuum control, and improved vacuum stability, connecting the vacuum application to two or more vacuum sources in parallel is an option.

Throttle valve regulation

In this type of vacuum control, a throttle valve installed in the sucked air or gas stream is used to adjust the flow rate to vacuum demand. A throttling valve is not recommended for liquid ring vacuum pumps because the valve may act as restriction, and may make the vacuum unstable.

By-pass regulation

This is the type of control most frequently used, because it allows the process volumetric flow rate to be set from zero to a maximum. Gas discharged by the liquid ring vacuum pump is returned to the suction pipe via a pipe equipped with a control valve. This pipe is fitted between the gas outlet line of the gas-
liquid mixture separator and the pump suction pipe. This method of control is not optimal if energy saving is the objective. Also with steam jet ejectors, it is common to bleed back some of their discharge gases to accomplish vacuum control (Sterling Fluid Systems Group, 2010).

Vacuum relief valve
One method used to control the vacuum level and to protect a liquid ring pump from cavitation is to have an automatic line pressure relief valve (Fig. 1) controlled by a pressure switch set to the desired pressure. The vacuum relief valve allows air to enter the piping system by creating a deliberate leak if the absolute vacuum pressure gets too deep, and closes when the design pressure is reached. The valve is adjusted so that the pump just pulls the vacuum required by the application. This is desirable because operation at deeper than necessary vacuums produces higher temperatures and greater workloads on the pump, thus reducing service life. When the pump’s suction pressure is below the setting of the vacuum relief valve, the absolute vacuum pressure on the seat side of the vacuum relief valve exceeds this specific pre-set value and will open the valve to bleed atmospheric air in (Aglitz et al., 1995; Aliasso, 2005)

The vacuum relief valve is positioned just in front of the vacuum pump inlet, but with the inlet filter still located between the vacuum relief valve and the vacuum pump. In that case, the air bleded along the
vacuum relief valve is also filtered, which prevents solid matter from being pulled into the vacuum source. Notice, however, that vacuum relief valves are very expensive, and are prone to wear. Especially the vacuum relief valve seat and the spring are sensitive to wear. Hence, a vacuum relief valve is not an excellent fitting to control vacuum. Usually there is too much or too little false air introduced into the vacuum system. After wear, the vacuum relief valve often already opens at 250 mbar vacuum absolute.

**Dual-level vacuum systems**

In some cases, it is desired to lessen the vacuum to a branch where the system as a whole has a less deep absolute vacuum. This means that apart from an installed absolute vacuum close to the vacuum source, that there can be a second, separately adjustable vacuum level downstream. This is done by bleeding air into the branch where the less deep absolute vacuum is desired. Although a different absolute vacuum level in a dual-level vacuum system can be required (Fig. 2), applications can be served by one and the same vacuum source. For this purpose, two adjustable vacuum relief valves can be used. The first one controls the deeper vacuum level, and is mounted into a filter jar to ensure that the modulated air leakage is drawn from the downstream leg of the circuit instead of from the atmosphere. The second vacuum relief valve is mounted conventionally, drawing its modulated flow of leakage air from the atmosphere when the preset less deep vacuum level is exceeded (Frankel, 2002; Gast Manufacturing, 2010).

**Vacuum tank**

A vacuum tank (Fig. 2) is used to provide a constant “reserve” of vacuum, to accommodate sudden or unusually high vacuum demands, to reduce fluctuations in vacuum, to maintain a constant vacuum level, and to prevent possible overloading and excessive cycling of the vacuum pumps. These vacuum pumps that are connected to the vacuum tank, must maintain the desired range of vacuum when the demand rises or falls depending on the number of inlets that open or close. However, the larger the vacuum tank, the less the vacuum source must pump. A check valve is normally used on the pump side of the tank, and an appropriate operating valve is used on the downstream side.

There should be provisions to regularly drain the vacuum tank. This can be done either manually or automatically. The manual method requires the installation of a valve drain line from the bottom of the vacuum tank. In order to manually drain the vacuum tank, it must be isolated and brought to atmospheric pressure. This procedure removes the vacuum tank from service for a limited time. The drain valve is then opened and the liquid discharged into the floor drain. A sight glass is provided to observe the level of accumulated liquid. Automatic drainage systems help to protect the vacuum tank against contamination and they permit uninterrupted use of the vacuum tank. The automatic drainage usually makes use of a separate, smaller drain tank provided with a level switch inside. That drain tank should be installed adjacent to, and lower than, the vacuum tank. The drain line installed at the bottom of the vacuum tank is provided with a solenoid valve to isolate the drain tank from the vacuum tank. The drain tank in turn is connected to a floor drain by means of a line that also is provided with a solenoid valve, and further with an air break. All valves shall be set to operate in the correct sequence when the level of liquid in the drain tank reaches its set point and sends a signal to each solenoid valve. The effluent is then discharged to the floor drain. (Frankel, 2002).

**References:**


“Vacuum tank with two vacuum pumps mounted in parallel on its top, allowing for control of the vacuum level absolute by means of cascade regulation. The vacuum tank provides a constant reserve of vacuum to accommodate sudden or unusually high vacuum demands, and therefore prevents excessive cycling of the vacuum pumps. One vacuum pump can be put in or out of action according to the vacuum demand (courtesy of Lynn Engineered systems)”.

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