OFS FOCUS - NOISE BY DESIGN

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Noise can be annoying to say the least; at worst it can cause equipment damage. Acoustic energy in the process flow path can damage equipment such as pressure taps or thermowells by inducing a forced vibration on the tube extending into the flow path. The acoustic pulsations can even damage components within the pulsation attenuator as seen here.

Figure 1: Acoustic pulsations can damage components in the pulsation attenuator

Industrial equipment designed for the petrochemical industry follows API guidelines for the application of pulsation attenuation devices. These guidelines provide some assurances that the attenuation will protect downstream equipment without significantly impacting the performance of the machine. Screw compressors are known to have high pulsation levels at the discharge of the compressor, and require a pulsation attenuation device to reduce the overall pulsation level transmitted to the downstream piping.

The API 619 Standard for oil free screw (OFS) compressors provides limits of pulsation amplitude of 1% peak-to-peak of the discharge flange rated pressure and no more than 1% of that same pressure for the pressure drop across the attenuation device. These conditions are at the rated design point and reactive design pulsation dampeners can be designed to effectively work at this point. The designer of the attenuation device has to be aware that the conditions of the compressor will fluctuate, and that the device must still be effective over a range of conditions rather than a single point design.

Communicating all of the gas conditions and the operating speed range is an essential part of getting a pulsation attenuator that is effective over the entire operating range of the screw compressor.

- A reactive pulsation attenuator is one that uses fixed geometry devices inside the pressure vessel to reduce the pulsation of a very narrow band width of acoustic frequencies (or one frequency). This device type is effective since it targets a very narrow bandwidth with a low pressure drop.
- By comparison, a passive or absorptive device uses packed materials or a series of baffles that are effective at attenuating a wide range of frequencies but at the cost of 5-7% pressure drop.
- There are devices that use both methods of attenuation that provide an effective attenuation with 3-5% pressure drop.

Remember glass pack mufflers, the automotive muffler of choice by many hot rodders? This muffler was a combination of reactive and passive attenuation. Packed or absorptive silencers are not used in API 619 service since the pressure pulsations in a screw compressor are high enough to destroy the packing layer. The packing in an absorptive silencer will also become packed with product if there are any solids or liquid in the discharge gas. Most attenuators with baffle designs have a higher pressure loss than is allowed by API 619. These limitations to the absorptive silencer design are the principal justification for using reactive silencers in industrial service with OFS compressors.

Periodic opening of the screw compressor threads during the compression process produces a gas pulsation at the lobe passing frequency. A compressor running at 3600 rpm with 4 lobes on the driven rotor will have a lobe passing frequency of 240 hz. Each internal tube of the pulsation attenuator has an acoustic natural frequency at which it sustains a resonance.

The tube natural frequency [f] is calculated using the speed of sound of the gas [v] and the effective length [λ] of the tube: $f = v / \lambda$

The speed of sound depends on the molecular weight and temperature of the gas at the discharge. The frequency used to calculate this effective length is the lobe passing frequency. It is fairly easy to see that if the speed of sound changes then the tuning of the tubes will also change.

Pulsation attenuation for a reactive attenuator must consider a single design point for optimization. The problem becomes selecting that design point. The API Standard is set for the rated point of the compressor. This may not be the best condition to base the design since the rated point may be a max flow condition that is required for plant output guarantees. This guarantee point may not be where the unit is run. If the compressor is run with a fixed speed drive with capacity control through a recycle loop then the compressor conditions are usually limited to a narrow range of pressure, temperature, and speed. A fixed speed application can be effectively designed if the molecular weight and temperature of the gas remains within 5% of the design value. If these gas conditions do change then the resonant length of the internal choke tubes would not be tuned to the correct length.

If the compressor is run with a variable speed then the lobe pass frequency would change and will have the same result, a choke tube that is not tuned to that frequency. Variable speed drives that also incorporate molecular weight changes in the process the problem becomes complicated and a good understanding of the process controls is needed to design the pulsation attenuator.

In most cases a solution that serves the range of conditions can be applied; however, it may come at the cost of additional pressure drop across the pulsation attenuator. Working with the compressor manufacturer will allow the engineers to evaluate the impact of that pressure drop. API limits to pressure drop in the pulsation attenuator are there to provide the end user with a reasonable expectation that the compressor does not suffer excess power consumption due to external devices. The additional pressure loss may not result in a significant increase in power and the resultant reduction in pulsation amplitude may be well worth the slight loss in pressure.

Communication between the end user and the pulsation attenuator engineering team is essential when the process conditions change whether it is in normal operation or due to a rerate in the system. New equipment design parameters should be reviewed carefully to make sure that the conditions in operation are well understood so that the designers can select the optimum condition for design. OFS compressors are very effective at positive displacement applications and, when applied with the right pulsation attenuator, can provide years of trouble-free service.

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