Lessons From the Field: Vacuum System Performance Surveys

Applying techniques discussed in issue four to solve real world vacuum equipment world s[illegible]

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Nylon Intermediate Production Facility: Nitrogen Gas Bleed For Pressure Control

40 torr

A U.S. Gulf Coast petrochemical company manufacturing nylon intermediates was operating a vacuum flasher supported by a precondenser and two stage ejector system. Overhead load from the vacuum flasher consisted of 160,000 pounds per hour

An ejector system with unstable suction pressure typically is operating in a broken mode. A broken ejector often is caused by low motive steam pressure, a fouled intercondenser, high cooling water temperature or low cooling water flow, or excessive noncondensable loading.

While inspecting the ejector system, the service engineer noticed a periodic audible change in ejector operation. This audible change plus an unstable suction and discharge pressure for the first-stage ejector confirmed this particular ejector was the trouble.

The service engineer noticed plant personnel had installed a pneumatic control valve that bled nitrogen to the suction of the first-stage ejector. Plant personnel installed a nitrogen bleed to control suction pressure so the vacuum flasher would operate at a consistent pressure, even at reduced charge rates. Pressure in the top of the vacuum flasher was sensed and a signal sent to the control valve to bleed nitrogen to the first-stage ejector if the vacuum flasher pressure fell below design.

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Bleeding nitrogen, which is noncondensable, to the suction of a multistage condensing ejector system will result in unstable performance.

An ejector system is designed to handle noncondensable loading associated with the process. Ejectors downstream of the first intercondenser are designed to handle process-related noncondensables and associated saturation vapors. Bleeding in nitrogen to act as an artificial load for the first-stage ejector and to elevate suction pressure resulted in noncondensable overloading of the downstream ejector.

The service engineer instructed plant personnel to disassemble the nitrogen bleed arrangement and to install recycle control piping around the first-stage ejector or bleed nitrogen to the inlet of the precondenser. For any multistage condensing ejector system the preferred way to maintain performance and suction pressure is to recycle discharge from an ejector immediately preceding the first intercondenser back to the suction of the system. In this way, noncondensable loading is never allowed to increase above design, ensuring broken ejector operation will not occur. Again, vacuum flasher pressure is sensed and a signal sent to the recycle control valve, which will modulate and permit the recycling of vapor flow back to the suction of the first-stage ejector. Once the plant installed this form of recycle control, stable ejector operation was maintained.

A caveat for this correction is that the suggested recycle control arrangement used to correct first-stage ejector instability will not work if a precondenser's operating pressure will permit steam condensation. The composition of recycle flow around an ejector consists of noncondensables plus steam. As the recycle flow is brought around to the suction of the first-stage ejector, the recycled steam will be drawn to the precondenser if the operating pressure will permit steam condensation. When this occurs and recycled flow goes to the precondenser rather than through the first-stage ejector, suction pressure control is not possible.

The most practical method to control operating pressure of a precondenser/ejector system is to control cooling water flowrate, which may be reduced when process charge rate is below design. By lowering water flowrate, the water temperature rise across the precondenser will increase, which has the effect of lowering the logarithmic mean temperature difference (LMTD). Controlling LMTD will control the precondenser operating pressure.

West Coast Petrochemical Plant: Improper Replacement Intercondenser

A West Coast petrochemical plant was operating a fuels vacuum distillation unit that experienced erratic performance after replacing an intercondenser supplied by the original ejector system manufacturer with one designed and built by a local heat exchanger fabrication shop. The system was designed to provide performance as described by Figure 2. The service engineer did not know the user installed a replacement intercondenser.

The first-stage ejector was operating in a broken mode, with both suction and discharge pressure remaining unstable. Furthermore, shellside pressure drop across the first intercondenser was almost three times the design pressure drop.

Motive steam supply condition was approximately at the design value, so the service engineer ruled out inadequate steam pressure. High-pressure drop across the first intercondenser would suggest a fouling problem, cooling water flowrate limitation, high inlet water temperature, high noncondensable loading or excessive hydrocarbon loading.

Prior to detailing a method to determine the actual cause, the service engineer discussed general performance characteristics with unit operators. At that time, it was discovered the first intercondenser had been replaced.

Upon visual inspection of the installed unit and its nameplate, the service engineer realized it was the design of another vendor. That vendor did match the original intercondenser's tube count and external dimensions, but after a thorough review of fabrication drawings, it was evident the vendor failed to properly design the shellside baffling to effectively manage hydraulic and thermal requirements. Vacuum condensers have special shellside baffling to ensure minimal pressure drop, noncondensable gas cooling, and separation of

Summary

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