Make the Case for VACUUM BOOSTERS

Reduce costs while increasing flow and improving energy efficiency
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BY APPLICATION ENGINEERING | TUTHILL SPRINGFIELD

 Vacuum boosters are positive-displacement dry pumps that provide an easy way to increase your flow — your cfm — and get deeper vacuum. Vacuum boosters use two-lobe rotors spinning in opposite directions to remove gas. This provides a quick way to get more cfm in the deep end with considerable money saving on equipment and horsepower requirements.

 The booster increases the vacuum system’s cfm, therefore reducing the evacuation time while increasing ultimate vacuum of the backing pump by as much as eight times. When used separately to discharge atmosphere, they typically are limited to inlet pressures of half an atmosphere.

 The vacuum booster’s advantage is evident when it’s placed in series with another vacuum pump. The booster then provides higher pumping capacity and lower pressures typically at lower cost and power consumption. The backing pump can be an oil-sealed piston or vane pump; a liquid ring pump utilizing a variety of different sealants from water, solvents or oil; or a dry vacuum pump.

 Vacuum Booster Use in Industry

 According to Keith Webb, Senior Engineer at Tuthill Springfield, vacuum boosters have a

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Figure 1. Tuthill 8000 Integral Lube Vacuum Booster.
reputation in industry for simplicity and reliability. “If you take a booster and put a backing pump behind it, you can run the booster at low pressures and derive the needed pumping capacity with lower overall horsepower, compared to opting for a larger backing pump alone,” he says.

Webb adds that most industrial applications for vacuum boosters require a deeper vacuum and increased volumetric flow. Typical pressures can vary from 0.1 to 100 mmHg. Typical industrial sectors are chemical, pharmaceutical, vacuum furnace and steel degassing with applications that include degassing, distillation, drying, freeze drying, transformer drying, metallurgical treatment and CVD.

He cites as an example higher-capacity pumping of solvent vapors for recovery purposes: “Vacuum boosters enhance the performance of a dry vacuum pump when used in combination and provide a lower cost alternative compared to a larger dry pump.” He says this can be an advantage in the chemical processing industry when dealing with multiple volatile solvent vapor loads in which the dry vacuum system with after-condenser can transport the solvent vapor and selectively condense it in the exhaust condenser.

Peter Rescsanski, Tuthill’s Northeast regional sales manager, explains that customers often rely on booster pumps for their unique performance characteristics and for an optimized blend of cost, reliability and quiet operation. He notes that units with helical gears on the boosters — as well as units with a five-bearing booster — provide smoother, quieter, and more reliable operation than the industry-standard straight-cut gears.

Rescsanski explains that boosters also allow users to pump down to the required vacuum more quickly while minimizing pump and motor size. He describes the experience of a customer that recently retrofitted nine vacuum furnaces with new 5-in. gear boosters with 24-in. rotors in tandem with the company’s rotary-piston vacuum pumps.

“Those boosters are rated to 1,600 cfm, provide vertical flow, are left-hand drive and have labyrinth slinger-style seals,” he says. “The furnaces, used to dry calcium, are large box-style units measuring 20 ft. by 8 ft. by 6 ft., and the customer had been pumping them down with stand-alone oil-vapor diffusion pumps. Pump down (from 10 torr to 0.05 torr) took four hours, while our solution reduced that to three hours. That dramatic time savings resulted in a return on investment in just two to three months.”

Vacuum Boosters in Chemical Industry Applications

Boosters are offered in various metallurgy, including stainless steel, for additional corrosion resistance, as well as a coating as a lower-cost corrosion resistant alternative.

Webb says, “Manufacturers can offer mechanical face seals for their vacuum boosters that deliver positive pressure with low gas leak rates of 1X10^-4 cc/sec per mechanical seal, or non-contacting
slinger seals that don’t produce heat and commonly are used in vacuum booster applications in which there are no gases that affect the oil or in certain heat (furnace) applications.

He points out that the recent improved carbon composition of face seals lasts significantly longer and withstands higher operating temperatures over previous face seal generations.

Rescsanski believes it’s important that customers in multiple segments of chemical, petrochemical and others select vacuum boosters designed with engineering acumen. “We sell more than just equipment; we sell solutions,” he notes. Many companies have cut back on their engineering staffs and maintenance departments and so have come to rely on vacuum booster manufacturers as technical experts and for applications support, he says.

“Customers see how durable and high-performing vacuum boosters are as a way to optimize reliability, while driving down operating costs and reducing the number of service calls needed to keep the systems running,” he adds.

**Energy Efficiency, Boosters and VFDs**

For increased energy savings, Webb suggests using variable-frequency drives (VFDs) with vacuum boosters, as well as for faster evacuations in which the booster runs continuously with its backing pump.

“A constant-torque VFD with current feedback allows you to adjust motor speed and prevent it from overloading,” he explains. “We can start the booster at atmospheric pressure and the motor will operate at a very low rpm to minimize the pressure differential across the booster. As the pressure is reduced, the booster then speeds up to maintain power demand on the motor (because hp \( \approx \) torque x rpm) until it reaches the motor’s full-load rpm.”

The VFD can even be used to set the limit on both the maximum and minimum rpm so that C-face motors can be used to direct drive boosters at non-synchronous motor speeds. (Figure 2 & Figure 3)

Rescsanski points out that pressure sensors can be added in the vacuum line and send the signal to the VFD controller, constantly monitoring the vacuum level and adjusting motor speed accordingly. “This can dramatically reduce energy consumption, anywhere from 30% to 80%,” he says.

**Vacuum Booster Selection**

Booster models range from 3.25- to 12-in. gear diameter and 2.5- to 48-in. rotor length. The standard construction materials are cast-iron for the housing, end plates, end covers and port fittings and ductile iron for the rotors and shafts. Also offered are stainless steel components for more severe duty. The boosters are designed to operate at 82 dB(A) or less at blank-off (open field; motor and background noise excluded) and are supplied with a heavy-duty driveshaft for either direct-coupled or belt-driven applications.

Match the booster to the application by selecting a model that operates within a performance range of 50 to 12,700 cfm. To help select the right vacuum booster for a specific application,
look into testing services, including special testing available to ASME PTC-9 (1 psig slip method), hydrostatic testing to 150 psig (10.35 bar g), pressure gas testing to 100 psig (6.9 bar g) and seal leakage and noise testing.

Many vacuum boosters also are offered with a C-flange setup that allows for a direct-drive motor to be connected, which saves space while eliminating belt and sheave issues.

**Vacuum Booster Vent Terminology and Uses**

- **A vent** is an empty space between the process chamber and the oil sump. It typically is isolated by the oil seal and a labyrinth seal.

- **A condensable gas** will change state (liquid) with a change in gas temperature or pressure.

- **Vent to drain** is a valve connected to the bottom of the vent that may be opened to drain liquids from the vent to an atmospheric drain — the principal being that any liquids that might accumulate in the vacuum booster vent will be drained out of the unit to a sealed container.

- **Standard lip/lab seals** have a wide application in pneumatic conveying, wastewater treatment and general process industries that require high-pressure, high-volume air. The seal areas are vented to atmosphere to relieve process pressure against the internal lip seals.

- **Single-envelope gas service** designs are used in such applications as closed-loop pneumatic conveying, process gas handling or elevated pressure applications up to 100 psig discharge. In this scenario the vent openings are tapped and plugged to prevent gas leakage. These fittings also can accept an inert gas purge for positive containment of the process gas.

- **Double-envelope gas service** designs are special units built to laboratory standards in which almost complete sealing is required. In addition to the features shown on the single-envelope series, the drive shaft is sealed mechanically and the oil sumps are plugged to provide an even higher degree of leakage protection.