Tip of the Month/No. 5

Tip of the month – The most common errors when using vacuum pumps and how to avoid them, Part 2 – Roots Pumps

The ideal vacuum solution at the best price is almost always the preference from the viewpoint of the customer. This fact poses the danger that a less optimal pump solution is selected for cost reasons, a decision which could eventually cause the customer to experience less uptime and higher maintenance cost. Selecting reliable vacuum pumps and the corresponding accessories as well as sensible monitoring and operating modes will pay for themselves in the long run.

In the following, you will find a summary of the important information and insights for the operation, equipment selection, and maintenance of commonly used vacuum pumps. In this issue and in upcoming "tips of the month" we will show you the most common errors when using rotary vane pumps, Roots pumps and turbopumps as well as measures to avoid them.

It must be explicitly stated that the accompanying images are only examples and no conclusions should be drawn about the reliability of the brands shown.

2. Roots pumps

The Roots pump operates on a purely volumetric level and, in comparison to the rotary vane pump, does not have internal compression. It compresses against exhaust pressure. All parts in contact with the media are oil-free, in contrast to the rotary vane pump, and what applies to a Roots pump one also applies to a dry-running pump. It is characterized by its compact design with high pumping speed. It is called a Roots pump after its inventors.

2.1 Operating at Ultimate Pressure

It is not recommended to bring a Roots pump running on maximum differential pressure directly to ultimate pressure without allowing it to cool down first. At ultimate pressure, the minimal or zero gas throughput does not dissipate any heat through the gas or through the casing surface because of the fast speed. Due to the sudden rise in temperature, the air gap between the rotor and casing is too small and the pump will seize. In extreme cases, this leads to a total failure.

2.2 Improper Temperature Fluctuations

Suddenly occurring, strong reductions of the ambient temperature result in the pump casing contracting while the Roots pistons are still hot, causing seizing of the pump. As seen in Fig.1, this is especially critical during operation at ultimate pressure. Temperature shocks like this must be avoided at all costs. In addition, the operator must take care that no rolling shutters or other doors in the vicinity are opened suddenly, especially in the winter, and that free-standing pumps are protected from the rain with a roof or canopy.

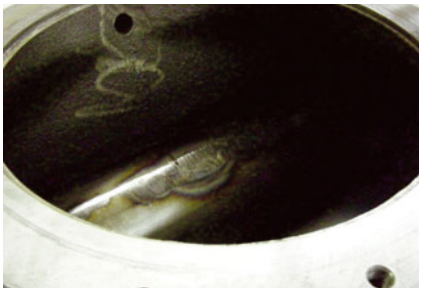

Figure 1 and 2: Roots pump seized by switching to ultimate pressure and the resulting local overheating

If, in case of fire, water is directly aimed at the pump, the casing could explode, especially the pump casing made of grey cast iron. The pump version in nodular cast iron is better suited to withstand such thermal fluctuations due to the higher strength of its material.

2.3 Temperature Control
If Roots pumps are operated around their maximum differential pressure, a temperature sensor must be attached to the exhaust to protect against overheating and any resulting damage. This will generate a warning at a defined temperature and will turn the pump off when it reaches the maximum permitted gas temperature.

2.4 Rapid Evacuation
In applications, in which cycle times of just few seconds must be achieved, the operator must ensure that the ratio of the Roots pump to the backing pump is at 1 : 2. This is necessary as most of the pump down time is required by the backing pump to evacuate the atmosphere to about 100 hPa and the Roots pump will only operate effectively beginning at 10 hPa. For this reason, the backing pump must be correspondingly generous in size.

2.5 Turning the Pump On
In the case of multiple-stage pumping stations or multiple parallel-operated pump combinations, it makes sense to turn on the pumps at staggered intervals, starting at the atmosphere pump, to prevent undue power spikes and cost-intensive circuit breakers. This can easily be realized in the controller and PLC using a timing element. An alternative is starting the pump slowly with a frequency converter.

2.6 Fluid Inrush
Sudden fluid inrush can destroy the pump, as abrupt cooling occurs, depriving the gas of the heat needed to evaporate the liquid. The additional quantity of vapor cannot be pumped away quick enough, as the backing pump is overloaded and the fore pressure may rise to excessive levels. To prevent such a case, it is useful to install a receiver between the process chamber and the Roots pump so the liquid is absorbed before reaching the pump.

2.7 Dust Accumulation
During processes that generate particles and are laden with dust, such as in metallurgy and crystal pulling, it would be useful to install dust filters on the intake side of the pump to protect the Roots pump as well as the downstream pumps. So-called splinter protection should be installed in the Roots pump's intake ports to protect against larger solids and beads of welding that could be emitted from the welded joints due to inadequate cleaning during the first use of a system. In this case, it is recommended to use the pump manufacturer's accessories, as the splinter protection is designed so that its free cross-section corresponds to the nominal diameter of the pump. This ensures that the pumping speed is not compromised due to undesired amounts of conductance losses.

2.8 Pumping Off Critical Gases
When pumping costly, pure gases such as Helium 3 or Helium 4, one must avoid an exchange with the ambient air during the process at all costs. A high level of tightness with a low leak rate in the area of less than 10^{-5} to 10^{-8} hPa l/s is required for the pump. There are pump manufacturers like Pfeiffer Vacuum, who offer a permanent magnetic coupling instead of the usual shaft feedthrough to the motor. This turns leaks in the shaft sealing rings into a thing of the past.

Figure 3: Magnetic coupling with can chamber (Pfeiffer Vacuum)

It is also possible to use a canned motor, however, the operator must rely on the pump manufacturer when servicing as the canned motor is especially developed for the pump. In case of magnetic coupling, cost-efficient standard motors can be used.

Pfeiffer Vacuum offers magnetic couplings for two-stage rotary vane pumps up to 250 m^3/h and Roots pumps up to 12,000 m^3/h.

We would be happy to assist you in optimizing your vacuum solutions for specific applications – go ahead and ask us:

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