Liquid Ring Vacuum Technology
for the Chemical Industry

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BUSCH
Vacuum Pumps and Systems

Liquid Ring Vacuum Pumps –
Classic Vacuum Technology and Yet Still State-of-the-Art

Vacuum technology has never stopped developing – not only in the recent past, but for decades it has continued to progress. Today, dry screw vacuum pumps are used in chemical processing technology and many other applications just as dry claw vacuum pumps have established themselves as standard vacuum generators in entire branches of industry.

Oil-lubricated rotary vane vacuum pumps are also state-of-the-art in many applications, not least due to their ongoing development. In their fields of application, they are generally the most used vacuum pumps. However, despite many improvements, new developments and further advancements, one principle of vacuum generation that has remained to this day in certain applications, and is still successfully applied, is the liquid ring vacuum pump.

The principle behind the liquid ring vacuum pump was already developed in 1890 as a "water ring pump". Due to their simple and robust construction, liquid ring vacuum pumps (figure 1) are suitable for vacuum generation in applications in which damp gases or vapors are evacuated or those in which condensation inside the vacuum pump tends to take place during the compression process. They are therefore ideally suited to humid processes and are thus used for low vacuum generation in process technology, the chemical industry, during petroleum production and plastics processing in applications such as distillation, drying, filtration, reaction, de-gassing etc.

Figure 1: Two versions of Dolphin liquid ring vacuum pumps that are available with pumping speeds from 18 to 6415 ACFM

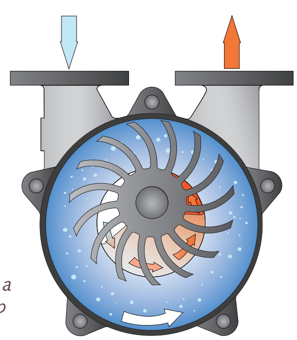

Figure 2: Cross-sectional view of a Dolphin liquid ring vacuum pump compression chamber

Operating principle

As an operating fluid, liquid ring vacuum pumps use water or a liquid compatible with the gas or vapor to be evacuated. Ethylene glycol, mineral oils or organic solvents are also used, as are other liquids that are already part of the process. The basic principle is the same in all sizes and versions.

An eccentrically mounted impeller rotates within a cylindrical housing (figure 2). This housing is filled with operating fluid to the extent that the vanes of the impeller are immersed in the fluid. The rotary motion of the impeller and the resulting centrifugal force cause the liquid in the housing to form the so-called liquid ring. The gas is pumped in the spaces between the individual vanes and the liquid ring. Thanks to the eccentric arrangement of the impeller, the volumes of these spaces change with the result that gas is sucked in, compressed and discharged again. The liquid ring seals the individual spaces down to the cylinder. Therefore, it is sometimes referred to as the sealing fluid instead of the operating fluid.

Mechanism

Due to the operating fluid used, this mechanism can only be used in the rough vacuum range. The reason for this is that the achievable vacuum level depends on the vapor pressure of the operating fluid, which is constantly pumped through the vacuum pump. This allows a liquid ring vacuum pump to be operated at relatively low temperatures, and in addition, the temperature rise of the medium is kept to a minimum during the compression process. Therefore, liquid ring vacuum pumps are ideally suited for pumping vapors and gases with a high moisture content. The low temperatures in the vacuum pump are favorable for condensation of process vapors. To an extent, this means that the vacuum pump additionally functions as a condenser and because condensation takes place when the mixture enters the vacuum pump, the volume is drastically reduced. In addition to the condensation effect, this also achieves an increase in the nominal pumping speed.

The operating fluid absorbs the heat of compression and as liquid ring vacuum pumps are virtually isothermal, they offer advantages when pumping temperature sensitive products, such as polymers.

One significant advantage of liquid ring vacuum pumps is that the operating fluid and the materials used for the components can be adapted to fit the pumping medium. This also makes it possible to pump corrosive or explosive gases and vapors. Due to the low operating temperatures, pumping explosive materials can, in any case, be considered much less problematic than with other mechanical vacuum pumps.

Construction

Basic differentiation is made between single- and two-stage liquid ring vacuum pumps. In the single-stage version, the compression process described above is performed in one compression stage. In the two-stage vacuum pump (figure 3), the pre-compressed pumping medium from the first stage is conveyed to a second compression stage and compressed again. Ultimate pressures of 100 Torr can be realized with single-stage liquid ring vacuum pump versions, while two-stage versions can achieve up to 25 Torr.

Even the sizes vary significantly. Busch Vacuum Pumps and Systems has different series and versions of Dolphin liquid ring vacuum pumps in its portfolio, with pumping speeds that cover the range from 18 to 6415 ACFM.

Variants

Supply and removal of operating fluid can happen in three ways:

1. Non-recirculating operation – once through operation This is the simplest variant for operating a liquid ring vacuum pump and is used any time there is sufficient operating fluid available. The compression stage is constantly supplied with operating fluid. The fluid is then discharged together with the gas and the condensate.

2. Open fluid circuit – partial recirculation operation In an open circuit (figure 4), the operating fluid is diverted into a liquid separator together with the gas after it exits the vacuum pump. Liquid and gas are separated there. The gas is discharged or transferred while the operating liquid flows back to the pump. Additional fresh operating fluid is supplied through the liquid separator in the circuit. This guarantees that there is enough liquid in the circuit and that the temperature does not rise. This type of open circuit can save up to 50 percent of the fluid when compared to non-recirculating operation.

3. Closed fluid circuit – total recirculation operation There is also a liquid separator downstream from the pump in a closed circuit (figure 5). Gas is discharged from the separator, while the operating fluid is diverted using a heat exchanger before it enters the vacuum pump again. The operating fluid is thus maintained at a constant temperature. This means that only small amounts of fresh fluid need to be added via the liquid separator. We therefore recommend the closed circuit any time that sufficient operating fluid is not available or when as much operating fluid as possible should be conserved.

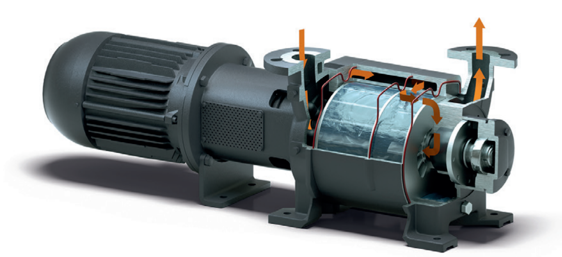

Figure 3: Two-stage liquid ring vacuum pump operating principle

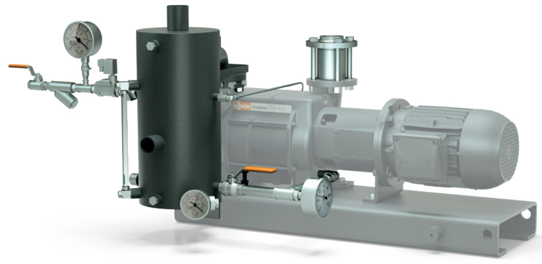

Figure 4: Dolphin liquid ring vacuum pump with an open operating fluid circuit

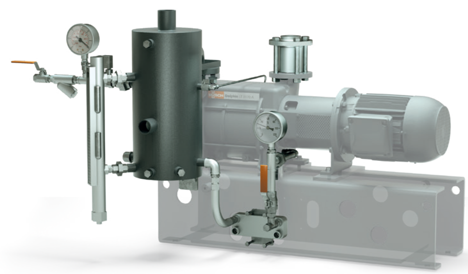

Figure 5: Dolphin liquid ring vacuum pump with a closed operating fluid circuit

Tailored vacuum systems

Liquid ring vacuum pumps are exceptionally well suited for use as modules in vacuum systems and installations. Lower ultimate pressures can be realized in combination with gas, air or steam ejectors (jets) or Roots type vacuum boosters. Technically and economically optimum solutions can be found for vacuum systems that are directly tailored to the individual application. Busch Vacuum Pumps and Systems has decades of experience in designing, configuring and building these types of systems, which are used in economical and safe operation worldwide in chemical processing technology, petroleum production and processing, power generation and many other areas. The individual Dolphin liquid ring vacuum pump sizes from Busch are available in different ATEX-certified versions.

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