TURBO FOR PROCESS GASES

Gas bearing drive system opens up new applications for turbo compressors

25.04.2018 | Within the world of classical process applications, turbo compressors are quickly reaching their limits. The miniaturization and use of gas bearings in drive systems has paved the way for turbocharger applications where previously small diaphragm, piston or rotary compressors have been applied.

Decision makers - What planners need to know

- Up to now, turbo compressors were hardly suitable as process gas compressors.
- Miniaturized turbo compressors equipped with gas bearings operate with no oil, have minimum wear and are highly efficient.
- These features allow this technology to be used in industrial applications where turbo-machinery was previously unthinkable.

Up to this point, the guiding principle for compressors has been: the smaller the compressor, the more complex and the less efficient it is. This principle applied especially to turbo compressors, limiting their use in industrial processes due to major challenges in their design, production and operation. The technical challenges exist primarily in the miniaturization of the compressors. The development of turbo compressors using gas bearings has paved the way for new applications of compressors that operate according to the dynamic compressing principle.

Ball, magnetic or gas bearings are generally used for rotating shafts. To achieve the required outputs, Celeroton's miniaturized turbo compressors operate at speeds in excess of 200,000 rpm. Since traditional bearings would quickly wear out at these speeds, a contactless bearing is required to meet the service life demands of the industry. The dynamic gas bearing developed by Celeroton does just that.

Many industrial processes use various types of gases, all of which have extremely high purity requirements. Compressors generally are a source of contamination and have short maintenance intervals due to mechanically-stressed seals, making them critical components. Compressors should not generate any abrasion and should never allow any lubricant to access the process gas. The process industry also puts very high demands on service life. In addition, the choice of materials allowed for use is limited and depends on their compatibility with the process gas. Additional criteria critical for decision-making are low energy consumption, high efficiency and process optimized design.

Contactless gas bearings and miniaturization open up new applications

Such technically demanding requirements encourage new approaches. As a young high-tech company, Celeroton offers oil-free turbo-compressors for the most demanding applications. To meet the challenges described above, the machines are equipped with contactless gas bearings, miniaturized aerodynamics and a high-speed permanent-magnet synchronous motor that exhibits a minimal loss of power even at high speeds.

Gas bearings were first successfully used in the form of foil bearings in the aviation and space industries during the 1950's and commercially in the 1960's. Common synonyms for gas bearings are “fluid bearings” or often simplified as “air bearings”. For example, a rotor-stator bearing uses a thin layer of air as a "cushion" between the rotor and the stator case. Since the process gas functions as the bearing, no oil, grease or other lubricants are required. This self-sustaining gas bearing requires no frictional seals and can be used with any gaseous materials. To create the required lift under the rotor, positive pressure is introduced into the space between the rotor and stator case. As the rotor is deflected, the pressure within the space increases. The air reacts to this deflection by exerting a force onto the rotor, thereby holding it in the centre of the stator case. The gas cushion provides the necessary rigidity and damping required for the bearing to work. Any interfering disturbance such as imbalance or vibration is simply absorbed by the cushion of gas.

In addition to the oil-free feature of the contactless gas bearing, its service life and service intervals are theoretically unlimited. In air applications, several tens of thousands of operating hours and several hundreds of thousands of start-stop cycles have been successfully demonstrated.

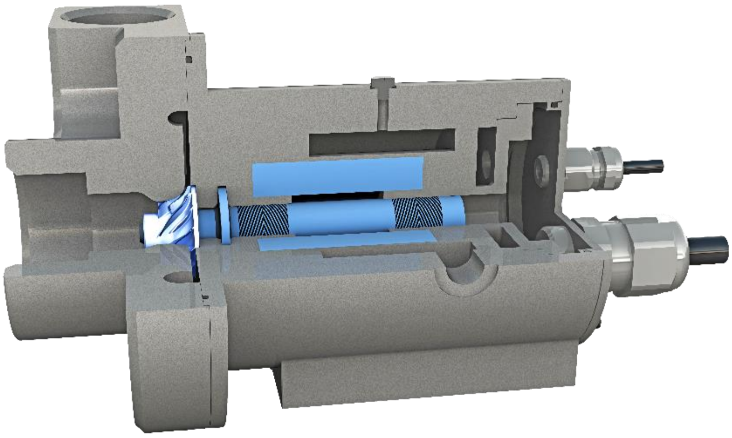

Figure 1: Cross section of a gas-bearing turbo compressor.

Figure 1: A sectional view of a typical gas-bearing Turbo compressor. The process gas flows around the entire rotor, the only moving part in the entire system. Components such as wiper rings, piston rings, labyrinth seals, oil supplies or valves are not needed, eliminating the necessity of service intervals. The high speeds at which these turbo compressors typically operate allow them to be miniaturized. The systems require significantly less surface area thus resulting in a lower overall weight. Since a gas bearing compressor uses only a small volume of gas, this means that a minimal surface area contacts the process gas. Also, the number of materials that are in contact with the process gas is relatively low. Its design is therefore particularly suitable for high purity or reactive gases. In addition, the amount of purge gas required for maintenance work is very small.

The speed regulating feature allows demand-driven power settings, which ensure maximum efficiency, even during partial-load operating mode, and thus lower operating costs. Low investment costs and low maintenance requirements result in low total cost of ownership (TCO).

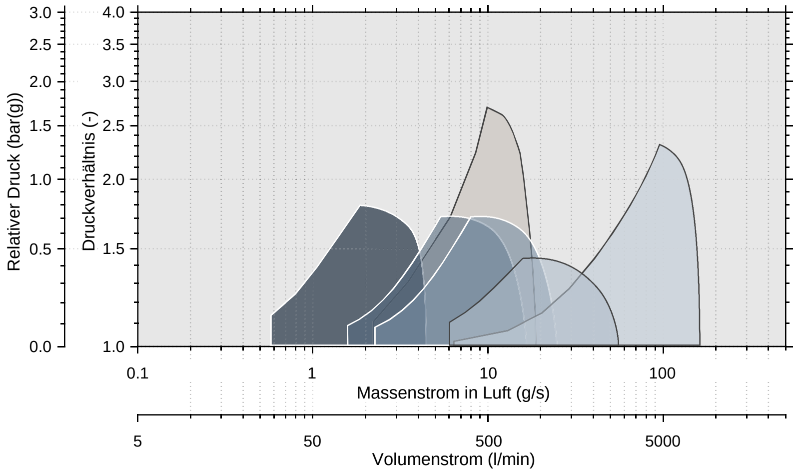

Figure 2: Miniaturization and high rotational speeds open turbo compressors to new areas of application.

In projects from the industry itself as well as in research and development, turbo compressors with gas bearings have been theoretically evaluated using various gases and to some extent implemented. The gases used include oxygen, nitrogen, noble gases such as helium or xenon, refrigerants such as R1234yf, R134a, R32, R400a and R600a and mixtures of toxic or reactive gases.

Success with toxic and highly reactive process gas

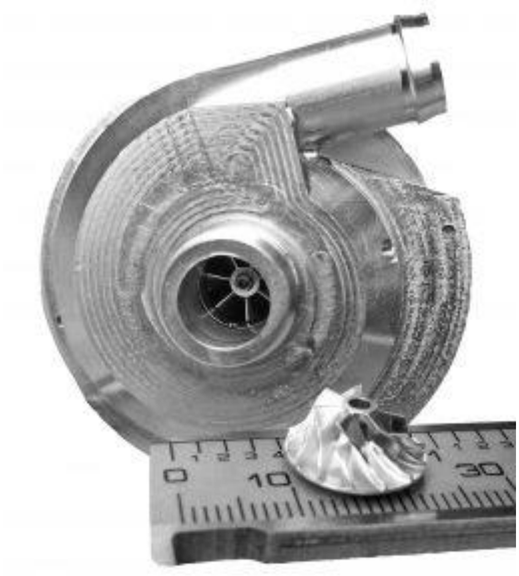

Figure 3: Miniaturized turbo-compressor with gas bearing.

One project involved compressing a mixture of helium and another toxic and highly reactive gas from approx. 1 bar absolute pressure to approx. 3 bars. The compressor supplies several intermediate processes and is itself fed by other processes. This is done by bleed air extraction. The compressors available on the market that could meet the requirements of pressure and flow rate with respect to purity and compatibility using process gas would be heavier by a factor of 90 and would have to run non-stop in the partial load range with low efficiency. The associated energy requirement was unacceptably high for the process operator. In addition, the couplings and seals in a conventional compressor would require frequent service intervals. Two shutdowns per year, each lasting several days, were not economically viable for the operator. Also, the high reactivity of the process gas prohibits materials such as various steels, some aluminum alloys, various plastics and oils and greases.

The turbo compressor with contactless bearings is virtually predestined for this requirement profile. To ensure the level of pressure and flow rate required to supply bleed air extraction, four turbo compressors per stage were used and connected in series. A total of 125 such stages are available. The four compressors that make up one stage and the various pressure levels allow an efficient supply of the bleed air extraction, thus minimizing energy consumption. To achieve a maximum number of identical parts, the drive and gas bearings have been designed so that they can be used for all four compressors. Only the actual compressor stage, consisting of the impeller and the spiral casing, was created as a separate variant on each compressor. Each compressor is equipped with a frequency converter that enables fully automatic and synchronized starting of the process.