Mechanical vacuum feedthrough using gas lubricated guiding elements

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ABSTRACT
Gas bearings with appropriate sealing systems can be used to transfer high-precise movements into a vacuum environment.

Within this paper, the usage of a journal gas bushing for the transmission of a mechanical movement into a vacuum chamber is described. The design and the theoretical layout of the necessary sealing and evacuation system as well as the experimental results are shown.

INTRODUCTION
For positioning processes with an accuracy in the nanometer range, the usage of gas bearing guides is beneficial, since the friction is negligible and no stick-slip effects occur.

In semiconductor industry applications or for high-precise measurements, positioning processes have to be performed within a vacuum environment since disturbing influences of gas molecules like absorption effects or the change of the refraction index have to be eliminated.

Different kinds of setups to realize the combination of vacuum and gas bearings are known, e.g. the operation of the whole gas bearing element within the vacuum chamber [1] or the integration of the gas bearing into the vacuum chamber wall [2].

For both operation modes, the flow of gas into the vacuum chamber has to be restricted while keeping the favorable guiding abilities of the gas bearing. The commonly used method to keep the vacuum quality is to exhaust the supplied gas before reaching the vacuum chamber using a plurality of exhaustion grooves and seal gaps comprising a high flow resistance [1,2].

![FIGURE 1. Schematic setup of a mechanical vacuum feedthrough with two-stage exhaust system.](image)

The investigated setup of a journal gas bushing, integrated into the vacuum chamber wall is shown in FIG.1. Using this setup, a translational as well as a rotational movement can be transmitted from normal atmosphere into a vacuum environment. The actuator is attached to the atmospheric side of the shaft and therefore a standard drive can be used.

Both exhaust grooves are connected to a vacuum pump. This results in a better vacuum level within the vacuum chamber, compared to the alternative setup where the first exhaust groove is connected to normal atmosphere.
ANALYTICAL CALCULATION
The pressure distribution in the sealing unit can be calculated using the mass flow rate of the bushing, the geometrical dimensions of the sealing and the evacuation system as well as the pumping speeds of the connected vacuum pumps. The transmission between continuous flow to intermediate and molecular flow have to be considered.

DESIGN
Based on the analytical calculation and on the available space, the design of the experimental setup has to fulfil certain requirements.

A small gap height is favourable to realize a low pressure in the vacuum chamber. The manufacturing and assembly tolerances between the guiding axis of the shaft and the rotational axis of the sealing surface have to be minimized in order to accomplish a small sealing gap height. Joining the sealing system with an adjustment bonding process to the housing enables the alignment of both axes.

To realize the connection of both exhaust grooves to the different vacuum pumps, the seal system within the vacuum environment is connected to the atmospheric side of the housing using the limited available space. In addition, the whole design and all interfaces are vacuum compatible.

The design of the experimental setup is shown in FIG.2.

FIGURE 2. Design of mechanical vacuum feedthrough using gas bushing and sealing system

RESULTS
The experimental results of the pressure distribution within the sealing system as well as the pressure in the vacuum chamber are compared to the analytical calculation. First information on the position stability of the shaft and the positioning accuracy are presented.

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REFERENCES