Why turbopumps have been called turbopumps for the past 50 years!

History
When Dr. Willi Becker took over as the head of the laboratory at Arthur Pfeiffer GmbH in 1945, he was interested in all of the possibilities for building pumps. To improve oil diffusion pumps, Becker designed a rotating baffle whose purpose was to keep the oil molecules from the pumps away from recipients. It comprised a rotating impeller and a stationary stator with axially-inverted blades.

Becker found that this enabled a considerable pressure ratio to be generated at the molecular level. It was therefore an obvious move to design a pump by interconnecting multiple such stages in tandem. The only oil this pump required was for lubrication of the bearings.

Back in 1916, Gaede had developed molecular pumps that incorporated a fundamentally different geometry requiring a very narrow gap between the stationary and rotating components.

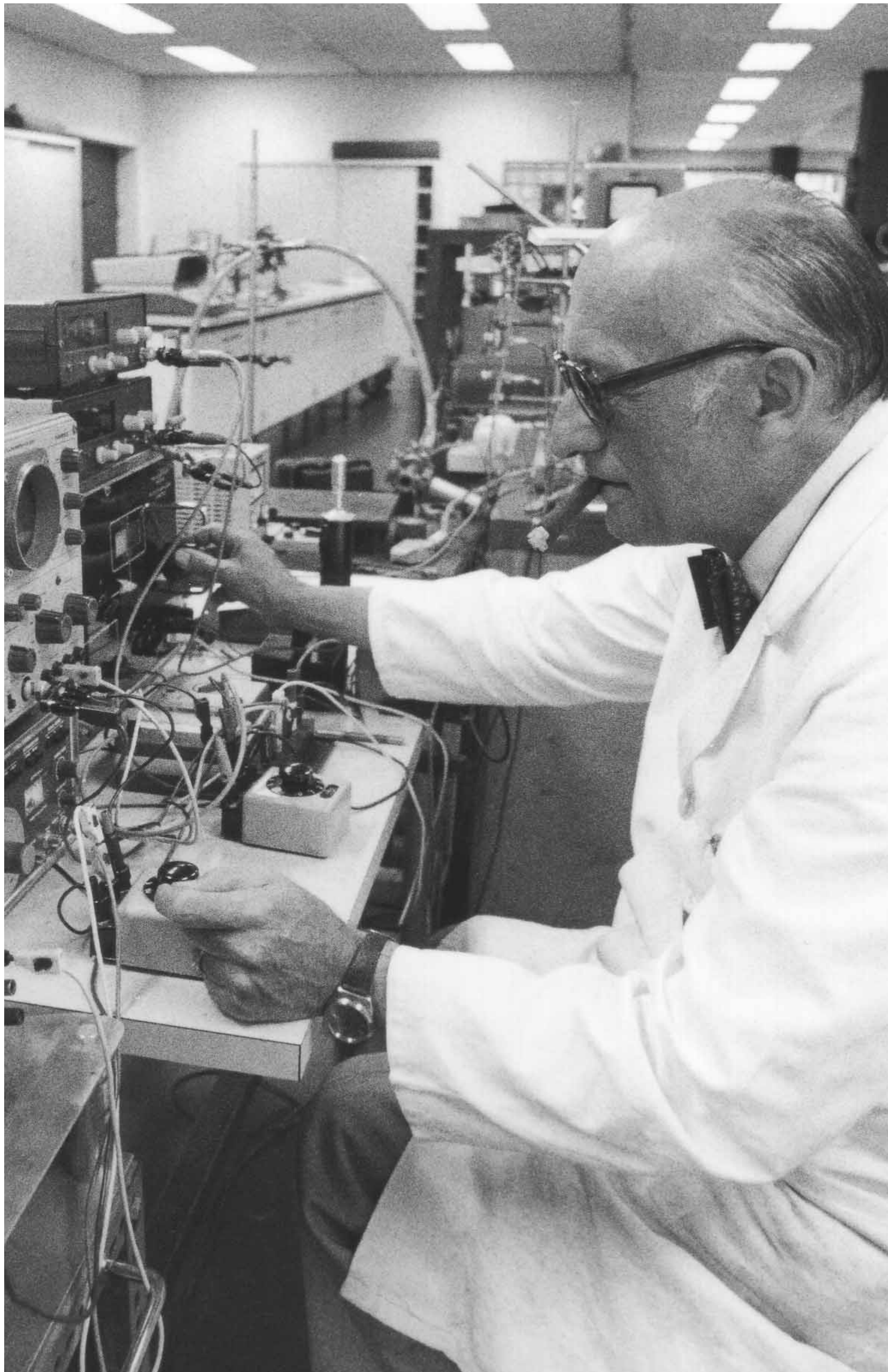
This resulted in a very high risk of destruction through even minute particulate matter. The new pump did not possess this crucial disadvantage. To differentiate the new pump, it was given the prefix "turbo," because its design was highly reminiscent of a turbine.

It was fifty years ago that the turbopump was developed at Arthur Pfeiffer GmbH. The objective at that time was to generate a hydrocarbon-free vacuum. Today, turbopumps from Pfeiffer Vacuum are the very embodiment of high-tech products that are highly reliable and offer optimum performance data.

Regular production
1958 saw the commencement of regular production of the first turbomolecular pump, which achieved a pumping speed of 150 l/s and weighed 95 kg. Although 100 to 200 pumps were manufactured per year during the initial years, predominantly for universities and research institutions, their simple handling and pure vacuum opened up new fields of application in the analytical industry and in industrial process technology. The breathtaking pace of development of microelectronics and the field of microchips, in particular, would not have been possible without turbopumps, which assure the required high vacuum under extreme conditions.

Evolution of the turbopump – Ever smaller and better
The first pump was of double-flow design. From the gas inlet, the gas was pumped down in two directions by two complete pump stage packages. Both packages were located on a single shaft, each end of which was mounted in a ball bearing. This was highly effective in keeping the lubricating oil away from the high vacuum side.

Responding to the growing fields of application, Pfeiffer Vacuum steadily evolved the classical turbopump. The double-flow design was relatively costly, which soon led to the development of single-flow turbopumps. These pumps were initially built with two oil- or grease-lubricated ball bearings, which resulted in an overhung bearing arrangement (i.e. the center



Dr. Willi Becker 1980 in Pfeiffer Vacuum laboratory of gravity of the rotor is located outside the bearings) and a very difficult-to-access upper bearing. The turbos were made smaller, more robust and more capable – without any change in their fundamental principle. In 1967, the original belt drive was replaced by an electronic drive. And in 1978, a miniature turbo weighing only 3 kg was developed for NASA for use in space; it was the first to incorporate magnetic levitation, offered a pumping speed of 16 l/s and operated at a speed of 90,000 RPM. As opposed to a lubricated ball bearing, the permanent-magnet radial bearing can be located in the high vacuum space.

Physical optimization
The pumping action differs for various gases. Over the course of time, the pump stages were repeatedly optimized, including the ability to achieve a high pumping speed for as many gases as possible. In addition to pumping speed, there are further key performance parameters for turbopumps: Such as compression, for example, i.e. the ratio between discharge and intake pressure, or gas throughput, i.e. the volume of gas that the pump can permanently advance. It is customary practice for pumps to be designated on the basis of their pumping speed class. Popular sizes range from 10 l/s to 3000 l/s. And some models are even larger. To increase the permissible backing pressure, turbopumps have been equipped with additional pump stages, such as Holweck or Gaede stages.

In addition to ball-bearing mounting, turbopumps have been developed – especially since the 1980s – that incorporate magnetic levitation alone. This kind of magnetic-levitation system can consist entirely of electromagnets or of a combination of electromagnet and permanent-magnet systems. The motivation for the pure magnetic levitation arrangement is to further reduce the hydrocarbons in the system, to reduce pump-induced oscillations and, last but not least, to keep the pumps maintenance-free. However magnetic levitation in the form of electromagnets, sensors and electronics involves considerable cost and effort.

Safety
Modern turbopumps reach peripheral speeds of over 400 m/s. And the kinetic energy of the rotor is correspondingly high, and would be transmitted to the housing, and thus to the anchoring of the pump, in a fraction of a second in the event of contact between rotor and stator. This means that the stability of the outer shell of the pump is an extremely important factor. This stability is reviewed both theoretically and experimentatively.
The pumps from the HiPace series are certified under UL 61010 and Semi S2. In addition to mechanical safety, this certification also includes fire protection and dual overspeed protection, which Pfeiffer Vacuum developed in conjunction with TÜV Rheinland.

Optimum customer benefits
The reliability of the pumps is an especially important factor. To further increase their dependability, Pfeiffer Vacuum has integrated extended diagnostic functions in the large, ball bearing-mounted pumps from the HiPace series.
This functionality enables maintenance to be performed as a function of the pump's condition. In particular, the need for maintenance is signaled in advance, thus making it predictable for the user. In addition to the unrivaled ability to perform bearing and oil changes on these pumps in the field, this also results in maximum availability.
Integrated controllers significantly reduce the need for cabling. Cutting-edge drive technology minimizes energy consumption, with a variety of control options being available. Protection Class IP 54 makes the pumps especially suitable for employment in industrial environments.
Their compact design even allows them to be integrated in situations in which space is limited. In order to keep costs low, various controllers can be selected for a given pump size.
Nor has the development work neglected the aspect of weight. A turbopump with a pumping speed of 250 l/s weighs only 6 kg.
Today, Pfeiffer Vacuum offers a complete line of turbopumps with differing pumping speeds, in both conventional and magnetic levitation technology, including integrated drive system.

Applications and properties
Today, turbopumps are used in a wide variety of fields:

Research and development
Basic physics research is often conducted at very low pressures, which means that the compression ratio is of above-average importance. When employed in radioactive environments, the drive electronics have to be able to be installed outside the radiation zone, i.e. at a sufficient distance from the turbopump.

Analytical applications
One example in this field is employment in a scanning electron microscope. In analytical environments, it is often necessary that little or no vibration be transferred from the pump to the system, as this would degrade the resolution of the microscope. For the same reason, if at all possible the pump should not emit any stray magnetic fields. Because of their integration in a system, a compact design is typically wanted. Magnetic levitation pumps are predominantly employed in connection with high-end systems.

Coating technology
One very broad field of application ranges from coating eyeglass lenses and architectural glass to tools and right through to solar technology. What are usually required for coating technology are medium to high gas throughputs, as well as a certain degree of insensitivity to particulate

Inspection of a rotordisc

matter in many cases. The ability to operate with a relatively high coolant temperature is also frequently needed.
These peripheral conditions cause the temperature of the turbo's rotor to rise; however for reasons of strength it must not exceed a specified upper limit. The actual temperature will depend, among other things, upon the nature and volume of the gas, the available cooling and the ambient temperature, as well as upon the speed of the rotor. To achieve the best possible performance, the pump must be operated at close to the temperature limit of the rotor, but without exceeding it. Pfeiffer Vacuum has integrated direct rotor temperature measurement into the corresponding models of its new HiPace turbopump line. This enables the pump to achieve its best performance, independently of all other peripheral conditions, while simultaneously offering maximum security against damage caused by overloads.

Semiconductor industry

Applications in the semiconductor industry pose the highest demands. In the semiconductor industry, it is often necessary to pump aggressive gases, such as halogens. To protect against corrosive attack, the rotor is coated, the drive motor stator is potted, and special oil is used for ball bearing lubrication. In addition, the motor and bearing chamber is protected against the process gas through the admittance of sealing gas.
The production of ever-smaller structures goes hand in hand with rising sensitivity to contamination. This is why magnetically levitated pumps are predominantly employed in the semiconductor industry.
In exposing (lithography) and inspecting (metrology) minute structures, it is important, as in the case of the electron microscope, that the system not be affected by any vibration. This is why magnetically levitated pumps are often employed here.

HiPace 300 turbopump, 265 l/s pumping speed, 5,8 kg weight

PFEIFFER VACUUM

Leading. Dependable.
Customer Friendly.

Pfeiffer Vacuum stands for innovative and custom vacuum solutions worldwide. For German engineering art, competent advice and reliable service.

Ever since the invention of the turbopump, we've been setting standards in our industry. And this claim to leadership will continue to drive us in the future.

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