# Physics of turbomolecular pumps and demonstration of conductance influence in HV

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The turbomolecular pump, a further development of the early molecular drag pump first introduced by Wolfgang Gaede in 1913 [1], is a high-vacuum (HV) pump which is used both for attaining very low ultimate pressures down to $10^{-10}$ mbar and for handling of high process gas flows up to inlet pressures of $10^{-2}$ mbar. The rich variety of high-vacuum applications requires a rich variety of high-vacuum pump designs. In particular, high-vacuum pumps have to handle gases with significantly different thermodynamic properties, they have to perform in the wide pressure regime mentioned above, and they have to perform at tremendously different gas throughputs. Before the development of a turbomolecular pump starts it is imperative to decide whether the pump design should be optimized for high compression ratios or for high pumping speeds.
First and foremost, the requirements with regard to ultimate total pressure (= compression ratios) and gas type-specific pumping speeds at certain inlet pressures determine the design of the inlet flange and hence, the dimensions of the pump, the design of the rotor and electric motor as well as the choice of the bearing concept.
Nowadays, there are two designs of turbomolecular pumps which are of commercial interest:

- The “classic turbomolecular pump”first described by Willi Becker in 1958 [2].
- The “compound turbomolecular pump” developed and optimized in the 1980s.

**Figure 1:** On the left: Classic turbomolecular pump; on the right: compound turbomolecular pump fitted with three Holweck stages in series

Both designs will be shortly presented highlighting the specific advantages and disadvantages.
Besides the performance of the turbopump itself there are several factors which influence the final performance of the vacuum system. Basic rules to obtain low pressures and fast pump down will be presented briefly. Those rules cover a suitable chamber design with minimized surface area, selection of appropriate materials as well suitable pre-treatment of materials and surfaces for HV conditions.
All fixtures between intake of pump system and chamber will lead to a reduction of pumping speed. This effect is described with the conductance C. The conductance is pressure dependant and has a strong influence in HV and UHV conditions. The conductance also depends on the geometry of the fixtures. Some basic guidelines to avoid conductance losses will be presented.

### References

[1] W. Gaede: Annalen der Physik 41 (1913) 337-380
[2] W. Becker: Vakuum-Technik 7 (1958) 149-152