Turbo Pumps

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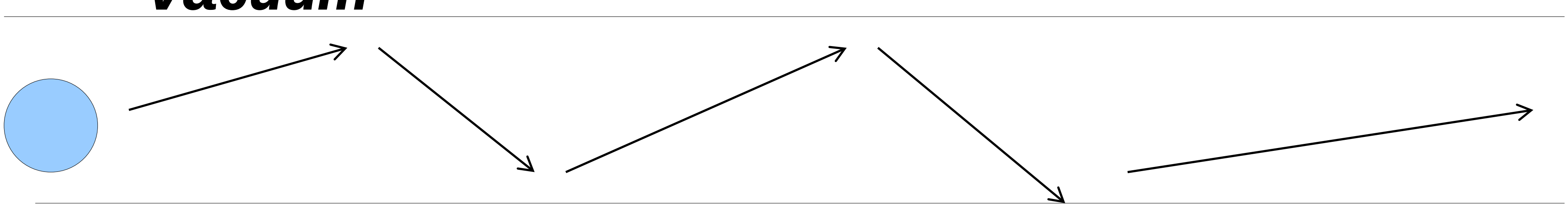
Outline

- Background
- Vacuum Pumps
- Turbo Pump Design
- Importance

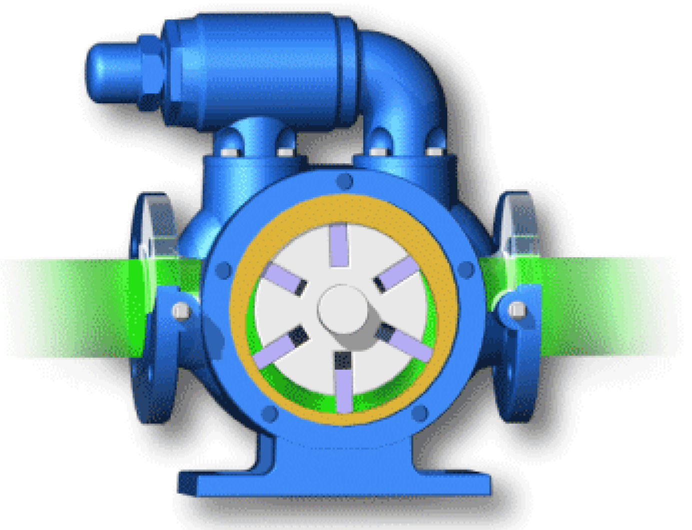
Background: Pressure

- Gas molecules are in constant random motion
- In a container, the collisions of the gas molecules with the walls are what we measure as **pressure** (force/area)
- Vacuum: Absence of gas (no pressure!)
  - Viscous flow with ***no vacuum***
  - Collisions between molecules become rare at ***high vacuum***



Vacuum Pumps

- Removes gas from a chamber to create a vacuum
  - Useful when you interactions with gas must be minimized (eg. Electron beams)
- Two pumps used in tandem
  - Roughing pump to achieve “rough vacuum” (via displacement)
  - Momentum transfer or entrapment pump further improves the vacuum

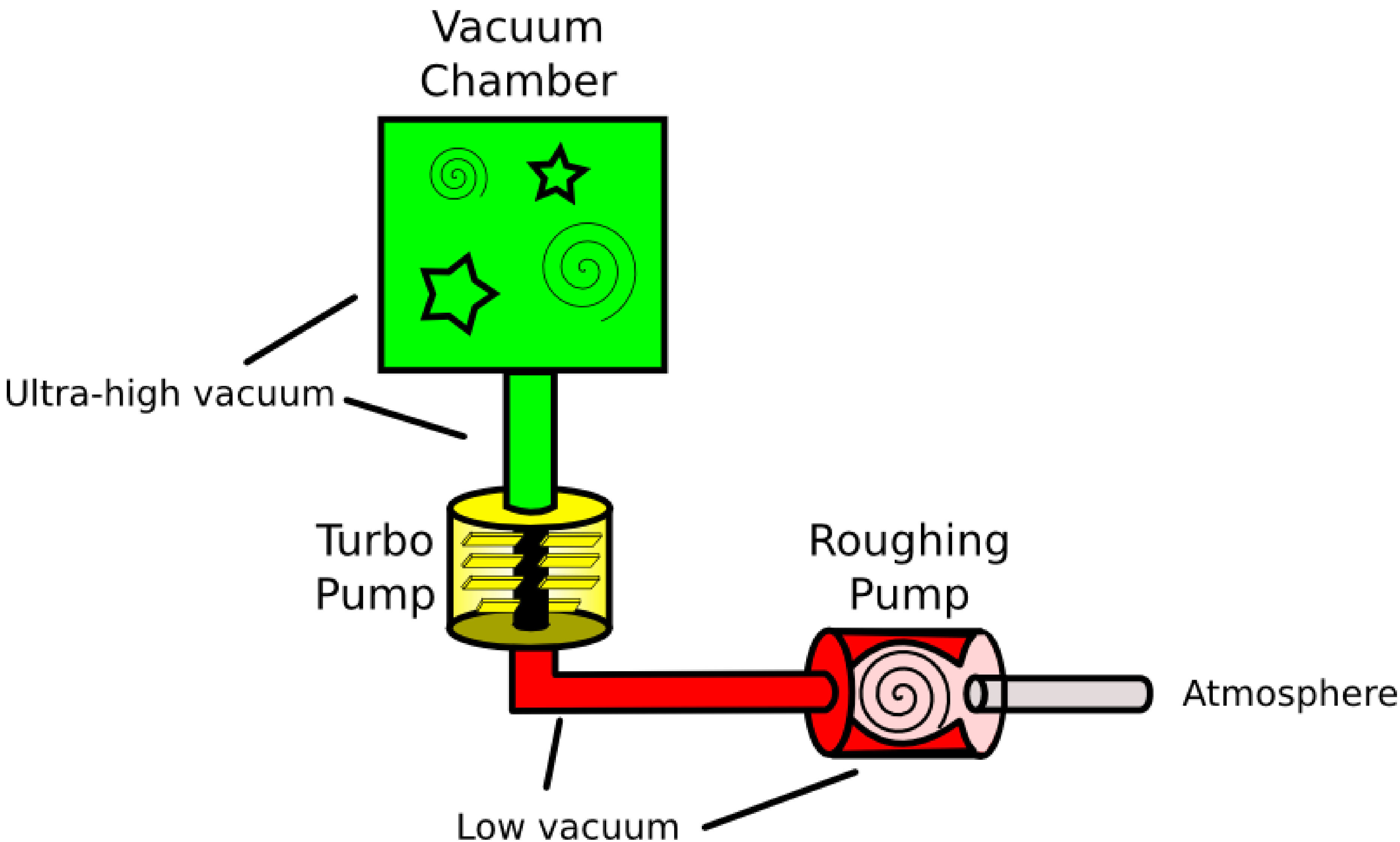


Rotary Vane Pump

Turbo Molecular Pumps

- Momentum Transfer
  - Titled rotor blades spin at up to 90,000 RPM
  - Gas molecules pass through the blades and pick up momentum when struck by the back of the blades
  - Some gas molecules more likely than others to make it through
  - Pressure build-up on outlet side requires backing pump otherwise backflow and stalling

Typical Setup



Turbo Pump Characteristics

- Pumping Rates
  - 20 L/s to 3,000 L/s
  - Different gases pump at different rates
- Compression Ratio
  - Ratio between the partial pressure of a specific gas in the foreline vs. chamber (ie. after/*before turbo*)
  - eg. If $CR=10^8$ for Nitrogen and $P_{foreline} = 10^{-4}$ mbar, then $P_{chamber} = 10^{-12}$ mbar

Other Characteristics

- Rotor design (SNECMA vs. Pfeiffer)
- Bearings
  - Ceramic, lubricated
    - Lubricant with low vapour pressure at UHV
  - Magnetic, levitating
    - Rotor shaft levitates without mechanical contact
    - No oil backflow, no mechanical wear!
- Throughput, Vacuum, Backpressure

SNECMA Design

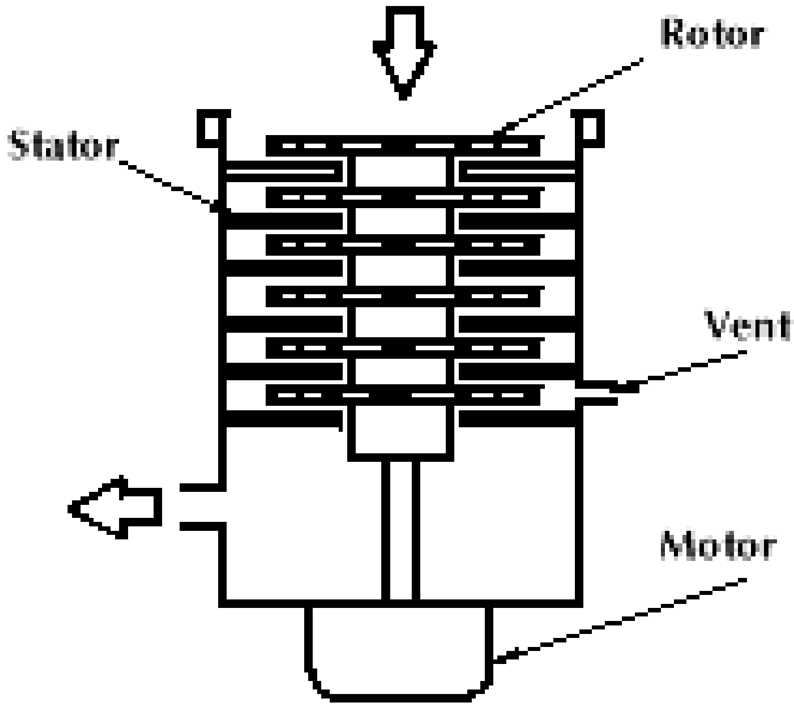


Fig. 11.9 Rotor used in a classical vertical turbomolecular pump. Reprinted with permission from Leybold Vakuum GmbH, Bonner Str. 498, 50968 Köln, Germany.

Pfeiffer Design

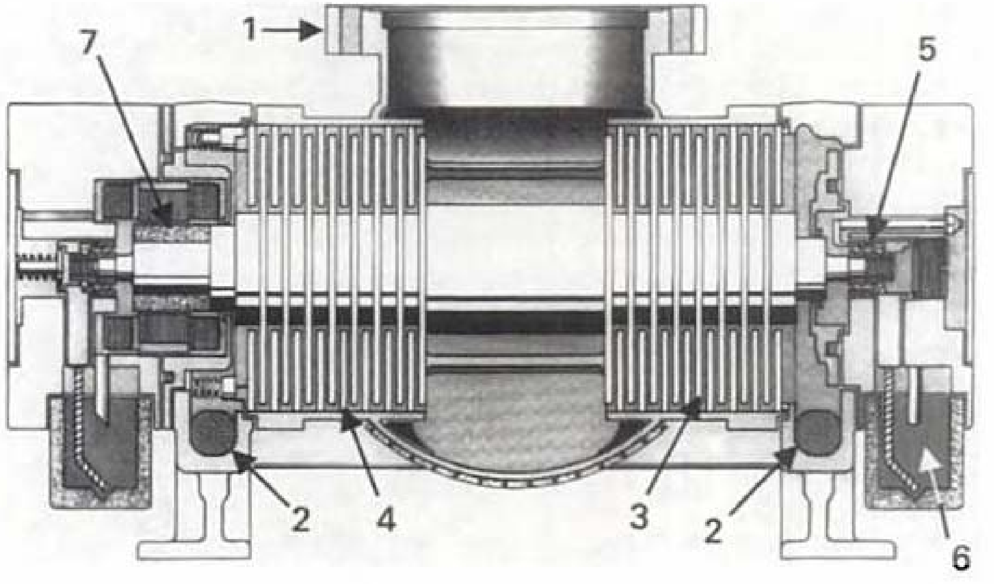


Fig. 11.1 Section view of Pfeiffer TPU-200 turbomolecular pump: (1) inlet, (2) outlet, (3) rotor disk, (4) stator disk, (5) bearing, (6) oil reservoir, (7) motor. Reprinted with permission from A. Pfeiffer Vakuumtechnik, GmbH, Wetzlar, Germany.

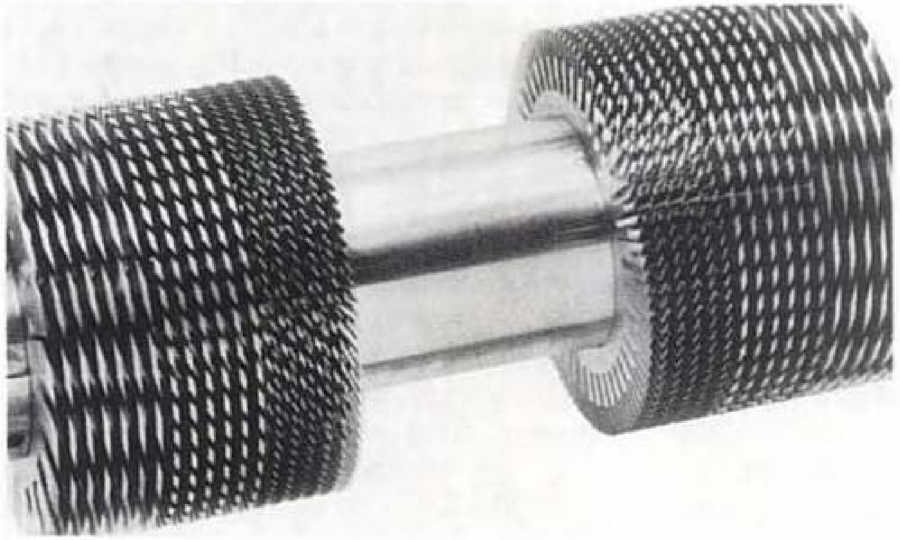


Fig. 11.8 Three-stage rotor from a Pfeiffer TPU-200 turbomolecular pump. Reprinted with permission from A. Pfeiffer Vakuumtechnik, GmbH, Wetzlar, Germany.

Practical Importance

- Turbopumps are an essential part of nanotechnology
  - Science: SEM, EBL, FIB, LEED, XPS, thin film deposition
  - Engineering: Semiconductor fabrication, ion implantation, [your research here?]
- Advantages: Reliable, good performance, corrosion resistant, fast(!), clean
- If one breaks on you, you'll have to know how to find a replacement.

Questions?

References

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2. Lesker Vacuum Notes
   http://www.repairfaq.org/sam/vacuum/tmpnotes.htm
3. **A user's guide to vacuum technology**
   John F. O'Hanlon, 2003, Wiley-Interscience