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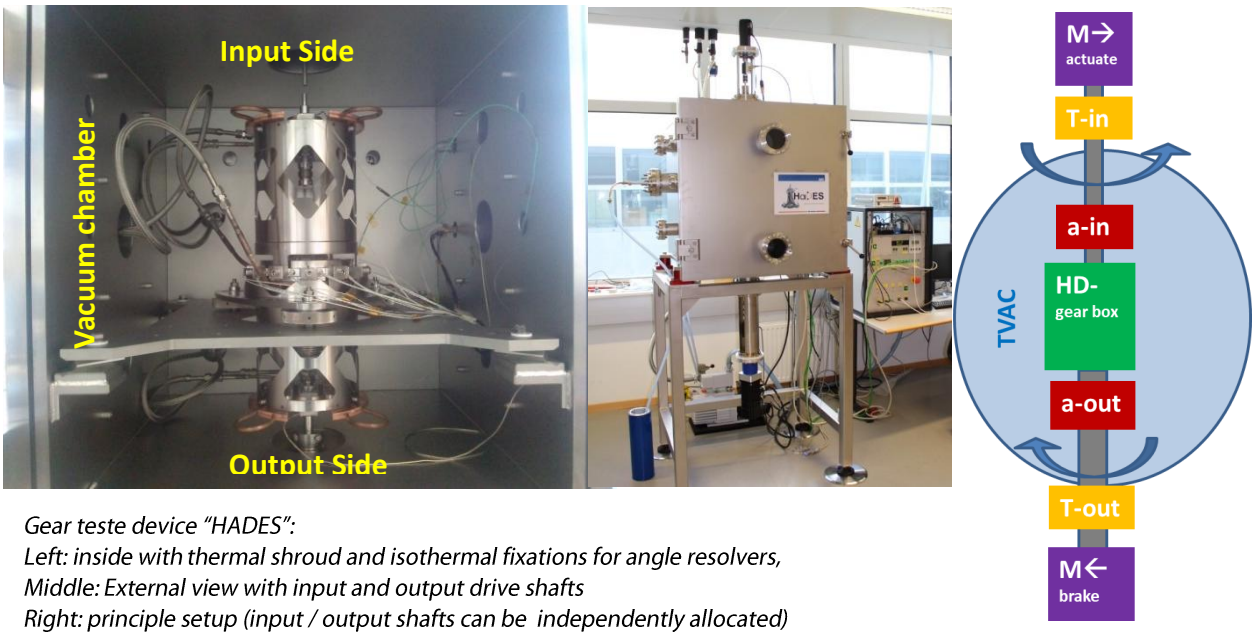
Gear testing

Several devices at AAC are offering testing of gears over wide temperature range. The devices “SALOTTE” and “HADES” offer life-testing over long durations from -170°C to +250°C. During life, also characterisation of the gears in-situ (TVAC), like stiffness, transmission ratio, NLRT, …., are possible. The devices are designed for gear types with input and output shafts being in-line. Life test campaigns were run on Harmonic Drive ® gears, on planetary gears or on magnetic brakes running up to several months, combined with interim characterisations over wide temperatures.

The test devices are based on “motion modules” which can be allocated as needed (see sketch below): use both input and output shaft to test gears, use only output drive shaft for actuators with high output torques up to 50Nm, or only input shaft with hysteresis brake for actuators with low output torques <0,2Nm. (Options for bearings using only one drive shafts are in separate info on Bearing testing).

These facilities enable to measure the torques (input and output) and the angle (position, in and out) with high accuracy while the test items being in TVAC. Environments may vary from high vacuum, non-aggressive gases (e.g. He, CO2) under controllable pressures (e.g. to simulate Martian environment) to air with controlled humidity. The tests can usually be performed over wide temperatures from -170°C to + 250°C.



Gear teste device “HADES”:
Left: inside with thermal shroud and isothermal fixations for angle resolvers,
Middle: External view with input and output drive shafts
Right: principle setup (input / output shafts can be independently allocated)

Standard test boxes (housings) are available for a Harmonic Drive ® gear in sizes 14, 17 and 20. This enables to efficiently test gears under dedicated mission parameters to e.g. validate optimum lubrication concepts (fluid/solid/hybrid) before any EM/actuator is machined. All support bearings are solid lubricated enabling wide temperature test range without interfering with the lubricant of the test item. Motors compatible with TVAC are also available to test planetary gears or magnetic brakes.

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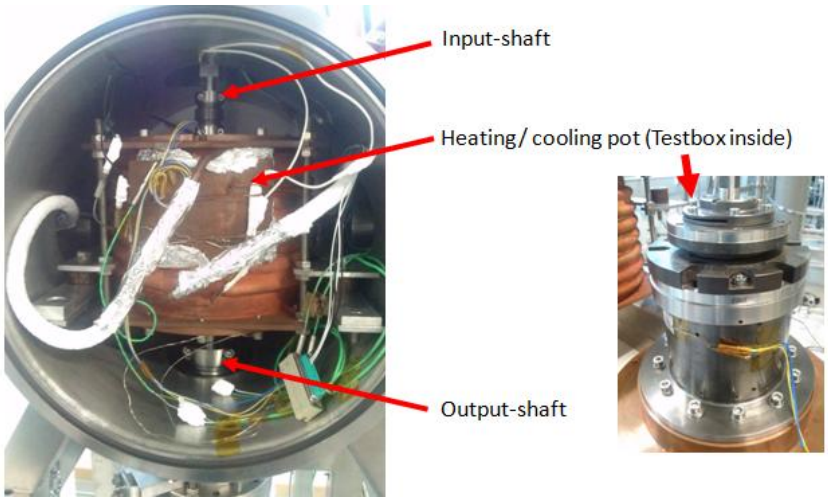
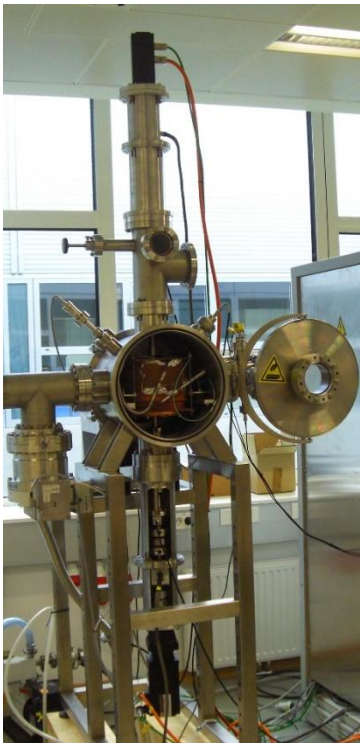


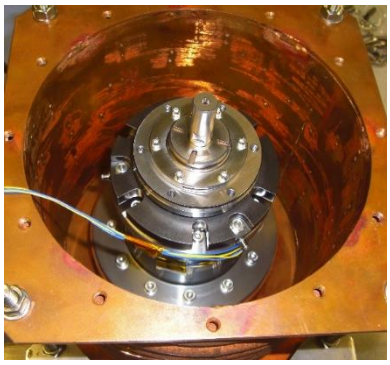


Gear teste device "SALOTTE":
Left: with thermal shroud inside vacuum chamber,
Middel: test box for HD-gears developed together with HDSE
Right: Device overall with input and output drive shafts

The devices are fully PC-controlled. Selectable parameters are e.g. test duration (revs), speed (input or output), motion types like unidirectional, oscillating or reciprocating, with predefined angles (several stops are feasible within one cycle). On-line-data acquisition offers to post-process data, e.g. for automatic calculation of efficiency, stiffness, transmission accuracy, ...

Available measurements for Harmonic-Drive ® gears:

- continuous monitoring of efficiency at constant speed and torque
- Efficiency profile:
  - efficiency during torque-ramp
  - efficiency at various speeds
- Transmission accuracy
- Stiffness
- Axial-force
- No-Load-Running-Torque
- No-Load-Back-Driving-Torque
- Environmental Data, Temperature



Gear teste device "SALOTTE": with HD testbox inside thermal shroud (developed in coop with HDSE)

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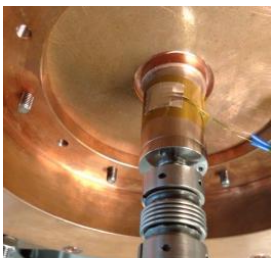
This device enables also testing of planetary gears under vacuum:
Here the setup is slightly different:

- The input motor is inside the vacuum chamber enabling input speed up to 4000rpm
- Input torque is measured using a piezo cell (i.e. no continuous monitoring is possible)
- Output load is applied by a hysteresis bake (i.e. no back-driving torque is possible)



Gear test device "SALOTTE": with a planetary gear

Available measurements for planetary gears:

- Efficiency measurement at pre-defined intervals (no continuous monitoring)
- Environmental Data, Temperature

Different environments are available:

a) Testing from air to high vacuum
b) Testing controlled gas environment: eg simulating Martian atmosphere (15 mbar in CO2)
c) Motion selectable from unidirectional rotation to oscillating motion
d) Contamination monitoring: a mass spectrometer to detect on-line contamination (e.g. outgassing of fluid lubricants or their cracks).

Post-Analysis may cover measurement of wear by profilometry (also 3D), SEM or microbalance. Investigation of surface structure, state of coatings or surface treatments (e.g nitriding) or material transfer by SEM/EDX. State of coatings can be investigated by FIB-cutting, thereby a microscopic cross section is done, avoiding the need to destroy the component. Thereby, subsurface structure can be determined using EBSD to assess cold welding or wear effects in case of failure.

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Specifications	
Samples	Gears • Testboxes available for HD-gears size 14, 17,20 • Planetary gears • Magnetic brakes • Actuators Further housings on demand (as part of test campaigns) (For Bearings see separate info sheet.)
Test	online measurement of • Torque (in and output) • Axial forces (using special gear box) • High-resolution incremental angular sensor on input- and output-shaft • Environmental Data • residual gas analysis (mass spectrometer of outgassing particles) Pre- / Post-Analysis; • Pre-Load (before and after test, ex-situ) • Wear (geometric or mass loss from cage) • Failrue analysis by microstructural methods (SEM/EDX/FIB/EBSD)
Loads (output)	Torque loads for the output sied are aavailble <0,25 Nm (hysteresis brakes) 1-50Nm (geared motor, closed loop)
Speed / Motion (input)	Motion selectable from unidirectional to reciprocating (angles selectable) 0,1 to 600 rpm (geared motors available for further speeds) For testing of planetary gears TVAC compatible motors up to 4000 rpms are available (Frameless motors are available too, see Bearing test sheets)
Vacuum / Environments	Vacuum selectable down to 10^{-6}mbar Air with controlled humidity Gases with controllable pressure (e.g CO_2 at 15mbar = Mars)
Temperatures	from -170 up to + 250 °C, thermal cycles feasible
Accuracy	Torque ± 0.001 N Angle: +/-3 arcsec Temperature in-situ (several points simultaneously): ±2°C