

# Closed loop test benches for gearboxes, couplings and gear-wheels: Airbus Helicopters uses ROTODIFF technology to considerably reduce its energy consumption

To verify that their mechanic power transmission systems comply with the severe requirements on quality, safety and reproducibility, Helicopter manufacturers worldwide use a Swiss made technology: at the heart of back to back test rigs, Viscotherm's ROTODIFF solution (Fig.1) ensures that they are run with a fraction of the turbine's power. In addition, it makes it possible to test gearboxes with different ratios in a mechanical closed-loop system, hence significantly reducing the installed power.

In Back to back test rigs in mechanical closed loop, two identical gearboxes' in- and output shaft are coupled to each other in a symmetric arrangement. The system is then accelerated and kept idling at the tested gearbox's nominal speed. Then torque is introduced into the rotating system, tightening both gearboxes against each other. As a result of the component's elastic deformation under load, a torsional angle results that is proportional to the introduced torque. The tests are performed at a fraction of the nominal power of the tested gearboxes, since only the power of the torque device and the one needed to idle has to be supplied (Fig. 2).

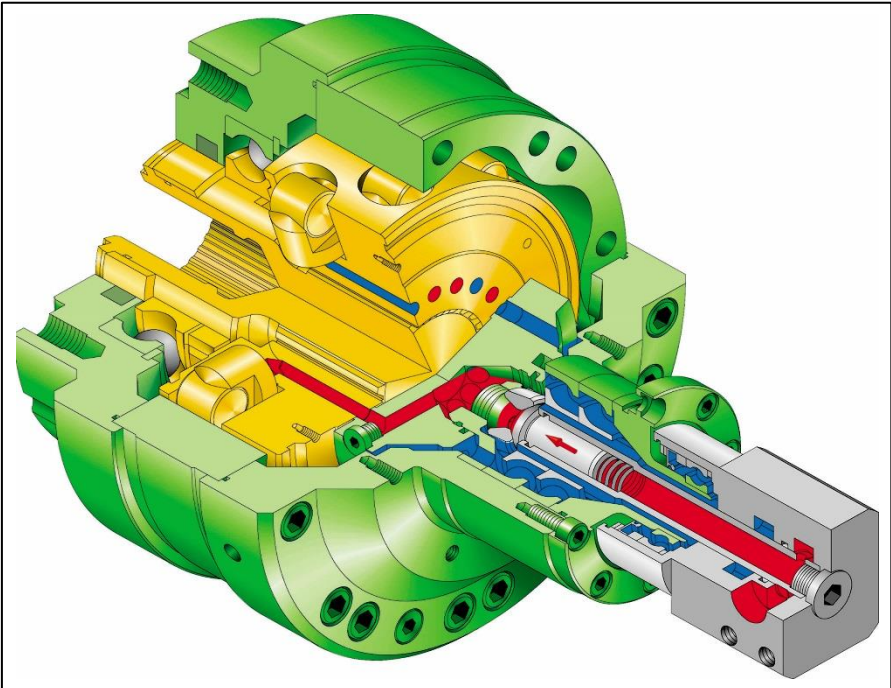


Fig. 1 Viscotherms ROTODIFF®

As a result, a renowned Helicopter manufacturer saves enough energy to supply an average city of 30'000 people with its yearly tests (Fig.5).

## Flexible adaptation to load scenarios and gearbox types

ROTODIFFs installed as the test rig's torque introducing device allow testing type of gearboxes when combined with features permitting to adapt the test rig to the different geometries of the in- and output shafts. The kinematic ratio is adapted by regulating the differential speed of the ROTODIFF. The result is a universally suitable test environment. To achieve this, the oil flow is adapted to the different ratios by the pump unit. This is possible since both rotor and housing of the ROTODIFF rotate. The differential speed between them is proportional to the displaced volume (Fig. 3). Since gearbox and test rig are coupled, the introduced torque is

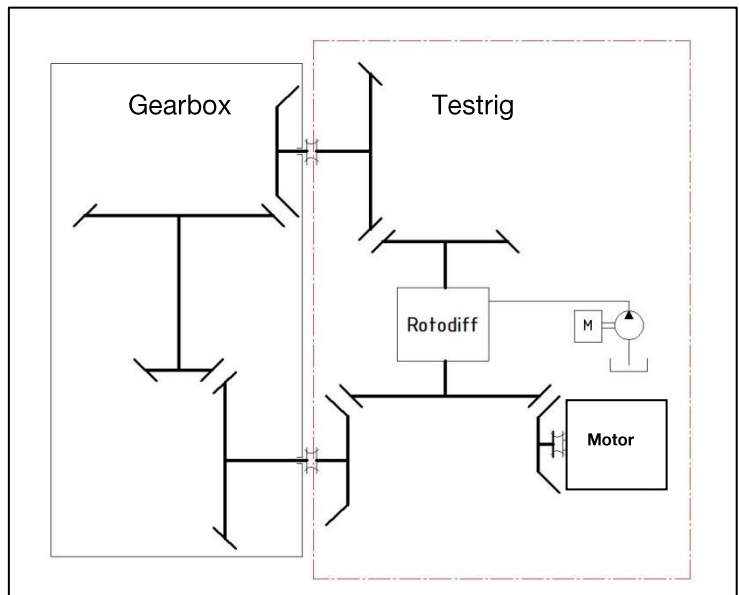


Fig. 2 Schematic arrangement of a back to back test rig with mechanical closed loop

proportional to the pressure which is regulated hydraulically. This hydraulic solution allows to completely eliminate ripple. Depending on the ROTODIFF's size, the Housing can turn up to 6500 rpm, with differential

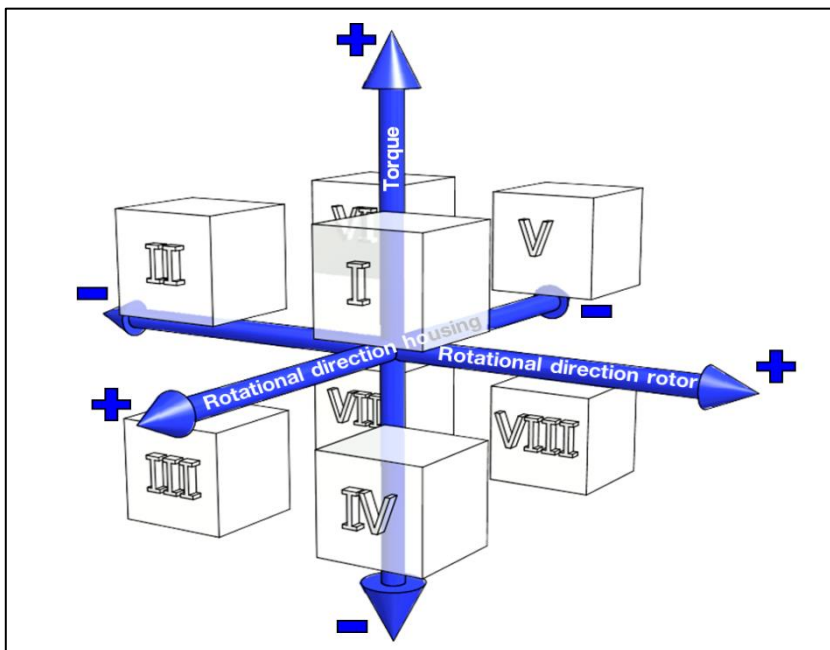


Fig. 3 ROTODIFF® Operational parameters

speeds up to  $\pm 200$  rpm and torque values up to 100'000 Nm (for exact figures [www.viscotherm.ch](http://www.viscotherm.ch)). By this means it is possible to adapt the torque and the direction of rotation to the tested gearbox (Fig. 4), while a pressure relief valve protects the gearbox against overload. The combination of these variables results in a flexible test rig, able to perform tests on different types of gearboxes at high torques and multiple frequencies with minimal power consumption. For instance, Airbus helicopter, in collaboration with Viscotherm, has developed its test rigs with

this technology up to the last generation of multi-purpose test benches.

## Motor or pump; rotor at higher or lower speed than housing

To visualize the functions of a ROTODIFF, the hydraulic configurations corresponding to the operating conditions in each of the 8 operating quadrants are shown schematically (Fig.4). In the quadrants I, III, VI and VIII the ROTODIFF operates as a hydraulic motor: the hydraulic power fed by the pump is transformed into Torque and rotational movement. In the quadrants II, IV, V and VII the ROTODIFF works as a pump: The

mechanical work introduced by the shaft is transformed into hydraulic power, for example, as shown here, to overcome the hydraulic resistance of a throttle valve.

In the quadrants II, III, V and VIII the rotor turns slower than the housing. In the quadrants I, IV, VI and VII the rotor turns faster than the housing. To insure this in quadrants IV and VII, the driving shaft must be connected to the rotor, in all other quadrants to either rotor or housing.

This functional diversity allows adapting back to back test rigs to the most diverse kinematics of the tested gearboxes and also to accurately adapt the parameters of the load with a hydraulic control circuit. With the multiple kinematic possibilities, its durable construction and remarkable efficiency, ROTODIFFs have proved themselves in test rigs all over the world. Moreover, its compact footprint and simple design leads to massive reductions in the infrastructural costs. Yet another advantage is the energy savings, even when compared to similar electromechanical systems.

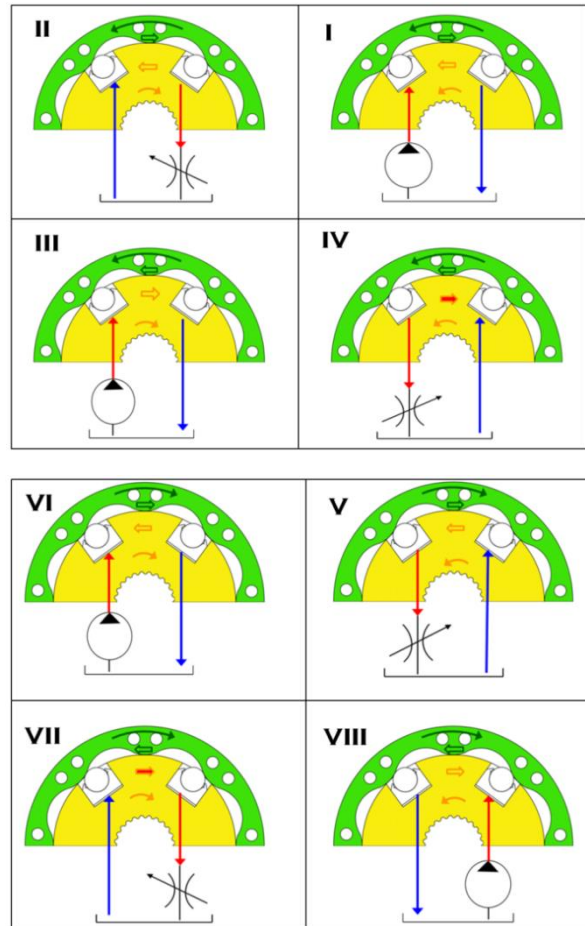


Fig. 4 ROTODIFF® hydraulic parameters depending on operational parameters

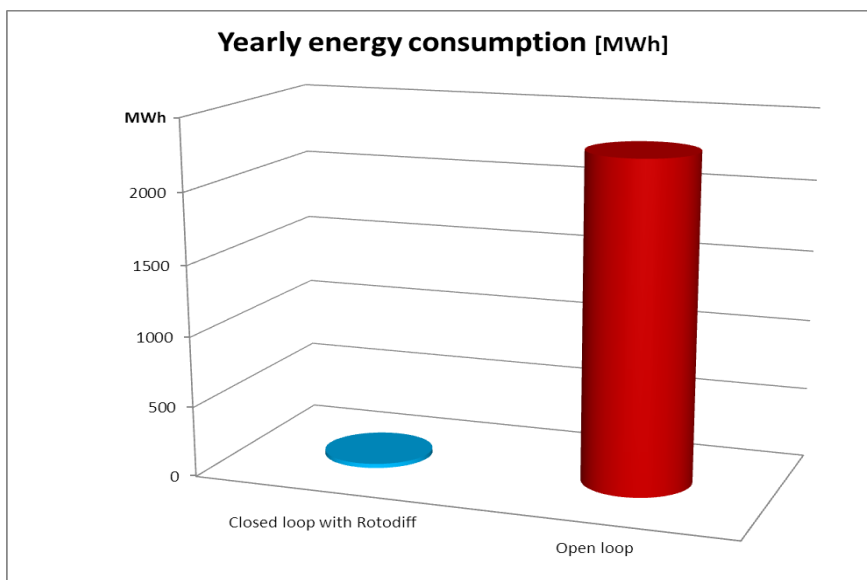


Fig.5 Comparison of the energy consumption of a Helicopter manufacturers considering a normal exploitation of the test rigs over one year in open loop vs. mechanical closed loop with ROTODIFF

Wherever large torsional angles or even adjustments of the rotational speed are needed to safely, flexibly and precisely test high torque Rotating components, Viscotherm's compact ROTODIFF is the most energy efficient solution.