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NEW GENERATION OF ZFL GEARBOX TEST RIGS FOR HELICOPTER GEARBOXES

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Abstract

Full-load tests are still required for the development of new helicopter gearboxes and for tests after gearbox maintenance.

This paper gives a summary of the state of the art of helicopter gearbox test rig construction and explains the advantages of the new generation of gearbox test rigs developed by ZFL Luftfahrttechnik GmbH using a moment change device developed by ZFL for test load generation (patent pending).

1. Comparison of the different main gearbox test rig designs

The following variants of full-load main gearbox test rigs are differentiated by ZFL, formerly Henschel Flugzeug-Werke GmbH:

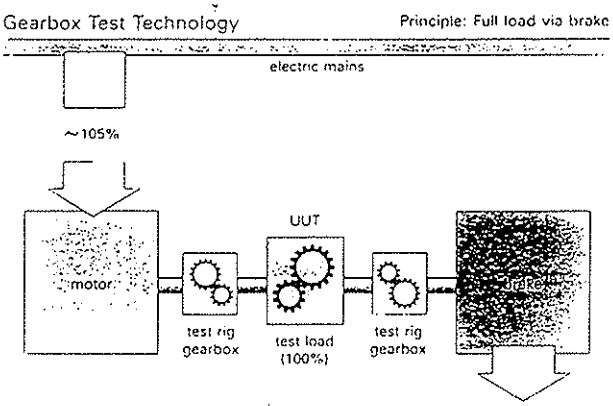

Fig. 1 - Full load via brake (100 % power loss)

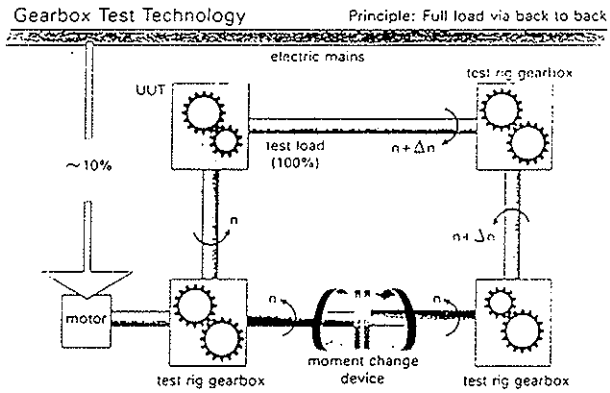

Fig. 2 - Full load via back-to-back (approx. 10 % power loss)

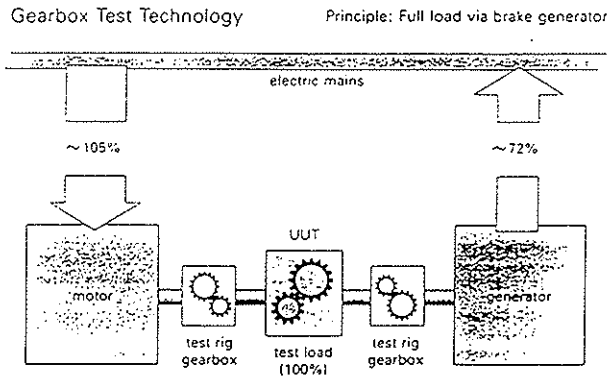

Fig. 3 - Full load via brake generator (approx. 28 % power loss)

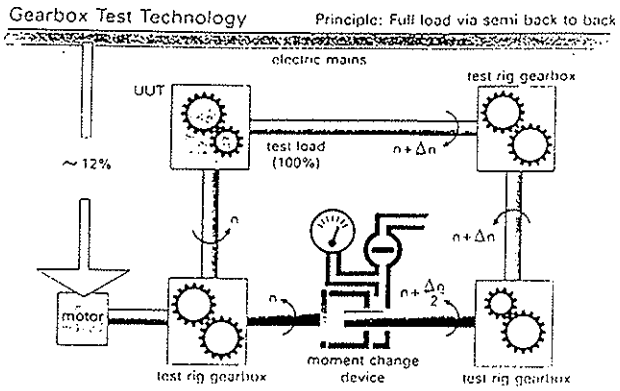

Fig. 4 - Full load via semi-back-to-back with rotordiff
(partial load eduction, approx. 12 % power loss)

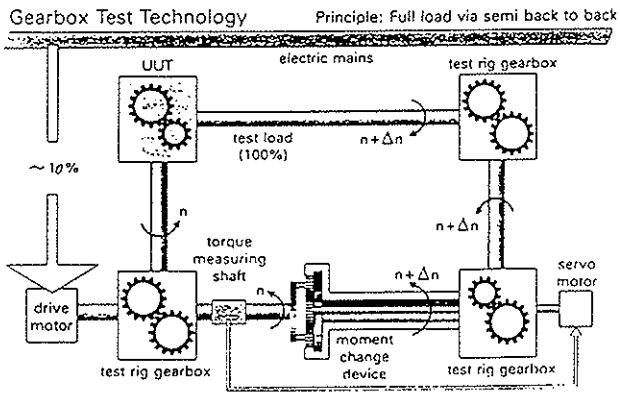

Fig. 5 - Full load via semi-back-to-back with ZFL System
(partial load eduction, approx. 10 % power loss)

The advantage of pure back-to-back systems lies in the low power loss compared with the test load.

However, great efforts are required to make them suitable for testing several test units and to adapt them to transmission ratio changes in the development phase of new gearboxes.

Pure brake systems are suitable for gearbox testing only with low load and short test periods or a low rate of test rig utilization.

The generator brake system is particularly suitable for universal test rigs, i.e. for testing several gearboxes with different transmission ratios on one test rig.

On a ZFL test rig concept with generator brake, five different helicopter gearboxes are presently being tested with minor modifications only.

Test rigs with hydraulic rotordiff require more equipment and space for hydraulic components.

2. The new generation of ZFL gearbox test rigs

The new generation of ZFL gearbox test rigs combines the advantage of the back-to-back system - low power consumption with the advantage of the generator brake system - universality - so that the total investment for the test rig can be reduced.

This new test rig technology is based on a moment change device developed by ZFL (patent pending). A test load of 1100 kW can thus be generated per power circuit.

The centrepiece of the moment change device is a differential gearing with a high transmission ratio.
Due to the moment change device, the mechanical power circuit can be closed via the relatively high speed in the turbine input and the low speed in the main rotor take-off by means of a few simple bevel gear or spur gear stages.

The test units can be converted outside the test cell on a carriage belonging to the test unit. The carriage is equipped with the adaptation gearing required for connecting the test unit to the test rig. Even if different

test units are to be tested in succession, only a minimum of time is required for conversion.

The tail rotor take-off is connected to a generator arranged at an angle of 90ø via a swivel-type bevel gearbox.

The bevel gearbox serves to reduce the very high tail rotor speeds of some helicopter types to common speeds for electric machines.

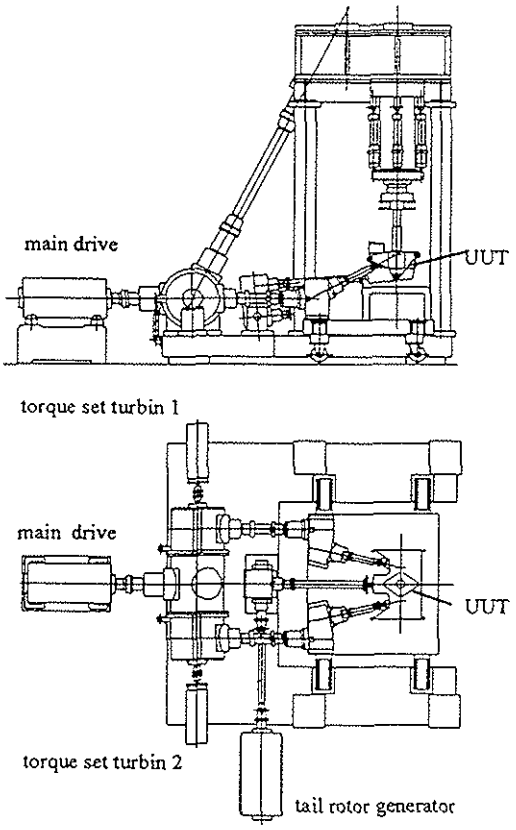

Fig. 6 Concept for a main gearbox test rig for approx. 8 different main gearboxes
top view and side view

The test speed is controlled by the main drive which has an output of approx. 10 % of the test load.

The test torque is set via a dynamic three-phase servo motor coupled to the input of the moment change device.

The moment change device can be integrated in a test rig transmission or be used as an installation or add-on variant to replace another moment change device on an existing mechanic semi-
back-to-back system test rig, if required.

The add-on and installation variants are shown on a development test rig constructed by ZFL in Kassel for testing the moment change device.

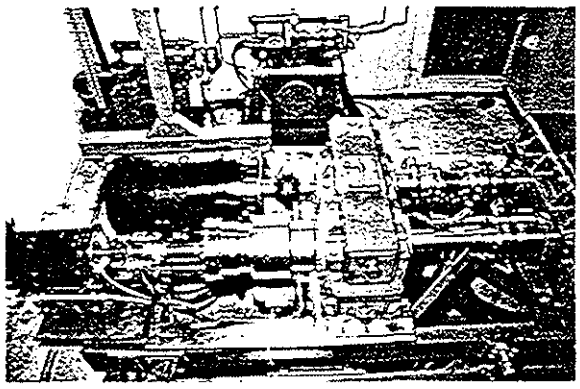

Fig. 7 Development test rig

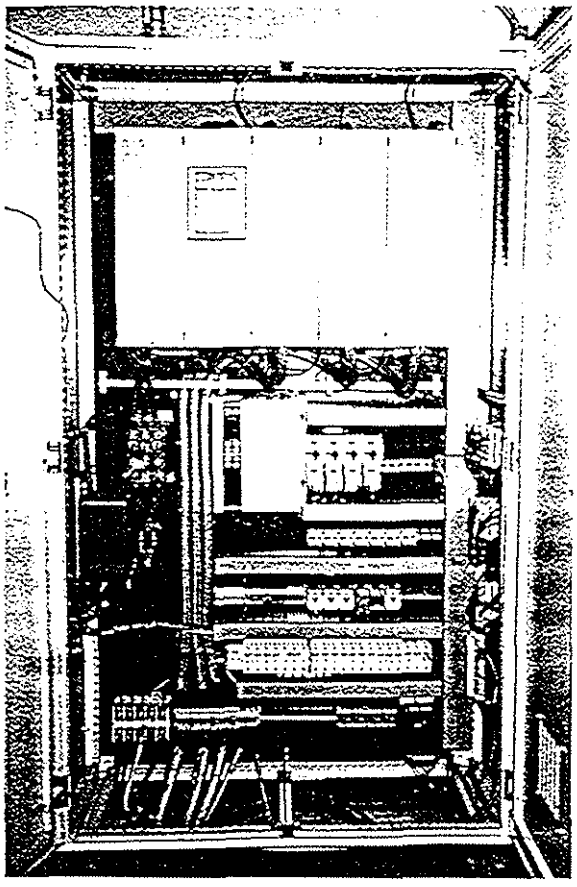

Fig. 8 Switch cabinet of development test rig

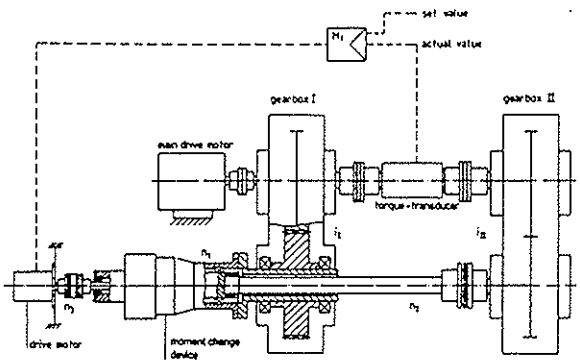

Fig. 9 Schematic drawing of test rig, add-on variant

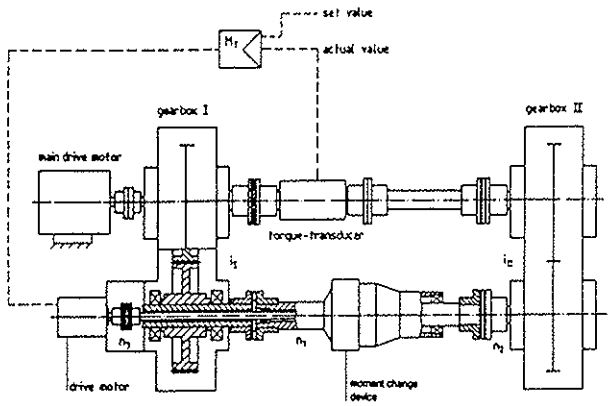

Fig. 10 Schematic drawing of test rig, installation variant

Advantages of the ZFL moment change device system

- Universal test rig for several test units
- Change of test unit transmission ratio possible in the development phase
- Low power loss compared with test load
- Mains interference immunity
- Speed control and torque control without mutual interference
- High control dynamics due to low inertia and absence of play
- No system-related torque oscillation
- Little space required for supply components
- Speed regulation possible under load
- No basement required for test rig units or foundations

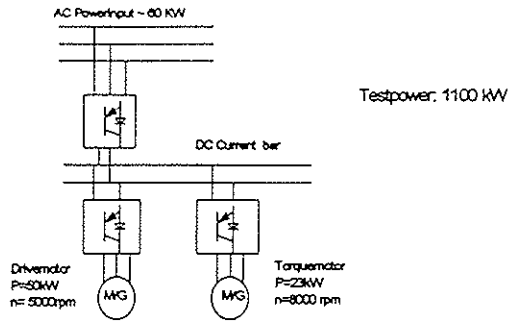

Fig. 11 Concept of development test rig drive system

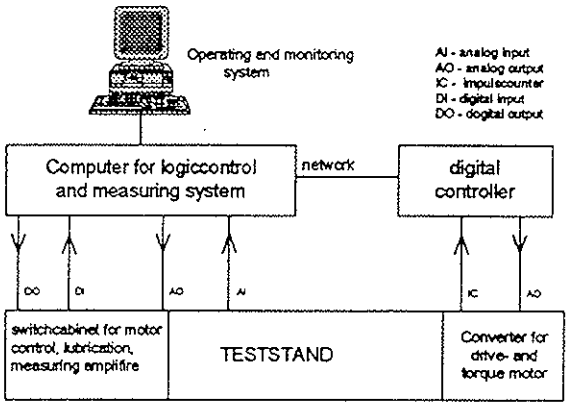

Fig. 12 Computer configuration of the development test stand

Operation, recording of measured values, logic control and control of a ZFL gearbox test rig are based on programmable logic control systems interconnected via a bus bar so that the cabling requirements are kept to a minimum.

Test programs are preset digitally and the measuring results recorded automatically. Complete digital processing of the entire measuring and control signals ensures exact reproducibility of test procedures and consistent accuracy of the measuring results over many years.

80 - 90 % controlled presetting of the test

torque is to ensure the highest possible degree of immunity from external interference. The test unit is protected by a redundant monitoring system.

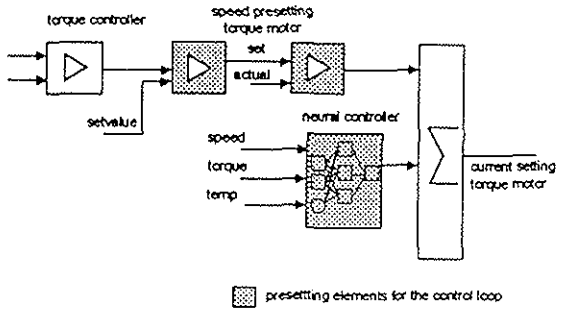

Fig. 13 Control structure of a power circuit

The data for controlled presetting are computed on the ZFL test rig and "learned" by a neural controller.

Approx. 80 - 90 % of the required servo motor power can thus be controlled for adjustment of the test torque as a function of test speed, test torque and a temperature parameter of the moment change device.

The test unit is therefore not directly affected by faulty actual value signals.

3. Summary

The ZFL moment change device system is a low-cost alternative to the planetary gear and rotordiff so far used as moment change device in main gearbox test rigs.

Economical test runs are rendered possible with an energy consumption of only approx. 10 % compared with the test load.

The good control characteristics of the ZFL technology enable operation of the test unit without any retroactive test rig interference.

For gearbox development, the new ZFL concept leaves sufficient margin for changing the test unit transmission ratio in the development phase without affecting any test rig components.

Tests can also be made with dynamic speed and torque variation.

The design as a universal test rig for several test units considerably increases the rate of utilization and at the same time reduces the total infrastructure cost.

The new ZFL main gearbox test rig concept has already been tested for the following test units:

- BO 105
- EC 135
- BK 117
- BELL 412
- MK 88
- SA 330
- MK 41
- UH 60
- MD 500

Test rig conversion for more test units will be possible at a later date without the exchange of any main components.

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