GEARBOX TEST RIG FOR SKYSPOTTER 150 HELICOPTER

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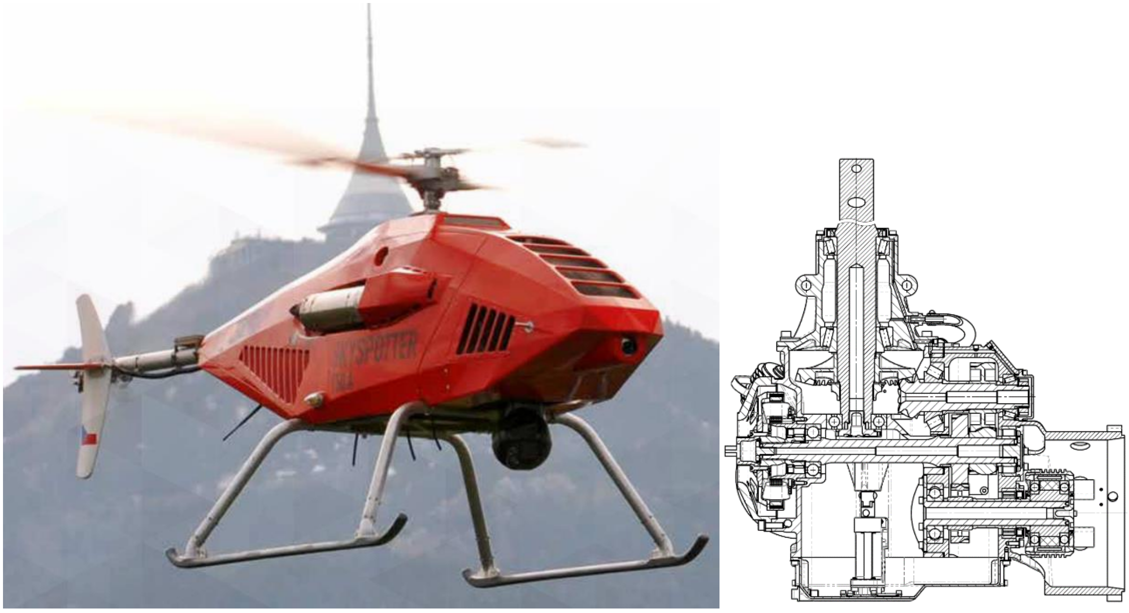
Abstract

SkySpotter 150 is an unmanned helicopter introduced recently by Modelárna LIAZ. The gearbox test rig developed for this helicopter has an innovative design. The drive is combined with a dynamometer and an axial force mechanism, which simulates the load from the main rotor on the gearbox output shaft. It leads to a special solution. The measurement methodology was developed including all sensors and design of the rig with a non-traditionally oriented dynamometer. The design has safety features that protect the test rig components and operator. The test rig is used for many tests during the development and improvement of the new helicopter generation. It also serves for verifying the gearbox parameters during its lifetime; it means tests of new gearboxes as well as technical diagnostic during periodical inspections.

Keywords

Angular gearbox; Test rig; Vibrations; Measurement.

Introduction



Source: [1] and its gearbox
Fig. 1: *SkySpotter 150*

The company VÚTS cooperates with Modelárna LIAZ on the development of the test station for angular gearboxes. The gearbox is mounted in the helicopter frame in the horizontal position, as shown in Fig. 1. The drones have weight limitations; therefore, the gearbox must be light, but also sufficiently rigid and safe. The gearbox must have a maximum ratio between weight and power. This cannot be achieved without extensive gearbox testing. Drones have great usage in the world nowadays. SkySpotter 150 should have wide usability in the military service (searching, monitoring, equipment transport and more) but also in the civil sector. The application can be found in firefighter units, geological exploration, rescue works and elsewhere. Its biggest advantage is the possibility to fly under difficult conditions for a long time.

1 Test Rig Design

The schematic diagram of the test rig is shown in Fig. 2. The scheme presents all main components used in the design and their locations. The main parts are a drive, two dynamometers and an axial force mechanism. The strain gauge flange sensors by Kistler are used for torque measurement.

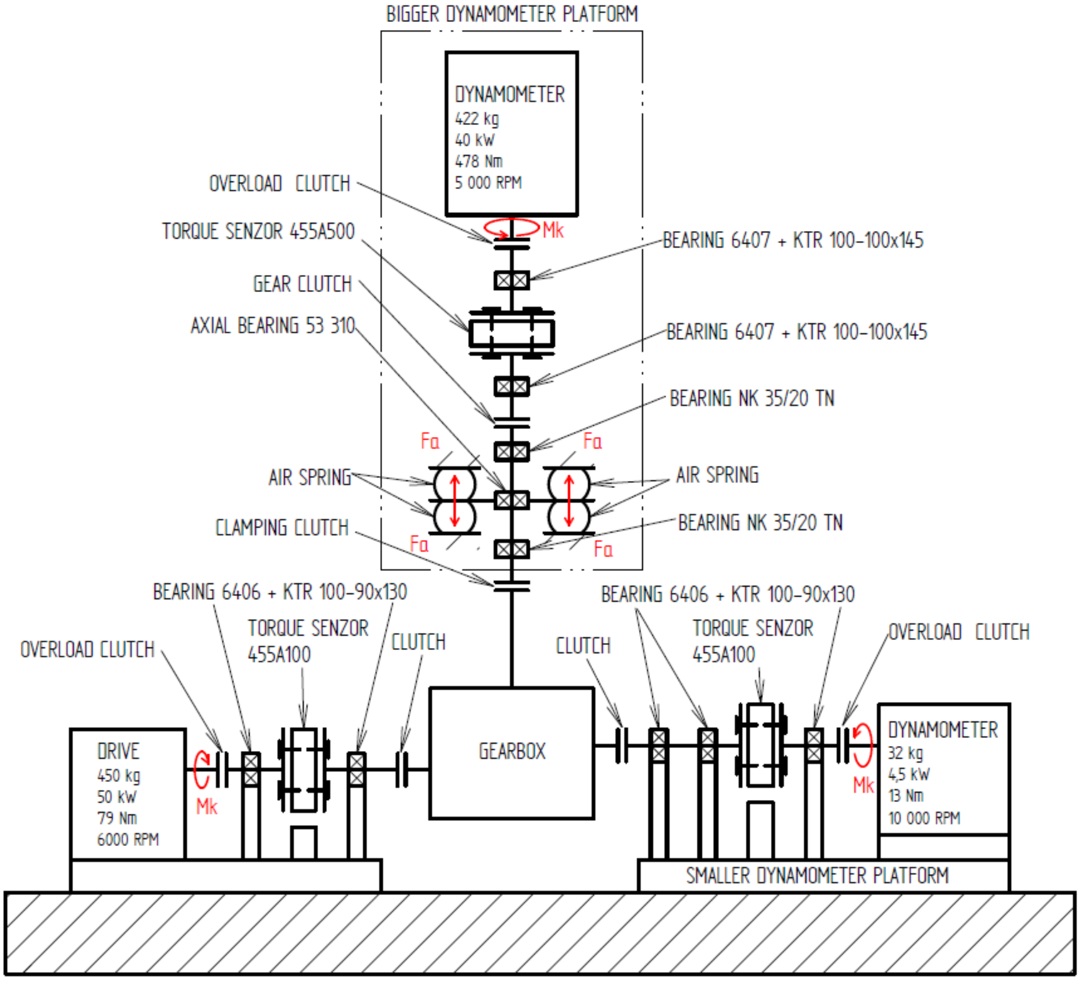


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Fig. 2: *Schematic diagram of the test rig*

The basis of the test rig consists of a welded frame shown in Fig. 3. All main parts are connected to the frame. The frame design allows bigger dynamometer mounting in the vertical or horizontal position, which means it is possible to test other gearbox types with different axis orientation or other helicopter components (for example an engine).

Source: Own

Fig. 3: *The test rig during assembling*

1.1 Drive and Dynamometer

The drive and the dynamometer were supplied by TES Vsetín. The drive is a standard product of this company. It is an asynchronous motor with a maximal power of 50 kW and an external air-cooling. The bigger dynamometer is Siemens asynchronous servomotor working as an electric brake (load). This part has a maximal braking power of 40 kW and it works in the vertical orientation. The dynamometer can work in this position due to a torque measurement realized by an external sensor and the usage of special bearings. The smaller dynamometer is also Siemens asynchronous servomotor, but its maximal power is only 4.5 kW.

1.2 Shaft and Bearings

The bearings are mounted through clamping sleeves or directly pressed to parts of the design for the proposed device. The shaft for the drive and the gearbox connection are designed as two parts shown in Fig. 4. The strain gauge flange for torque measurement is mounted between these two parts. A bearing 6406 is pressed on each part of the shaft. Bearings are mounted in clamping sleeves KTR 100 – 90 x 13.

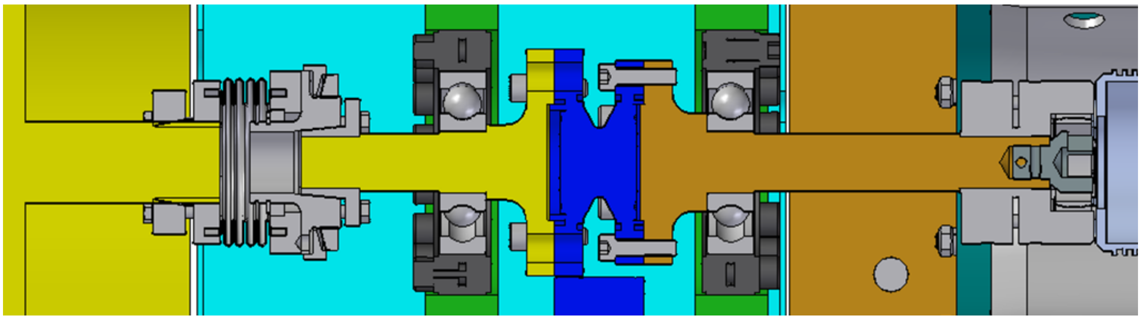

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Fig. 4: *Shaft connecting drive and gearbox*

The same solution was used for the shaft connecting the gearbox and the smaller dynamometer shown in Fig. 5. The only difference is in the usage of two bearings on the gearbox side shaft part. Two bearings are used because of the transportation possibility of the independent smaller dynamometer platform.

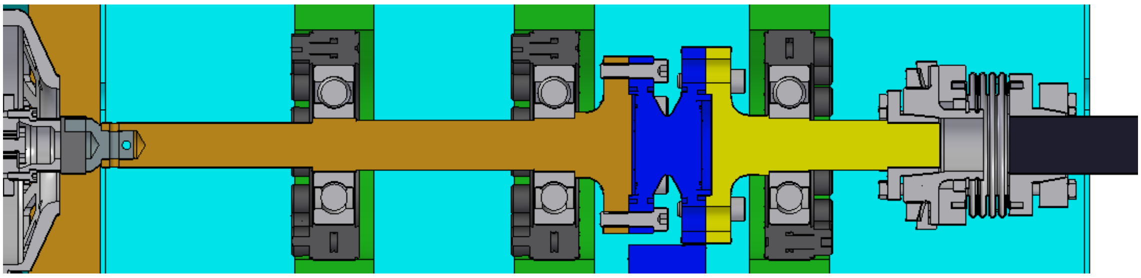

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Fig. 5: *Shaft connecting gearbox and smaller dynamometer*

The last shaft assembly for connecting the gearbox with the axial force mechanism and the bigger dynamometer in the vertical position is shown in Fig. 6. The shaft between the gearbox and the axial mechanism must enable its axial displacement. It is ensured by two bearings NK 32/20 TN, which are needle bearings without an inner ring. The shaft has a ground surface at the bearing location allowing the axial displacement. These bearings are pressed in parts of the frame. The axial force is transferred via axial bearings 53 310. The shaft between the axial force mechanism and the bigger dynamometer uses the same mounting as the drive shaft. The only difference is the application of larger bearings 6407 and clamping KTR 100 – 100 x 174.

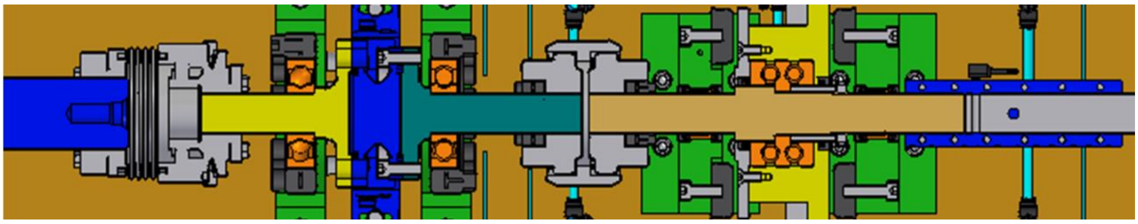

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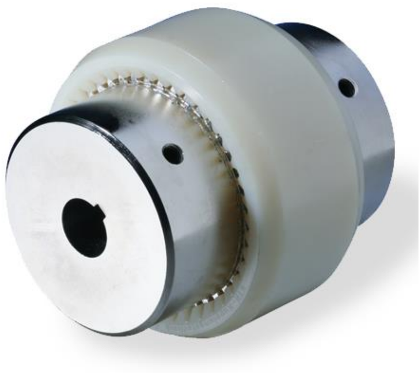
Fig. 6: *Shaft connecting axial force mechanism and bigger dynamometer*

1.3 Clutches

The gearbox is connected to the test station shafts by the same clutch as in the helicopter. Each shaft has a safety clutch (between the drive or the dynamometers and the torque sensors) ensuring the test station protection against overloading. The safety clutch disconnects the torque when an unexpected condition occurs.



Source: Own

Fig. 7: *Gear clutch [2]*

An aluminum clamp clutch transfers the axial force from the axial force mechanism to the gearbox output shaft. This material was chosen for the reason the gearbox shaft is undamaging. The clutch between the axial force mechanism and the bigger dynamometer torque sensor does not transfer the axial force because it could damage the torque sensor. Therefore, the gear clutch is used as shown in Fig. 7.

Each clutch was dimensioned for the maximal load of the drive and the dynamometer. The assembly was made by a conical clamping on a smooth shaft.

1.4 Axial Force Mechanism

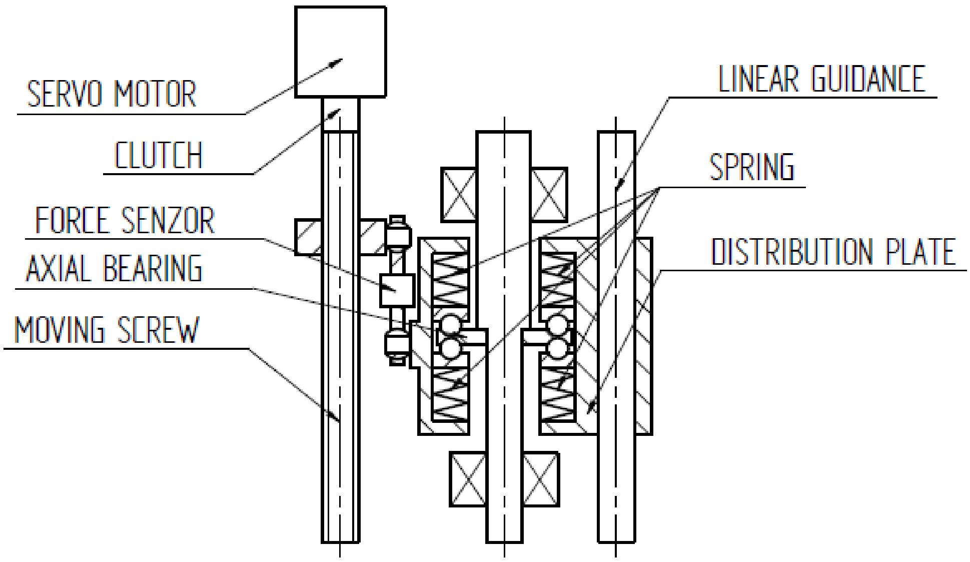


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Fig. 8: *Version with servomotor*

The first draft for the realization of the axial force loading mechanism was proposed for the use of the servomotor. The schematic diagram of this solution is shown in Fig 8. A moving screw driven by the servomotor produces the axial force acting in the axis of the output shaft.

The nut on the moving screw transfers the force to a distribution plate. Appropriate springs should be placed between the nut and the distribution plate because the moving screw angular movement without the springs is close to zero. The disadvantage of this solution is its higher price and complicated design.

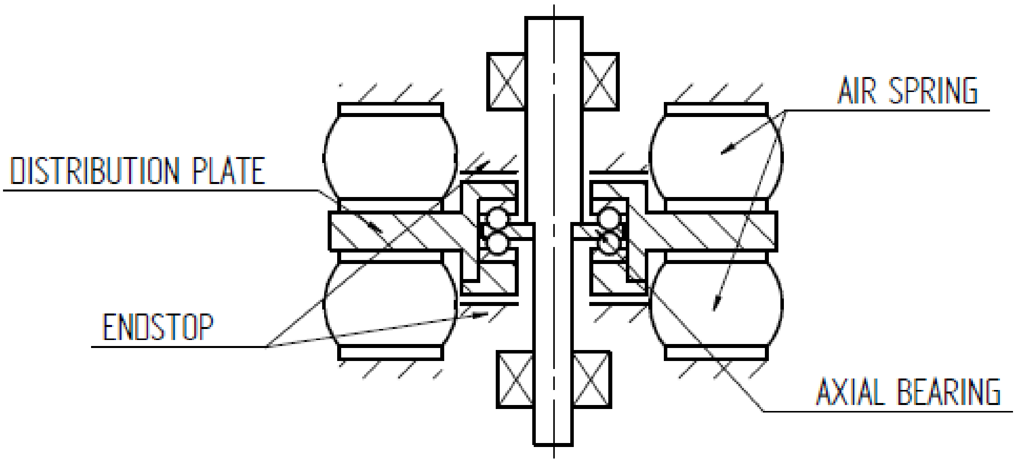

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Fig. 9: *Version with air springs*

A new solution with air springs was designed as a cheaper and simpler solution, as it is shown in Fig 9. The air springs directly produce the axial force. All parts of the mechanism must have sufficient stiffness for high force precision and repeatability. An air pressure sensor is connected to supply the circuit of each pair of the air springs. The axial force can be controlled and regulated by a proportional valve; the measured air pressure serves as the feedback signal. The distribution plate position is controlled via a displacement capacitive sensor. A linear guidance is not necessary to use because two pairs of the air springs lead the distribution plate. The mechanism has a mechanical endstop defining dead points of the distribution plate displacement for regimes without the compressed air and/or too big pressure.

Conclusion

Development and design of the test station for angular gearboxes with axial force and torque load is presented. This solution is primarily focused on testing of gearboxes used in unmanned helicopter developed by Modelárna LIAZ company. The test station can load the gearbox by defined torque and axial force on the output shaft and simultaneously measures actual values of torque, angular speed, axial force, vibrations, temperature and noise.

Acknowledgements

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Literature

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TESTOVACÍ ZAŘÍZENÍ PRO PŘEVODOVKY VRTULNÍKU SKYSPOTTER 150

Bezpilotní vrtulník SkySpotter 150 je vyvinut firmou Modelárna LIAZ. Testovací zařízení pro převodovky vrtulníku nejsou standartní pracoviště. Je zde pohon provázaný s dynamometrem a axiálním zatěžovacím mechanismem simulujícím zatížení od rotoru na výstupním hřídeli převodovky. Proto je potřeba speciálního pracoviště. Byl navržen měřící řetězec včetně jednotlivých snímačů a konstrukce se speciální orientací dynamometru. Konstrukce má bezpečnostní prvky, které chrání testovací zařízení a její obsluhu. Testovací pracoviště je využito k vývoji nových generací vrtulníku. Dále slouží k ověřování parametrů nových převodovek, ale i k technické diagnostice převodovek při opakovaných kontrolách.

TESTANLAGE FÜR DIE GETRIEBE DES HUBSCHRAUBERS SKYSPOTTER 150

SkySpotter ist ein unbemannter Hubschrauber und wurde von der Firma Modelárna LIAZ entwickelt. Bei der Testanlage für die Getriebe des Hubschraubers handelt es sich um keinen Standardarbeitsplatz. Hier wird der Antrieb mit einem Dynamometer und einem Belastungsmechanismus verbunden, wobei der Belastungsmechanismus eine Belastung vom Rotor auf die Ausgangswelle des Getriebes simuliert. Daher bedarf es eines speziellen Arbeitsbereichs. Es wurden eine Messkette inklusive einzelner Abtaster sowie eine Konstruktion mit einem speziellen Orientierungsdynamometer entworfen. Die Konstruktion verfügt über Sicherheitselemente, welche die Testanlage und deren Bedienung schützt. Die Testanlage wird zur Entwicklung neuer Helikoptergenerationen genutzt. Weiter dient sie zur Überprüfung der Parameter neuer Getriebe, aber auch zur technischen Diagnostik der Getriebe bei wiederholten Kontrollen.

STANOWISKO BADAWCZE PRZEKŁADNI ŚMIGŁOWCA SKYSPOTTER 150

SkySpotter 150 to bezzałogowy śmigłowiec opracowany przez firmę Modelárna LIAZ. Stanowiska badawcze przekładni śmigłowca nie mają standardowej konstrukcji. Napęd jest połączony z dynamometrem i mechanizmem obciążenia osiowego, który symuluje obciążenie głównego wirnika na wale wyjściowym przekładni. Z tego powodu potrzebne jest zastosowanie specjalnego stanowiska. Opracowano tor pomiarowy obejmujący poszczególne czujniki oraz konstrukcję ze specjalnie ukierunkowanym dynamometrem. Konstrukcja posiada elementy bezpieczeństwa, które chronią stanowisko badawcze i jego obsługę. Stanowisko badawcze jest wykorzystywane do projektowania śmigłowców nowej generacji. Ponadto służy ono również do weryfikacji parametrów nowych przekładni, a także diagnostyki technicznej przekładni podczas przeglądów okresowych.