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FULL SCALE FATIGUE TEST OF NEW UNDERCARRIAGE FOR COMMUTER AIRCRAFT

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Abstract

Fatigue testing of the new main landing gear for the PZL M28 aircraft was conducted in Polskie Zakłady Lotnicze Sp. z o.o. in Mielec using MTS Aero 90-LT system. The test was conducted in a flight-by-flight manner with loads resulting from landing, taxiing, maneuvering and braking. The undercarriage structure is made of high tensile strength low alloy steel. FEM analyses were performed before the tests in order to find critical points and to obtain information about loads which may be neglected. During the test fatigue damage was observed, which led to splitting the test into two separate tests performed in independent rigs: the test of the undercarriage leg and the test of the shock absorber.

1. INTRODUCTION

In order to establish the service life of the new main landing gear for the PZL M28 aircraft, the Full Scale Fatigue Test was performed at the test laboratory of Polskie Zakłady Lotnicze Sp. z o.o. in Mielec. The landing gear (see Fig. 1) was designed for operation on prepared and unprepared airfields. Maximum take-off and landing weight of the PZL M28, which is certified in commuter category, is 7500 kg (16535 lbs.). The undercarriage is of a fixed, tricycle type.

Fig. 1. The new main landing gear of PZL M28 aircraft

The main landing gear is of an articulating type with a braked wheel. It is mounted at the ends of the main landing gear beam, which is part of the fuselage structure. The main parts of the landing gear are:

- leg – see Fig. 2;
- oleo-pneumatic shock absorber – see Fig. 3;
- wheel axle;
- wheel with a brake.

The leg and shock absorber structure is made of high tensile strength low alloy steel 4330V – see Table 1 for chemical composition and Table 2 for mechanical properties. The leg consists of three parts welded using the electron beam welding method.

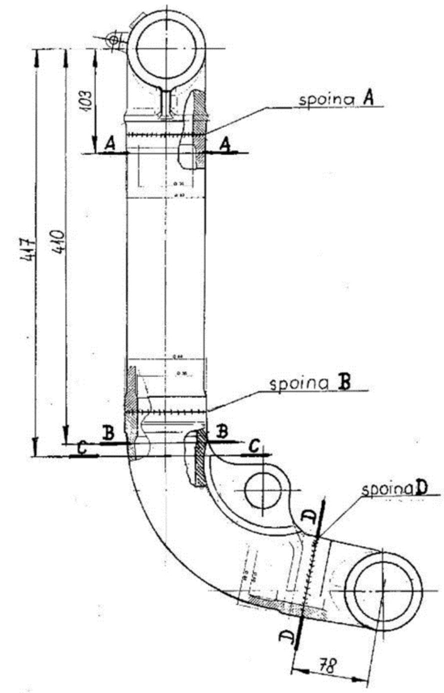

Fig. 2. The leg of the new landing gear

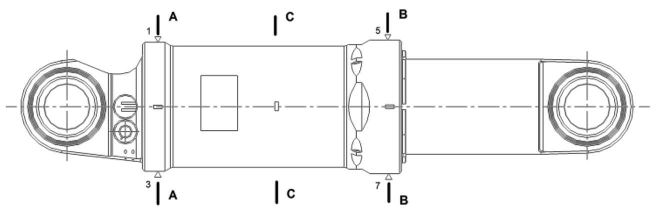

Fig. 3. The oleo-pneumatic shock absorber of the new landing gear

Table 1. Chemical composition of 4330V steel [1].

C [%]	Si [%]	Mn [%]	P_{max}[%]	S_{max}[%]	Cr [%]	Ni [%]	V [%]
0.30÷0.34	0.15÷0.35	0.75÷1.00	0.025	0.010	0.75÷1.00	1.65÷2.00	0.05÷0.10

Table 2. Heat treatment conditions and tensile properties of 4330V steel **[2]**

Heat treatment conditions	Ultimate tensile strength Ftu [MPa]
I. Normalize at 871÷927°C, air cool. II. Austenitize at 843÷871°C, oil quench. III. Tempering at 260÷371°C.	1517÷1655

Note: For longitudinal direction, for Ftu = 1559 MPa, 0.2% yield strength is 1297 MPa, elongation 13.0%, and cross section reduction 58.3%.

2. FATIGUE TEST

The main landing gear fatigue test was performed at the structural tests laboratory of Polskie Zakłady Lotnicze Sp. z o.o. The right-hand gear leg was attached to the rig as in the aircraft – see Fig. 4. The wheel axle was loaded through the wheel bearings. The braking moment was applied to the wheel axle as a pair of forces, which can be seen in Fig. 4. The applied loads were:

- vertical force,
- side force,
- fore and aft force,
- braking moment.

The following loads have been taken into account in the test program: loads resulting from taxiing on prepared and unprepared airfields, maneuvering (side force), braking and landing, as required by the MIL-A-8866C norm. The load spectrum (vertical loads) due to taxiing on an unprepared airfield was measured during the taxiing tests on the emergency strip of the Mielec airfield.

Fig. 4. The main landing gear on a stand during fatigue testing (front-side view). The test is performed in the structural tests laboratory of Polskie Zakłady Lotnicze Sp. z o.o.. The test program **[3]** ***was adapted from that prepared by the Institute of Aviation in Warsaw for the previous main landing gear***

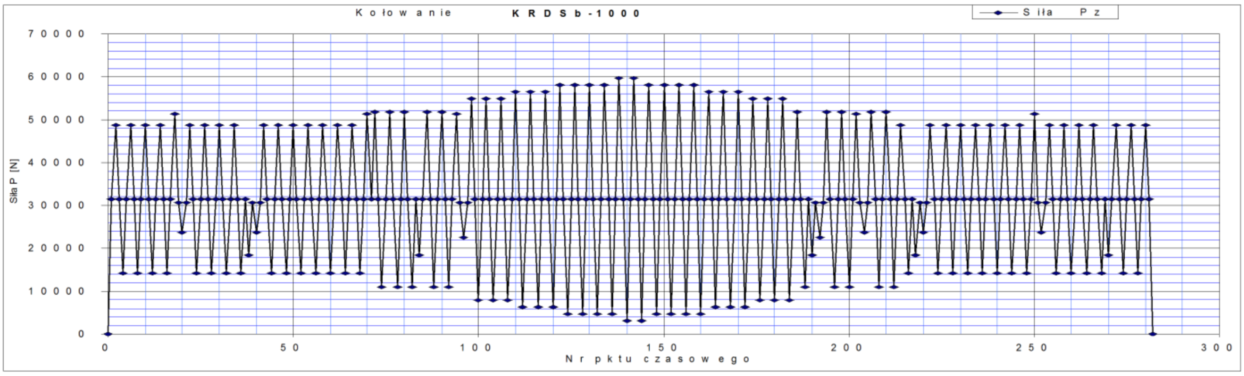

Fig. 5. A typical plot of vertical force during one flight in the new main gear fatigue test

The test was performed in a flight-by-flight manner ([3]). One flight contained about 50 cycles – see Fig. 5 for vertical force variation in a sample flight. Because there were 6 applied taxiing load levels and 10 landing load levels, there were 14 load combinations defining the particular flights. The full spectrum of flights was performed in 1000 flights.

The loading system was the MTS Aero 90-LT with four loading channels.

Twelve strain gauges were installed on the leg in order to monitor the structural integrity in the most heavily loaded places and to check the calculated stress levels. Initially, two sections of the leg were recognized as critical:

- section below the upper weld region with maximum calculated stress level of 498 MPa (section A-A in Fig. 2),
- section above the lug for mounting the shock-absorber with maximum calculated stress level of 473 MPa (section B-B in Fig. 2).

The shock absorber was omitted.

During the test a crack occured in the shock-absorber cylinder – see Fig. 6. The FEM analysis of the damaged area showed a local stress concentration due to a small radius of the undercut at the end of the thread for mounting a nut – see Fig. 7.

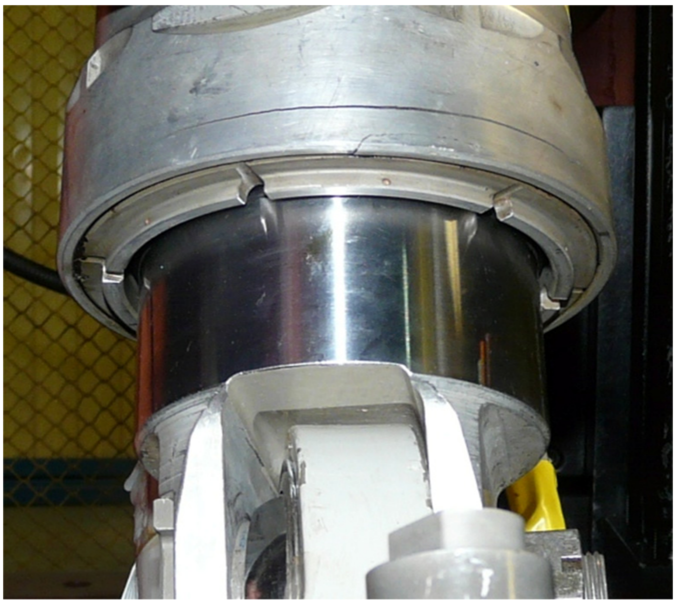

Fig. 6. The new landing gear shock absorber with a visible crack at the bottom end of the cylinder

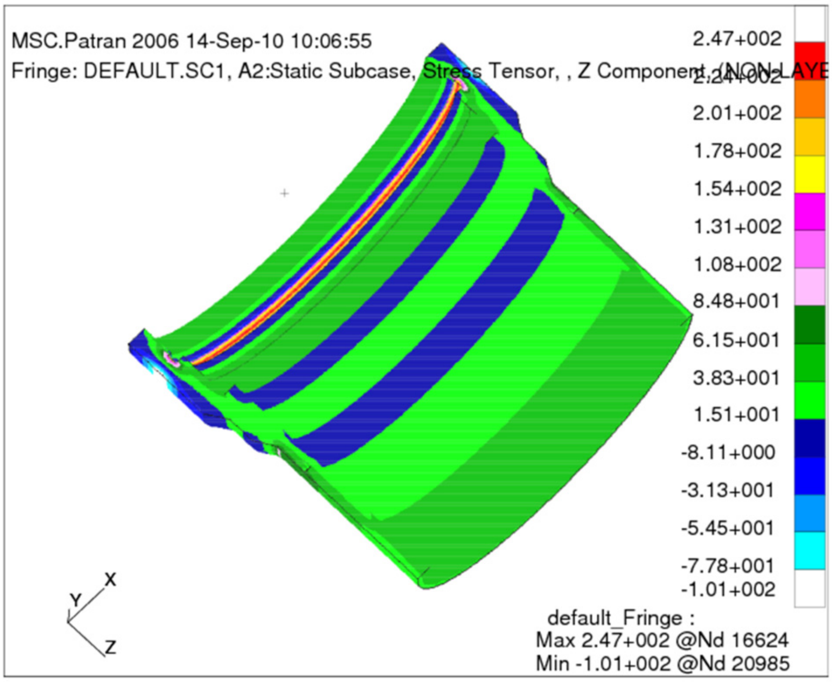

Fig. 7. A stress map of the loaded shock absorber cylinder inner surface as a FEM analysis result. The cylinder is loaded by internal oil pressure and the force acting on the nut

It was determined to continue the test for the landing gear with a mock-up shock absorber, in order to gain time to develop and introduce design changes to the shock absorber. The modified shock absorber was tested at a separate rig – see Fig. 8. Only one loading channel was required ([4]). The axial force spectrum from the Full Scale Fatigue Test was applied – see Fig. 9.

Fig. 8. The modified shock absorber on a stand during fatigue testing

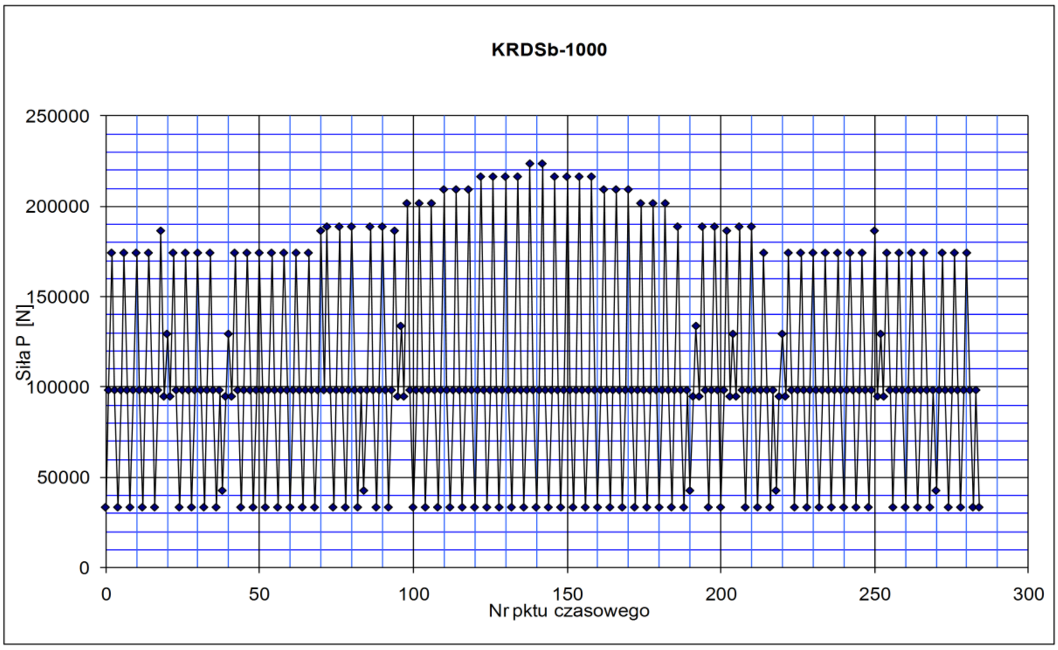

Fig. 9. The axial force spectrum applied in the shock absorber fatigue test

Ten strain gauges were installed on the cylinder in order to check the calculated stress levels and monitor the structural integrity at the most heavily loaded places.

During the Full Scale Fatigue Test of the new main landing gear and the fatigue test of the modified shock absorber, cracks in other parts were observed. However, it is relatively easy to replace these parts during airplane operation.

The test results for the leg have been satisfactory so far. The test of the modified shock absorber is going on and will be accomplished soon.

3. CONCLUSIONS

The fatigue tests of the new main landing gear for PZL M28 aircraft showed significantly longer fatigue life compared with the previous structure (more than 3 times). It is worthy to emphasizing that:

(1) the new landing gear is fully interchangeable with the previous structure, and the same wheel, brake and wheel axle were used;

(2) the total main landing gear weight increase was below 6 percent.

The author wishes to thank the staff of the test laboratory in Polskie Zakłady Lotnicze in Mielec, and especially Mr. Jerzy Chodur.

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