STATIC STABILITY TEST OF WING WITH USING SCALE-BEAM SYSTEM

Peter Žoffčak – Stanislav Fábry

The experience gained from the operation of aircraft show that the failure of the structure airframes are much more severe than for land vehicles. Any problems experienced by the airframe can lead to a serious accident involving a threat to human life or major property damage. Therefore, in the current aviation law is great emphasis on strength calculations for various parts of the airframe and tests of these parts. One of the tests of wings is static test with scale-beam system.

K e y w o r d s: scale-beam system

1 INTRODUCTION

Small sport and recreational aircraft are widely used these days. A wide range of small sport aircrafts is increasing by new types. Each of these aircraft must pass airworthiness certification, which includes static tests of construction.

Category of small sport aircraft requires a specific approach to solving problems. The difference from the test procedure of large transport aircraft is mainly in simplification of many influences and less demands on the test process.

The wing is the key part of the airframe. Static wing test of small sport aircraft can be performed in different ways. One of the ways is scale-beam utilization test. Scale-beam system offers certain advantages that the tests are welcome for the simplicity of the process at small wings.

2 SCALE-BEAM SYSTEM

Scale-beam system can simulate the load acting to the wing of an aircraft. There is used a continuous load replacing, coming from aerodynamic and mass forces, by system of single forces whose values result from the continuous load. Forces can be differently introduced not only along the length of wing, but also along the depth of wing. Load which acts to the structure of airframe (wing, fuselage, tail, ...) can be introduced by the tensile scale-beam systems.

Scale-beam system is used in cases where:

- one force has to be replaced by several elements;
- force from the loading mechanism has to be unevenly distributed with unequal scale-beams arms;
- distributed loads or load inertial forces should be replaced by point forces.

The benefits of scale-beam systems include the ability to observe the behavior of the structure during the test process and, if necessary, based on observation of loading, can be test process stopped immediately. This makes it possible to reveal the probable location of the initial failure, whose resources are then analyzed.

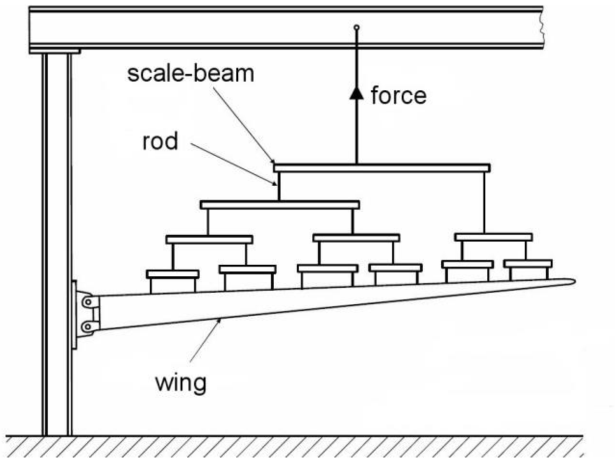

Fig. 1 Schema of single wing test

In recent decades, is for airframe testing frequently used method of mounting with floating body. Free hanging as far as possible describes the real situation in the introduction of aerodynamic and inertial forces in the structure. It allows for rocking the test piece during the measuring process. There is usually a need to introduce balancing forces and moments, which is a complicated self-realization and the testing process.

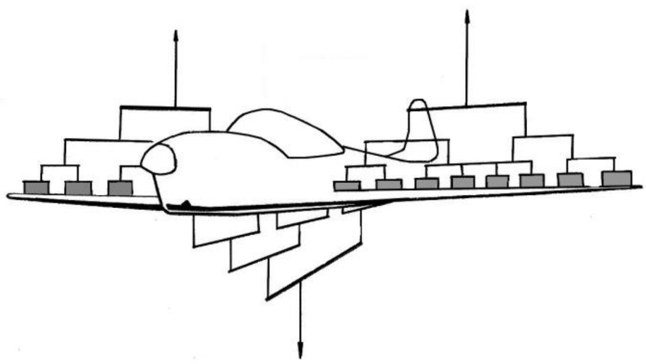

Fig. 2 Free hanging of tested aircraft

3 DESIGN OF SCALE-BEAM SYSTEM

It should be stated that the scale-beam systems design run parallel with general arrangement tests design, taking into account the range and meaning of deformations. At the same time it is also applied to design the method of loading.

The procedure for designing the scale-beam systems is in terms of other engineering disciplines. One of the best procedures can be as follows:

a) draw diagrams of the depth of individual sections loading;

b) draw diagrams of the range and its eventual modification with respect to bending deformations at less rigid wings;

c) sizing rods and rocker arms according to individual strength, by operating torques and forces.

At the point b) it is necessary to point out that the usual requirement for bending of less rigid wing tends to forces introduced into the individual sections are perpendicular to the creased lines. Scale-beam systems sizing in strength testing labs is done according to standards. The universal scale-beams systems use an upper limit maximum bending load capacity beam balance, resulting from a yaw control.

Having the size of central load torque and the intended wings test procedure, should be sized fixture of wings and load mechanism.

4 PROCEEDINGS OF THE TEST

First, it is necessary to ensure proper fit of the wing. If the wing is tested alone, thus not tested the whole plane where the wing is attached to the airframe, it is necessary to use an installation body. This part is specific to each wing structure and its attachment to the fuselage. Stiffness of the mount frame itself could also influence test of the wing. In particular, it is necessary to take into account what arm is wing attached to a frame like, because the length of this arm is reflected in the size of the bending moment. This must be taken into account already in the calculation.

The most common wing mount to the scale-beam systems is sleeve method. Sleeve copies leaf surface, or can by glued with fixing hinges. These elements are then secured to the rod to capture the scale-beams. The deployment of these elements is already determined at the design proposal of the scale-beam system.

Each rod is fixed to the beam arm according to the calculated position. Beam arms are usually made from metal profiles. When scale-beam system is installed it has to be taken into account that in larger deformations of tested wings the particular parts are threaten by contact of surrounding parts, scale-beam arms, frame or grid.

To produce the power a load mechanism is needed. For large aircrafts and their components are used hydraulic cylinders. They use fluid pressure to produce load.

For testing small components, the cylinders are unnecessarily expensive and operationally difficult. For this category suit mechanical hoists. They provide a simple way of load application and they have relatively high strength and a wide range of movement. The disadvantage can be greater speed of loading steps. For easier control can also be used electric hoist. Another suitable type of loading mechanism is an electric actuator. Its advantage is ease of use and installation. It is used only for smaller loads and it has a disadvantage in the limited regulation speed of actuator stroke.

After mounting of grid components and wing, installation of necessary measuring and recording devices, load elements and components checking, there can be started loading procedure. The first load is done for 30-40% of the maximal load and it serves as a control of the correct functioning of the system, and also because of doing of preliminary measurement of the structure tension. The second load is performed for about 67% of the maximal load and it characterize operating load. There is measured the strain and tension in the wing structure. Result of this test is a graph of the load test time proceeding. The force is controlled by loading device. Special attention is given during loading to the points of growing stress concentration, measured by the strain gauges. Subsequently forwards the load by 100% of computational value. The test sequence is smooth and this phase is the most important, because the result should confirm the suitability of chosen materials and construction solutions for given computational assumptions. The final phase of testing is loading up to failure of the structure.

The technical possibilities of strength testing are restricted by the emergence and initial failure. The results of the test are charts of load dependence, which can be read in the way to show the extent of load to the extent of deformation. The entire testing process used to be carried out for all flight modes that are selected and calculated by the wing test program in compliance with the regulations.

BIBLIOGRAPHY

[1] Drexler, J.: Strenght ant tests of airframes, Military academy of Antonin Zapotocky, Brno

[2] Hub, J.: Methods of tests aircraft airframes, Military University, Brno 2012

AUTHOR(S)´ ADDRESS(ES)

Zoffcak Peter, Eng.
p.zoffcak@gmail.com
Fábry Stanislav, Eng., PhD.
Letecká fakulta TUKE
Rampová 7, 040 21 Košice
stanislav.fabry@tuke.sk