AIRPLANE STRUCTURE FATIGUE TESTING METHODS

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Summary. The presented article deals with the fatigue testing of aircraft structures. The fatigue process has certain stages, his character is cumulative and irreversible. The most important data about the fatigue resistance of structures can be obtained only by fatigue tests. Fatigue tests are performed on samples, models and entire structures. The aim in the fatigue test is simulate an operation loading. The selected method of the loading affects the credibility of the results. Applying all knowledge is implemented in the draft program loading of the fatigue test. In this draft are described the basic procedures that are part of each fatigue test aircraft structures.

Keywords: fatigue testing, aircraft structure

1. INTRODUCTION

Nowadays with the increasing globalisation of the world connected with exploiting of air transport, in the first place puts emphasis on the safety of aircraft. Long term statistics show that the largest percentage of faults is occurring in operation caused by fatigue. Therefore, fatigue testing of aircraft structure is still actual problem. Experimental testing is still an irreplaceable part of demonstrating resistance to fatigue. Its importance is growing with the development of new materials used in the aircraft structure.

2. FATIGUE OF AIRCRAFT STRUCTURES

Fatigue of materials is a certain analogy with the word fatigue in the normal sense. After a certain time occur to irreversible changes, which result in the fracture, if the object is exposed to variable loads. The violation of the object occurs even in periodically variable load causing tension considerably lower than the yield strength of the material. The fatigue is cumulative and irreversible. The fatigue starts to tangibly show up at the end, which may result in dangerous circumstances. It reduces fatigue life of aircraft structures and can cause dangerous accidents, including human losses.

The process of fatigue can be divided into three successive stages:

1. stage of changes the mechanical properties,
2. stage of fatigue crack initiation,
3. stage of fatigue crack propagation ending fatigue fractures.

It is not possible to determine the exact interface between the individual stages, it depends on the specific determination [1].

2.1. Fatigue tests

Fatigue tests constitute one of the most important stages in the design of a successful aircraft structures, because the most important data can only be obtained in the experiment. In these tests, we try to simulate as closely as possible real operating conditions. We strive to achieve a very close approximation of the experimental results with later obtained data from real structures in the operation. But still most perfect process of verification lifetime, reliability and functionality of all elements of the structure is considered sufficiently long trial operation.

In experimental tests there are a number of fundamental advantages against operation testing:

- the option to choose any mode of operation,
- choose strict conditions which must the construction withstand while keeping the lifetime,
- no need to be in the actual operation,
- the possibility to continue the test during failure of some components or with incompleteness,
- the test is faster and more easily realizable,
- there is a more precise detection of behaviour of individual components,
- limiting the influence of the human factor.

On the other hand, laboratory simulates operational loads is a very complex problem with these disadvantages:

- expense and technical difficulty,
- the problem faithful simulation of operating conditions,
- problems in determining the realm and direction of external forces.

We distinguish these types of tests:

1. The testing of samples - basic test by means of which detect the fatigue properties of the material. Tests carried out on the sample itself allow only limited generalization of the results to design parts and assemblies. For research in the field of aviation are used by various types of test samples such as samples for evaluation of properties of riveted joints (Fig. 1).

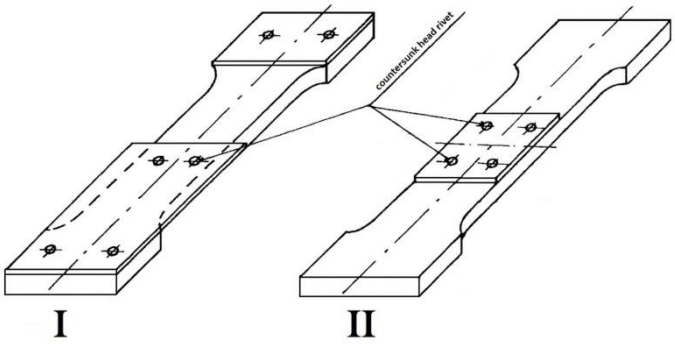

Figure 1 Samples for verifying the characteristics of riveted joints [2]

2. The testing of model - in result of difficult production of the whole structure, approach to the simplification of the whole structure on the model (Fig. 2). Proper execution of fatigue test of the model allows obtaining results that correspond with some precision the decisive places to the real construction.

Figure 2 The rear fuselage for fatigue testing [3]

3. The testing of real structures - carried out on the construction of full-scale (Fig. 3). These tests are used to demonstrate the technical life, as much as possible approaching reality.

Figure 3 Fatigue testing of the entire aircraft [2]

Manner of loading at the fatigue tests:

1. Loading tests on one loading level - apply for simple assemblies such as the control system, ailerons and rudder, the means for increasing lift, speed brakes. Typically, these tests are carried out at least three to four loading levels. Use these tests to demonstrate the real lifetime of whole construction is now outdated. The following diagram (Fig. 4) shows the load cycles on one level for loading landing gear, wing and fuselage during testing of the prototype L-39.

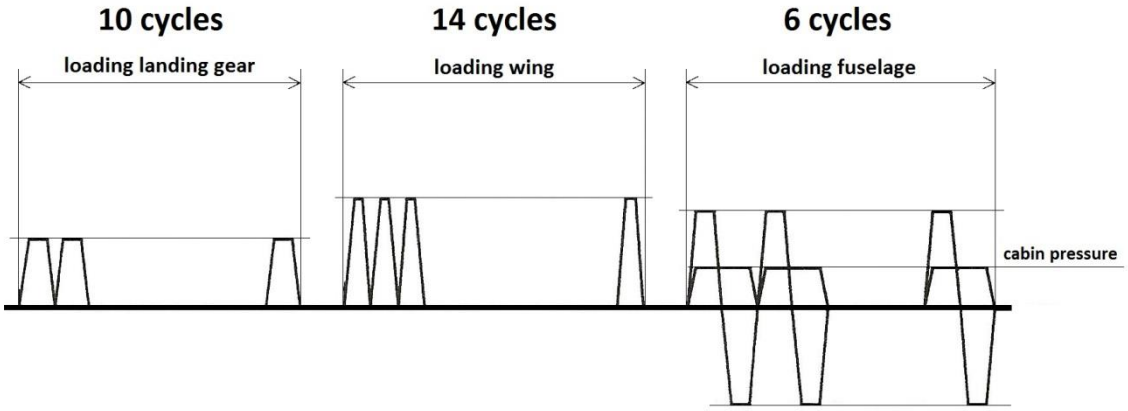

Figure 4 Loading cycles used for the prototype aircraft L-39 [2]

2. Loading tests with program blocks - used mainly for experimental demonstration of more complicated construction units such as the landing gear, the wing and tail surfaces. In the tests, the operational range is replaced by 3 to 12 burdensome levels. In practice, the number of cycles distributes to a number of equal parts, of which compiles the entire program unit. It is repeated during test until the fracture components. Great influence on the result have sequence of loads in the block, this impact can be seen in the picture (Fig. 5).

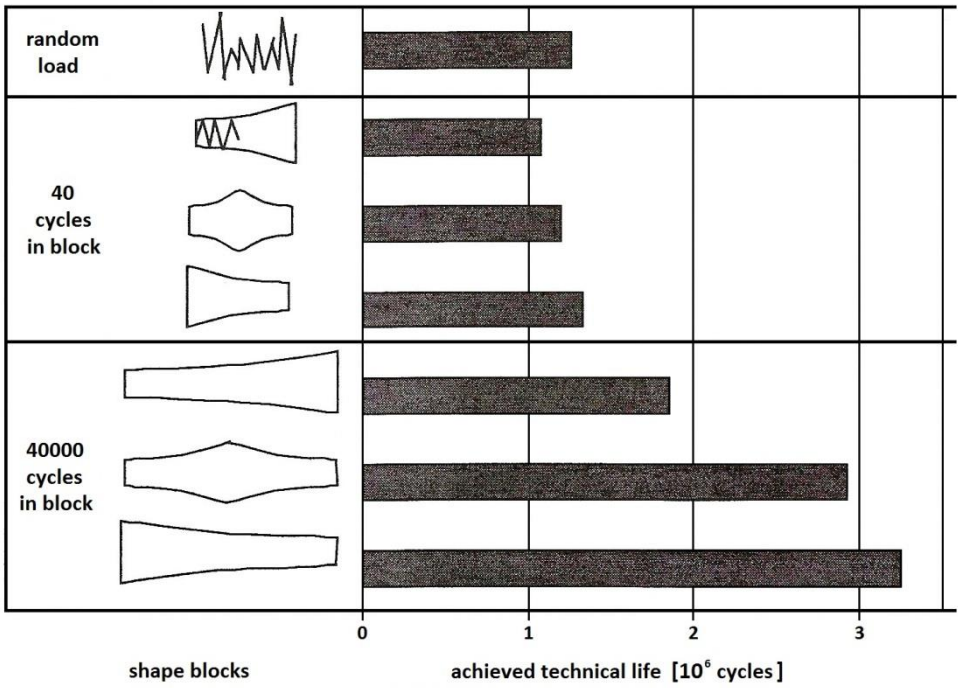

Figure 5 The dependence of the achieved technical life on the shape and length of the program block [2]

3. Load tests with random load - the time course of most operational loads are random processes whose essential characteristic is the impossibility to predict their course. By using tests with random load leads to convergence to the real operation. This leads to obtaining objective information about fatigue life [1].

3. DRAFT PROGRAM LOADING OF FATIGUE TEST

The draft program encompasses a range of procedures which lead to fulfillment of set goal. Of all mechanical tests, just fatigue tests provide to each other significantly different results, which depend on many factors. The aim of this proposal is to develop a draft program for the loading small passenger plane, which is loaded mainly by gusts. The draft is implemented with respect to the requirement of simplicity and the resulting economic modesty [1].

3.1. Determination of operating load

Reliable determination of operating loads is a fundamental prerequisite for obtaining results that will correspond to the real operation. The theoretical determination of the traffic load in complex structures such as the aircraft is not possible, it would be necessary to include random environmental influences, characteristics of service, manufacturing inaccuracies and the like.

Own measurements operation processes are performed on the aircraft of the same category as that for which the draft is carried out. Very difficult task in measuring is forming typical operating conditions as a source of typical operating loads. Similarly, a complex issue is the choice of the type, location and number of sensors, which are measured operating conditions.

The processing of measured and the recorded signal characterizing the operating process is carried out in special laboratories with the required computer equipment. In substance it is the transformation of all of the recorded information to the signal. This signal will be in experimental test using a control computer ensures the loading of a tested construction.

In general, the signal processing and its difficulty depend on the way in which we want to loading the given structure. A compromise is a way of loading with program blocks that will be chosen for our draft. This method allows achieve sufficiently reliable results while maintaining the simplicity of

managing fatigue test. Transmitting data of so-called generalized flight cycle to the graph time course of the overloading (Fig. 6) enables the visibility of variable amplitude loading of aircraft structures.

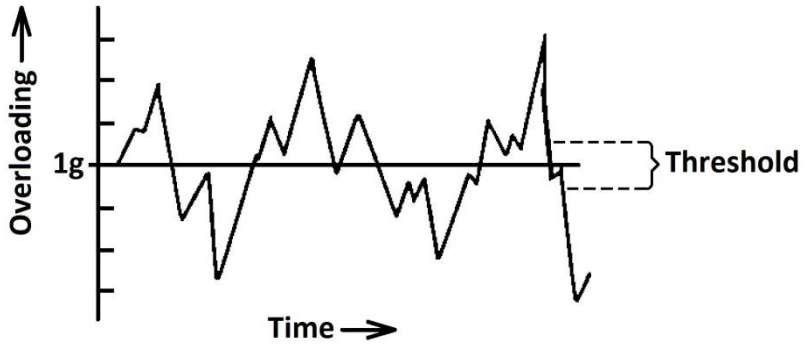

Figure 6 The course of the overloading small aircraft from gust and maneuvers [1]

For the fatigue test will be selected eight loading levels, which according to several sources are the minimum number to achieve acceptable results. Therefore, in the draft are required based on measured operational processes set eight loading levels that approximate operating range. Subsequently split number of cycles any loading level on a number of equal parts, from which drawing up a full program unit. As an initial must be chosen approximately the mean value of loading. In the picture (Fig. 7) are shown for simplicity, only three loading levels, which together form the program unit of loading. The ready waveform is represented by the programming unit that will constantly repeat during the test [1].

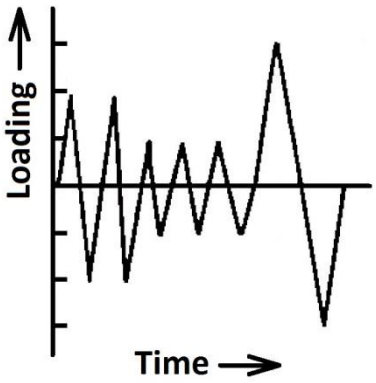

Figure 7 The course of the loading program unit at fatigue test of the small aircraft[1]

3.2. Preparation the fatigue test

Testing is done in laboratory conditions and it is difficult to the space and technical equipment. Task is to set up a test in order to implement the load generated in the same places as acting on the construction in the operation, while ensuring almost continuous implementation of forces. For simplicity we choose for our draft the introduction of forces in the one direction. This allows us to use simple canvas hangings that are glued directly on the skin. As the source of the load will be used hydraulic cylinders controlled by a computer. Are chosen three hydraulic cylinders, and expansion forces to the individual hangings will take place by the lever systems.

From the aspect of the draft measured value are selected two essential values. The first value is a loading force that will be measured using a load cell, which to be inserted between each hydraulic cylinder and lever systems. For each hydraulic cylinder we must to ensure, in addition inlet and outlet of hydraulic fluid, also signal from the control computer for their operation. The second value will be tension obtained from the measurement of local deformations by using strain gauges. At the small passenger plane is to use several dozen proportionate. Strain gauges are positioned in places where we want to know the tension, and provide us with information about tension response of the structure.

Data from the load cells and strain gauges are in the form of electrical signals fed to the measuring computer hardware, which will be recorded during the test. The control computer simultaneously with generating control signals for the hydraulic members also communicates with the recording computer. This is made up the feedback enabling ensure the required loading process [1].

3.3. Realization of fatigue test

Fatigue test may start realizing only after completion of all preparatory works and subsequent final inspection. The arrangement of fatigue test of small passenger plane is in the image (Fig. 8). The whole course of the test is controlled and also checked by the control computer. This computer provides to the operator information about course of the test, or allows intervening also in the testing process.

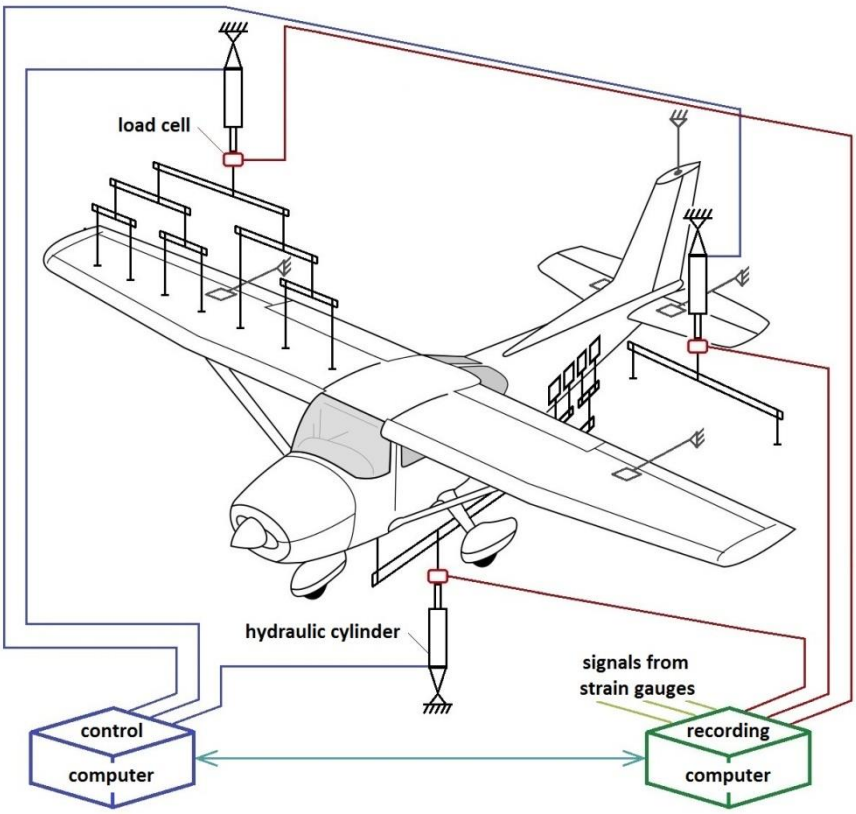

Figure 8 The arrangement of the fatigue test of the small passenger plane [1]

During the test, the recording computer records the individual waveforms of measured values as well as the entire control process. In the test, loading process runs up to the time criticality construction, which characterizes a significant fracture that disables further continuation [1].

3.4. Evaluation of fatigue test

Processing of all recorded data is performed by computers with appropriate software. Damaged areas highlight to critical points of the construction which during operation will be necessary to pay attention.

The basic result of the fatigue test is the number of cycles when occurs failure of the construction. Based on processing all aspects identified in testing aircraft is evaluates compliance with the requirements of relevant legislation for demonstrating the technical life of the aircraft structures. It determines the technical life of the aircraft at flying hours during which is secured a safe and reliable operation. The procedure described in this draft is used to experimentally determine the technical life.

It can be used in the opposite philosophy – establish technical life based on user requirements and experimentally proving that the structure complies [1].

4. LITERATURE LIST

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