The Modular Test Stand for Fatigue Testing of Aeronautical Structures – Design Phase

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Abstract

The Modular Test Stand for Fatigue Testing of Aeronautical Structures is presented in the paper. Several different fatigue tests can be executed at the same time by means on this stand. In this way authors intend to diminish cost of fatigue test and makes it affordable for low cost projects eg. student projects. Authors describe an essential assumptions and limitations as well as design phase where they tried to meet them.

INTRODUCTION

Fatigue behavior investigation of structures can be a significant problem in some areas of mechanical engineering. Especially sensitive to fatigue damage are aeronautical structures. The reason for this are mass limitation and variable repeated load acting the flying structures. The fatigue phenomenon can be hardly predicted in analytical way. The analytical solution can be achieved for samples and simple structures. Results of fatigue calculations for more complex structures have unaccepted level of precision and should be validated by a fatigue test. The fatigue test is a common way to prove a fatigue durability of a structure or can provide data for validation of numerical or analytical analyses. In contrast to static mechanical tests fatigue tests are usually more complicated and it teaks longer to complete a test. In result the fatigue test are more expensive than a static test. Cost of a fatigue test is a real obstacle especially in a small low cost project e.g. students research.

The proposed Modular Test Stand (MTD) is a typical aeronautical structure subject to fatigue load. The idea is that a test article consists of one, two or three independent segments connected together in such a way that all can be tested in the same time. Each section is designed as a typical aeronautical structure (e.g. wing section). It consists of a two spars, upper and lower surfaces (skin) and ribs. The idea is that only skin areas (upper and lower) or a connections between skin and spars or skin and ribs are subject of the test. The MTD is a perfect tool for testing:

- connection methods (riveting, bonding, etc.)
- composite patch repairs
- structural Health Monitoring (systems, sensors, ect.)

in typical for aeronautical structures conditions (fatigue loads).

The advantage of MTD lies in the fact that at the same time up to six different tests can be conducted using one stand (two surfaces of three segments). It can results in reduction of price for each test. Additionally loading system is already prepared and MTD gives opportunity to reduce a time usually needed for test preparation.

GENERAL ASSUMPTIONS AND LIMITATIONS

There are several assumptions that determined the design process. Below the assumptions are listed with a short descriptions.

- Loading – the test article (up to three connected segments) can be loaded by bending moment or twist moment.
- Dimensions – The whole test article must be 2 [m] long and 0.6 [m] wide. The thickness is less important but a general proportion of a segment should represent typical an aeronautical structure. The figure below shows design size of test article.

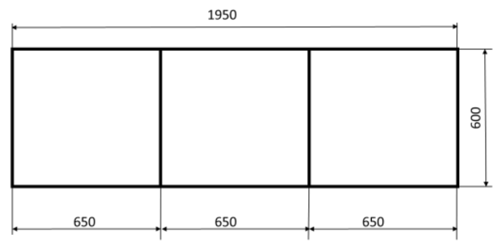

Fig.1. Dimensions of test article (three sections) - assumption

- Fixing – One side of test article is fixed while a moment is acting on latter side. Two actuators are used to create moment loading. The actuators are connected with a test article by means of rigid bars.
- Internal load distribution - the goal is to achieve an uniform stress distribution on each panel while the test article is subject by bending load. The design stress level is 100-120 [MPa]. This stress level should be achieved for skin thickness up to 3 [mm].
- Connections and replacements – The test article should be easy to put together or to disassemble. Each section can be removed and replaced by other. Damaged section can be repair. The damaged part of fixing or loading sections should also be easy to replace be a new one.

DESIGN PROCESS AND CALCULATIONS

In design process CAD and CAM techniques were applied. After several iteration a desired test stand was design. In the figure 2 the CAD model is presented.

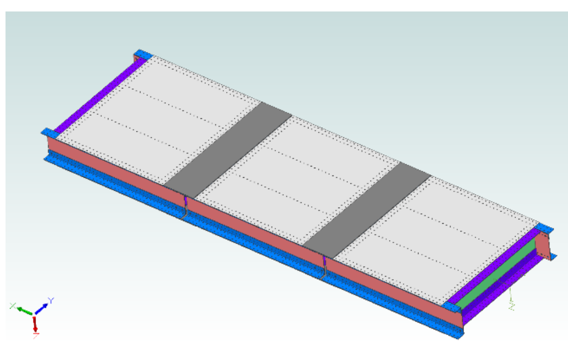

Fig.2. The CAD model of test stand

Simultaneously to the test stand a loading and fixing systems were design.

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