40th Danubia-Adria Symposium on Advances in Experimental Mechanics
September 24 - 27, 2024, Gdańsk, Poland

DURABILITY TESTS FOR THE AUTOMOTIVE INDUSTRY

Tadeusz SZYMCZAK[1], Zbigniew L. KOWALEWSKI[2], Adam BRODECKI[2]

[1] Motor Transport Institute, Department of Type-Approval and Testing,
ul. Jagiellonska 80, 03-301 Warsaw, Poland, E-mail: tadeusz.szymczak@its.waw.pl

[2] Institute of Fundamental Technological PAS, Department of Experimental Mechanics,
ul. Pawinskiego 5B, 02-106 Warsaw, Poland, E-mail: zkowalew@ippt.pan.pl; abrodec@ippt.pan.pl

1. Introduction

Durability tests are a type of experiment used for examining the fatigue resistance of different kind of components. Generally, they are employed by two branches of industry such as automotive and aviation, where many working elements at these sectors are operated under cyclic loading. From an engineering point of view, this indicates that each inspection should be done to capture cracks occurrence, as they can lead to the element failure.

Different testing stands are possible to be used for examining a durability. They can be represented by two-level platforms for mounting tested objects and subsequent examining [1], [2]. Depending on their complexity they enable an application of different types of loading: cyclic and dynamic torsion, dynamic axial loading, thermal cycles, etc. [1]. More complex multi-element devices enable a biaxial loading (in both directions, i.e. horizontal and perpendicular) [3]. Testing stands can be delivered with environmental chambers of temperature range from -40°C and 120°C and providing special conditions by application of water, salt and mud. The multi-axial systems are recommended for examination of the mechanical resistance of components with different shapes and dimensions [3]. Effective testing of vehicles is possible thanks to an usage of the multi-servo-actuators and close-loop feedback [4]-[6].

2. Details of experiments

To reach the required technical level of durability tests a digital controller should be applied. Such device enables to reflect a different signal types, such as displacement, force, rotation angle and torque. Usually, it is equipped with a several measurement cards for identification of digital and analogue signals. A computer with special software for tuning, testing and data collecting supports durability testing.

The main parameters of durability tests, such as amplitude and frequency, can be established based on the specific requirements. For example, the UN Regulation No. 55 [7] is used in the case of tests for mechanical coupling devices. Besides the above-mentioned parameters, the document provides an information about the direction of the force vector, Fig. 1. Also, it indicates the basic regime of the components mounting for examination. Any deviations from the procedure are not allowed, since the durability tests play a crucial role in the component qualification concerning its quality, approval, application and final sale.

Fig. 1. A mechanical connection of the servo-motor and towing frame (for the recovery vehicles to highways and expressways), through a spherical grip and A50-X coupling ball.

3. Results

Results of durability examination are strongly dependent on a type of signal used to control the testing stand. If a signal force is applied, then changes in displacement values are possible to be collected. They should be analysed in various stages of the cyclic loading, including the last ones, Fig. 2. Even small differences in the response of the tested object can be effectively evidenced applying such procedure. It is particularly visible in changes of the minimum values of the signal captured.

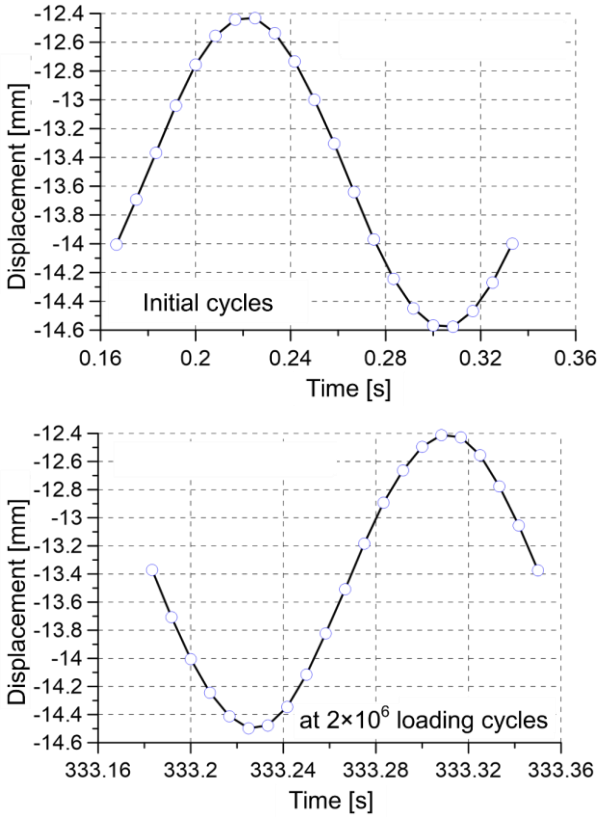
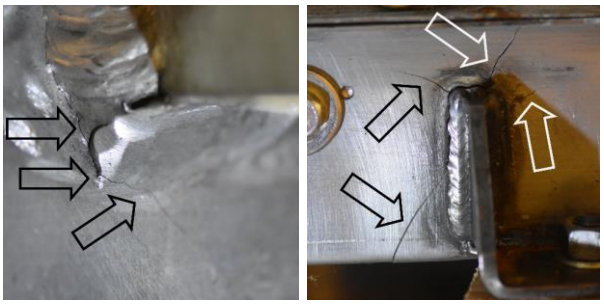


Fig. 2. Displacement captured during the durability test of towing frame for the heavy recovery vehicle (test carried out at amplitude of ±18.6 kN and frequency of f = 6 Hz).



(a) (b)

Fig. 3. Cracks in the platform with a coupling function after 2.24×10^6 loading cycles under amplitude of ±10.3 kN and frequency f = 4 Hz for: (a) aluminium alloy, (b) steel.

Durability tests also enable identification of cracks in the tested objects, Fig. 3, through their visual inspection, which should include every construction material used to make all sub-elements of the tested object. In the case of aluminium alloy, the dominant type of damage becomes hairline cracks, which are difficult to examine, while in the case of steel, the cracks are usually more visible and easier to indication. Such analysis enable to indicate the causes of cracks or deformations.

The second stage of the durability test is to determine the causes of cracks. To achieve this goal, tensile tests of welding joint are helpful, because the recommended basic mechanical parameters of the object are selected by comparing the tensile characteristics of the base material and its weld, Fig. 4.

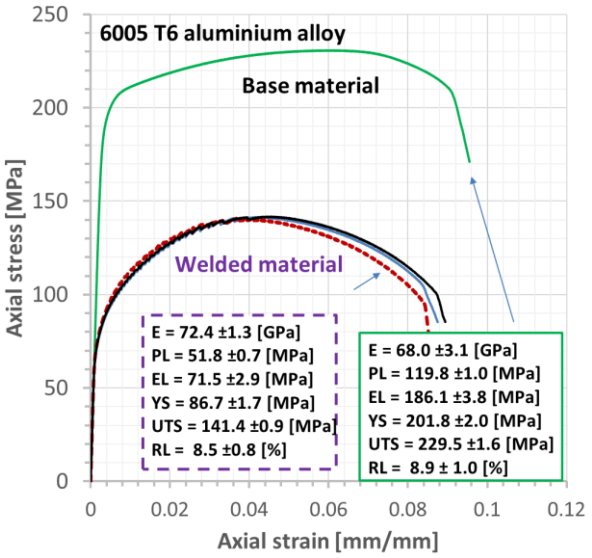


Fig. 4. Tensile characteristics of 6005 T6 aluminium alloy and it's weld.

4. Summary

To determine the quality of a given object, durability testing requires to meet the following conditions: (a) an assembly should reflect the object operating conditions, (b) tests should be carried out for at least 2×10^6 cycles, (c) the inspection should cover all types of connections, (d) test results must indicate the causes of cracks or deformations.

References

[1] www.servotestsystems.com
[2] SSTM, Anthony Best Dynamics OUTLINE SPECIFICATION SSTM 6102 issue 2, 4 pages.
[3] www.mts.com
[4] https://www.invetr.com/
[5] www.instron.com
[6] https://wieltongroup.com/news-press/aktualnosci/centrum-badawczo-rozwojowe-wieltonu-otwarte/
[7] UN Regulation No. 55, Uniform provisions concerning the approval of mechanical coupling components of combinations of vehicles