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Railway stocks and their components: the influence of their production technology on fatigue strength, methods, and tools for their verification

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Abstract

This paper shows the possibilities and methods of the Research and Testing Institute in Pilsen (hereinafter only VZU Plzen) to increase the operational reliability and quality of the technology of rolling stock components and their parts.

Keywords: fatigue tests, vibration tests, thermal spraying, static simulation.

1 Introduction

The lifetime and operational reliability of structures is a unique combination of technical and economic knowledge, knowledge and experience, whose successful mastery and ability to continually modernize them significantly contributes to a substantial increase in critical safety parameters including health and property protection, optimization of production costs and significantly increases the competitiveness of individual industries and, as a result, the whole economy.

Unique technical competences, the necessary long-term experience, international references, and the appropriate technical background are indispensable prerequisites for active activity in the field of life testing especially in the field of large structures.

2 Methods

Current mathematical methods and tools allow the theoretical solution of dimensioning problems. However, the results are very sensitive to the correct estimate of the input parameters of the calculations and the suitability of the calculation methods and models used and can be affected by significant errors. Objective sizing procedures are based on the systematic linking of mathematical modelling methods to experiments prior to industrial application. This process is technically very demanding and requires a base capable of analysing the actual operating load of the structure and then simulating this time-varying load in laboratory conditions, see Figure 1.

Although the calculation methods of strength and operational reliability of railway stocks and their components are already at a high level, they cannot take into account the quality of the production process in their predictions. A symbiosis of theoretical approaches and well-performed experiments simulating exceptional and operational stresses of structures is necessary for a perfect assessment of strength properties. Accredited test methods are used to verify the static and fatigue strength of railway stocks using a multi-channel electrohydraulic loading system. Complex spatial simulations of the main operating forces are already inadequate, with the progressive weight optimization increasing the strength potential of structural material to limit values. The structural failure, such as fatigue fracture, is also due to secondary operating stresses, such as in the case of load-bearing vehicles from shock absorbers, stabilizers, braking systems, and other elements that are subject to the dynamic effects of time-varying loads when operating the structure. Their force effects were previously either neglected or estimated by computational models for static simulations. With decreasing weight of structures and their load-bearing components, these secondary loads can also cause fatal failure with an impact on major material damage and passenger lives.

Figure 1: Testing laboratory

3 Results

The paper summarizes the areas that are important for the research and development of rolling stock parts in terms of its running, strength and operating characteristics and verification of their production technology. The basic precondition for verifying the complex structure of a part of a rolling stock is the creation of its functional model so that the stress fields of the structure can be identified, and critical points of the structure revealed. In addition to high-performance hardware, methodology and 3D model of the structure, high-quality experimental material characteristics of the materials used are required for this.

Another important stage in the development of the railway component is the comparison of the predicted stress with the results of the experimental static simulation and the determination of the strength utilization of the construction material at its critical points. In this way, both the mathematical model is verified, and the fatigue life is predicted. The next step is to perform a fatigue test using a many-channel loading system for simulations of main and partial operating forces, in Figure 2. This phase of the development of a complex engineering structure, by its very nature, will test its production technology in particular. Subsequent operational measurement of the final structure and its postprocessing determine the rigor of laboratory approaches with respect to the real track and provide a true idea of the fatigue strength of the service life.

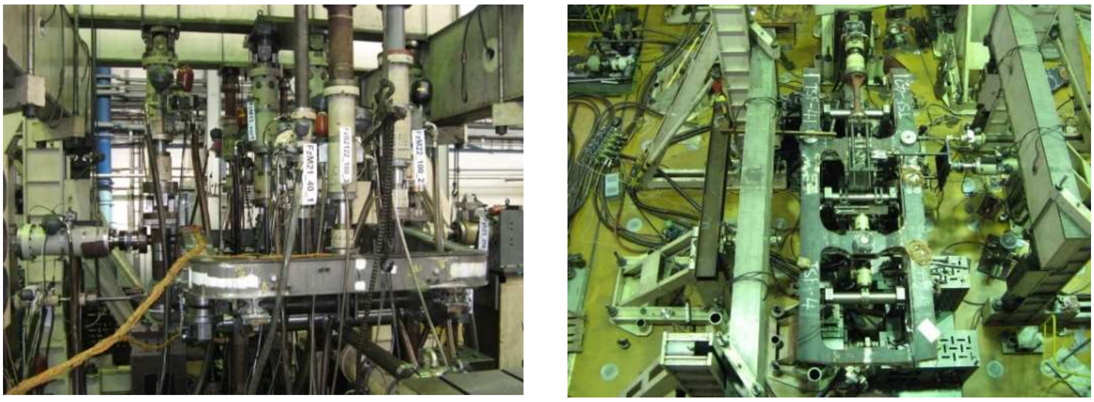

Figure 2: Fatigue tests of bogies

In addition to stress, the components of the rolling stock are also exposed to operational vibrations, which increase their stress and generate noise. Both of these quantities must be kept within the permissible values and these parameters verified experimentally. Electro-hydraulic testing tables and power spectral density spectrum are used to determine both functional and lifetime tests to ensure vibration resistance of electrical components of rolling stocks, see example in Figure 3.

Figure 3: Vibration resistance tests

Given the requirements of reducing weight of the rolling stocks, it is a burning issue to ensure comparable strength while reducing weight. Maintaining the strength properties of components in this phenomenon brings with it the problem of how to ensure sufficient fatigue strength. One possible way is to modify the surface of the structure in order to create surface compressive stresses. An application of protective coatings using thermal spraying methods is a very useful tool for refurbishment and repair of damaged parts by creating new surface resistant to wear, abrasion, erosion, corrosion, high temperature, etc. based on metal, alloy, superalloy, cermet, and ceramic materials, see Figure 4.

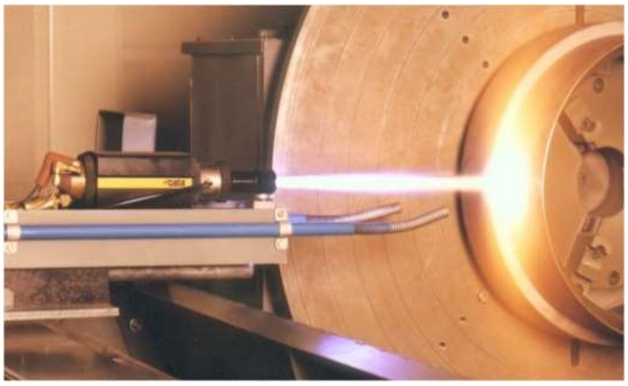

Figure 4: Thermal spraying based on metals, alloys, superalloys, cermet and ceramics

4 Conclusions and Contributions

This paper shows tools and professional activities of the Research and Testing Institute in Plzen on the field of development and quality increasing of railway stocks and their components. It presents individual fields and scientific disciplines in which the Institute and its experts have high knowledge, skills, and experience. Its advantage is a combination of theoretical mathematical approaches and procedures and a highly sophisticated experimental base that is able to simulate complex operating conditions and thus optimize computational models and refine their real outputs and results. In the field of thermal spraying, modern methods of coating surfaces based on metals, alloys, super alloys, cermet, and ceramics, which are resistant to abrasion, abrasion, erosion, corrosion, and high temperatures, are described. It is suitable to use these resources for repairs and reconstructions of parts of rail vehicles. The activities described in the paper are supplemented by state-of-the-art experimental techniques and areas of material testing, fatigue testing, noise and vibration measurements, operational measurements on the track and surface spraying. The global customer references also testify to the considerable erudition in the field of experimental technology and human experts. The company's activities include an extensive portfolio of accredited rolling stock, energy, and aviation processes.

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