NUMERICAL SIMULATIONS AND EXPERIMENTS
FOR DESIGN OF RAIL VEHICLES

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Abstract SKODA VÝZKUM s.r.o. is the company with a hundred-years old tradition in the field of research, development and testing. It is the important member of the grant project team Research Centre of Rail Vehicles. SKODA VÝZKUM is involved into the following activities of the project: research of durability and passive safety, research of airflow and aerodynamics, investigation of noise and vibrations and material testing. The paper describes examples of numerical simulations and experiments with rail vehicles.

Key words: rail vehicle, numerical simulation, experiment, dynamics, strength, crashworthiness, noise, vibration, fatigue life,

RESEARCH CENTRE OF RAIL VEHICLES

The Research Centre of Rail Vehicles was established by University of West Bohemia in Pilsen (Faculty of Mechanical Engineering), University of Pardubice (Jan Perner Transport Faculty) ŠKODA VÝZKUM Pilsen and VÚKV Prague. An important role has the partnership the Centre with producer of rail vehicles ŠKODA Transportation. The Centre started their activities in the year 2005 with financial support from the Ministry of Education, Youth and Sports of the Czech Republic. The Centre is interested especially in applied research, i.e. the development of the theoretical applications, calculations, lab and functional experiments.

ŠKODA VÝZKUM participates on the following activities of the Centre:
• research of dynamic loading, durability and passive safety of rail vehicles and their components
• research of airflow and rail vehicle aerodynamics
• research of noise and vibrations of rail vehicles
• research of material characteristics and their applications in the rail vehicle design and the manufacturing their components

The next sections describe typical examples of numerical simulations and experiments which ŠKODA VÝZKUM has been performed.

MULTIBODY SIMULATIONS AND TESTS OF COAL WAGON

ŠKODA VÝZKUM have been created a two-axle open coal wagon multibody model intended for the laboratory tests simulations performed in the accredited Dynamic testing laboratory. The multimode model was created in SIMPACK simulation tool.

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With the multibody model it is possible to simulate the laboratory excitation of wagon wheels in vertical direction, which corresponds to the real loading states performed on the test stand (see Fig. 1). Time histories or frequency domain responses of kinematics and dynamic quantities reflecting the wagon examined properties are the output of the computer simulations and the experimental measurements. The aim of the computer simulations and laboratory tests is especially the evaluation of the impact of using two-leaf composite springs of the wagon suspension instead of five-leaf parabolic steel ones on the monitored kinematics and dynamic quantities [1].

**CRASHWORTHINESS INVESTIGATION OF LOCOMOTIVE**

Before the design process of the new high speed locomotive ŠKODA 109E, the former locomotive ŠKODA 85E was analyzed during the certain crash event. The structure of the locomotive was analyzed under the collision scenarios given by the draft prEN 15227 – “Crashworthiness requirements for railway vehicle bodies”. The FE-code LS-DYNA was used for simulations. The hardest scenario from the point of view of the energy absorption in the vehicle front end structure simulates the collision with a 15t lorry at the level crossing at speed of 110 km/h. The results of the simulations showed (Fig. 2) the former structure has to be significantly changed to withstand the loading condition of the collision scenario.
Therefore the newly designed structure had to undergo several trial and error design iterations leading to a structure which is able to absorb a significant amount of energy and to hold the deformations of the structure in the acceptable boundaries [2]. The final crash concept for the new locomotive SKODA 109E is shown in Fig. 3.

![Crash concept for new type of SKODA locomotive.](image)

**ACOUSTIC MANAGEMENT OF TRAM**

The measurement and analyses of noise and vibrations are often performed in the stage of a vehicle prototype and only from the point of view of legislative procedures. An additional noise and vibration elimination could be a technical problem. SKODA VYZKUM would like to interconnect experimental research, that is noise measuring and vibrations on real vehicles with possibility of software means for noise prediction, which are available at the present, for example AutoSEA. Fig. 4 shows the first complex acoustic model of a SKODA tram, which was created for this type of research [3].

![Acoustic model of SKODA tram.](image)
RESEARCH OF DURABILITY AND FATIGUE LIFE

ŠKODA VÝZKUM is a research leader in area of dynamic loading, durability and fatigue life of rail vehicles and their components. In the dynamical testing lab is available equipment for this type of the research: electro-hydraulic loading systems, computer controlled electronics, a lot of loading actuators and static and dynamic measuring units.

The project team has been started the research of durability of welds and other technological joint types, the development of measuring methods and statistical analyses of random operational stressing of rail vehicles components including the application of probabilistic approach to their fatigue life prediction and the investigation of important trends in multi-axial testing the rail vehicles [4,5]. An example of a multi-axial test of a locomotive bogie at ŠKODA VÝZKUM laboratories is shown in Fig.4.

Fig. 4. Stand test of locomotive bogie frame - 11 loading actuators.

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References:


