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APPLICATION OF SENSITIVITY ANALYSIS IN DESIGN OF CHARACTERISTICS OF DAMPING JOINTS IN LOCOMOTIVE RUNNING GEAR

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Abstract: *Operation of railway vehicles at higher speeds is conditioned by assurance of a stable run of the vehicle in straight track with a high level of geometric parameters. This property is usually reached by retrofitting of a joint between the vehicle body and the bogies with an efficient damping with suitable characteristics. Because the relative motion between the vehicle body and the bogies in the straight track shows low amplitudes and high velocities, special longitudinal dampers – so-called yaw dampers – are used for these purposes. The aim of this paper is a theoretical analysis of the yaw damper characteristics on the stability limit of a locomotive performed by means of sensitivity analysis.*

Keywords: ***Sensitivity analysis, stability of vehicle run, critical speed, yaw dampers, simulations.***

Nowadays, computer simulations of running and guiding behaviour create an integral part of development of new or modernized rail vehicles. The simulations are practically the only possible way for verification of dynamic properties of the vehicle in the design stage. It is possible to use them for optimization of suspension and damping parameters, as well.

Jan Perner Transport Faculty of the University of Pardubice co-operates with the company CZ LOKO, a.s. on solving of R&D project "TIP" of the Ministry of Industry and Trade of the Czech Republic; the aim of this project is manufacturing of a prototype of a locomotive Class 744.0 as well as preparation of a broad-gauged version of this locomotive according to the GOST standards. The computer simulations of dynamic behaviour of the new locomotive, which create one of the main parts at the project solving, are performed by means of an original multi-body simulation software (Zelenka, 2009). The first simulation results of the broad-gauged version of the locomotive Class 744.0 CZ LOKO are presented in paper (Zelenka & Michálek, 2011). On the basis of current documentation and measurement of real parameters of the locomotive suspension (Zelenka et al., 2011), simulation input data were specified. Investigation of the influence of change of relevant parameters, which is related with the modification of the locomotive for the "Russian" track gauge 1520 mm, was also performed and its results are presented in paper (Kohout et al., 2011).

From the point of view of the vehicle dynamics, the locomotive comprises complicated non-linear dynamic system. Therefore, for purposes of determination of influence of different input parameters on dynamic behaviour of the whole locomotive a sensitivity analysis can be used. The sensitivity analysis allows acquisition of an image describing a qualitative behaviour of such complicated system (locomotive) with respect to variable input parameters.

One of the most important parameter of the rail vehicle is its critical speed. The critical speed represents the maximum speed at which the rail vehicle shows so-called stable run, i.e. running behaviour without lateral oscillations of wheelsets, bogies and the vehicle body. Value of the critical speed is influenced by many parameters and exceeding of this speed can lead to exceeding of the safety limits of the vehicle run (see the EN 14363) and degradation of the ride comfort. For purposes of sensitivity analysis of the locomotive Class 744.0, four weight variants (with a total weight of 80, 84, 86 and 90 t) were considered. Besides to that, influence of some other parameters was observed,

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above all the equivalent conicity (i.e. the wheel/rail contact geometry), friction coefficient in the wheel/rail contact and the influence of yaw dampers.

For purposes of assessment of the stability of vehicle run (i.e. determination of the critical speed of the vehicle), several methods are usually used – see paper (Polách, 2010), for example. In case of the locomotive Class 744.0, the sensitivity analysis was performed by means of non-linear method on theoretical straight track; the excitation of the dynamic model of the locomotive was carried out with isolated lateral track unevenness. For purposes of the stability assessment, lateral motion of the wheelsets (lateral oscillations) was observed at the decreasing vehicle speed.

As an example, in fig. 1 there are shown simulation results of this investigation. In the graphs, amplitudes of the lateral wheelset motion in dependency on vehicle speed are presented. The locomotive with a total weight 80 t (top) and 90 t (bottom) was considered; the graphs on the left side represent the locomotive without yaw dampers, results of the locomotive with yaw dampers are shown on the left side. These simulations were performed for a value of the friction coefficient in wheel/rail contact of 0.35 and for two different conditions of the wheel/rail contact geometry. Influences of the yaw dampers and the total weight of locomotive are evident from these graphs…

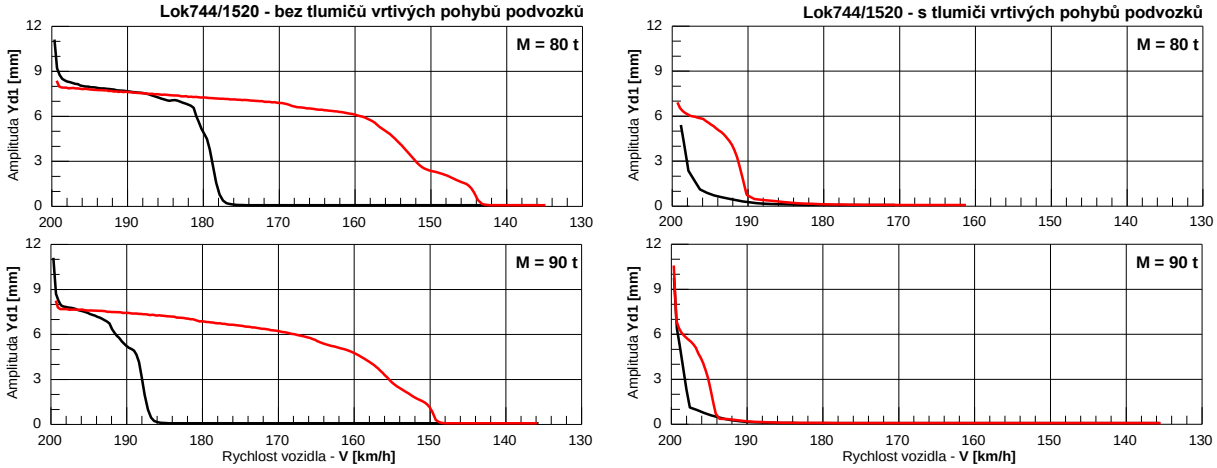

Fig. 1 Amplitude of the lateral motion of the 1st wheelset after the excitation on the ideal straight track for various total weight of locomotive and various contact conditions (decreasing speed; value of the friction coefficient in wheel/rail contact: 0.35; red – λ_{ekv} = 0.403, black – λ_{ekv} = 0.207).

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