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HIGH SPEED STABILITY OF A RAILWAY VEHICLE EQUIPPED WITH INDEPENDENTLY ROTATING WHEELS

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Abstract: *The paper is devoted to the study of lateral oscillation and the assessment of the motion stability of a four axle railway vehicle equipped with wheelsets with independently rotating wheels. First, a linear four degrees of freedom mathematical model of the unconstrained wheelset in a straight track has been built. The wheelset model was consequently utilized in a model of the whole vehicle representing typical railway passenger car. The model has 25 degrees of freedom and it is described by a system of 50 first order homogeneous differential equations. Linear algebra methods were used to assess the stability. The influence of a running velocity, the torsional stiffness of wheelsets and the viscosity of coupling element between wheels was studied. Results of this study shows that wheelsets with independently rotating wheels and viscous coupling element enable stable behaviour of a vehicle at speeds exceeding 500 km/h. Prospectively, this type of wheelset is applicable to high-speed railway vehicles, because it offers either further increase of running speeds or simplification of running gear while preserving high speed stability.*

Keywords: railway wheelset, independently rotating wheels, lateral dynamics, stability

1. Introduction

Wheelset is a basic technical device providing guiding of railway vehicles. Nearly without exception all railway vehicles, from the beginning of railway transport until now, are equipped with conventional wheelsets (Fig 1, left). Conventional wheelsets are consisted of two wheels firmly fixed to a rigid axle. This forces the both wheels to rotate at the same speed. A wheelset with independently rotating wheels (IRW) is obtained from the conventional one by enabling independent wheel rotation (Fig 1, right). IRW wheelsets are utilized particularly in the construction of low-floor trams in order to lower the floor height in the area above a bogie. Nevertheless, apart from spatial problem solution, IRW wheelsets can offer further advantages.

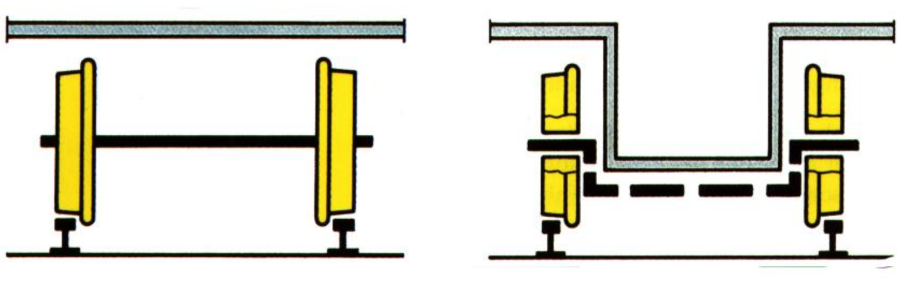

Fig. 1: Conventional and IRW wheelset

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element at the velocity of 500 km/h, plot of the dependence of the oscillation increment on the viscosity b_w was calculated (*Fig. 5*). As can be seen from the graph the maximal stability at the vehicle velocity of 500 km/h is reached by the optimal value of the viscosity $b_{w, opt, 500}$ = 0,32 kNms^{-1}rad^{-1}.

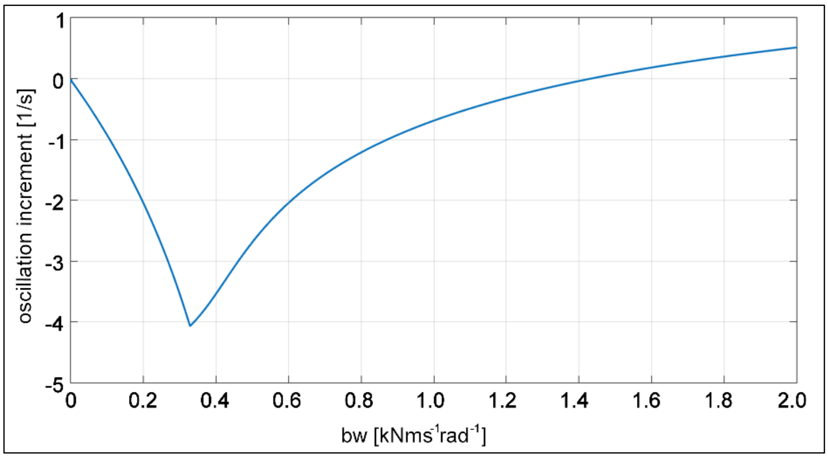

Fig. 2: Dependence of the oscillation increment δ on the viscosity b_w at speed 500 km/h

It can be shown that the value of the optimum viscosity decreases with increasing speed. However, the viscosity must be high enough to assure natural centering of a wheelset in the track.

2. Conclusions

A system of linear differential equations describing lateral dynamics of railway vehicle was formulated. Based on the calculation of eigenvalues and the oscillation increment of the system a high-speed stability of railway vehicle was assessed. The results confirm significant increase in a critical velocity of a vehicle with IRW wheelsets compared to a conventional one. However, wheelsets with purely independent wheel rotation lose the ability to naturally center towards a track. Therefore, various types of coupling between the wheels of wheelset were examined. The goal of such coupling is to provide wheelset centering, whilst preserve high-speed stability of IRW wheelset. It has been found that elastic coupling between wheels causes a reduction in stability and critical speed. Nevertheless, the viscous coupling appears to be promising. The optimum viscosity value, which provides stable wheelset oscillations even at speeds of 500 km/h, can be found. However, those results were obtained by linear model that does not fully respect all the phenomena associated with the rolling stock moving at high speeds. Experimental verification is required. Because track tests are financially and organizationally extremely demanding, utilization of the CTU roller rig (Myamlin et al., 2017, Kalivoda and Bauer, 2016) is planned in order to verify the simulation results described above.

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