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Numerical Evaluation of Curving Resistance in Freight Wagons Equipped with Y25 Bogies

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1 Objective

The longitudinal forces that are generated in the coupling devices of freight wagons play a role of primary importance in the dynamic behavior of trains. The IRS 40421 [1] correlates, in fact, in a direct way, high values of longitudinal forces with the risk of derailment. The preliminary calculation of the longitudinal forces inside the composition is therefore of fundamental importance to evaluate its safety before the entry into service. The estimation of such forces is commonly made with the use of specific numerical codes, which consider the wagons as concentrated masses with the only longitudinal degree of freedom, while the coupling devices are modeled by means of force elements with non-linear characteristic and hysteresis. The resisting forces to motion are normally simulated by means of concentrated loads applied in the center of mass of each wagon and can be classified into ordinary resistances (friction forces resisting motion and aerodynamic forces) and accidental resistances (gradients and curves).

For the calculation of the curving resistances, simplified methods are commonly used which allow the estimation of the resistant force as a function of curve radius only. This simplified approach does not take into account several factors such as the unbalanced lateral acceleration, the gauge widening, the longitudinal stiffness of the primary suspensions, the bogie wheelbase, the presence of flange lubrication systems, etc.

The work describes a numerical analysis to evaluate the curving resistances of freight railway vehicles, equipped with Y25 bogies. In particular, the results of the numerical analysis allow the definition of a new law for the estimation of such force, able to evaluate the effects of the most influential parameters.

2 Method

The determination of the resistant force to motion during running in curve is carried out by means of the use of a multibody model, developed in the Simpack environment, of a freight vehicle equipped with Y25 bogies. The vehicle is modeled with a high level of detail, including the non-linear effects due to the main friction elements, such as Lenoir-link, pads, center pivot, etc. In the first phase of the analysis an isolated wagon is considered during curve negotiation in order to calculate the traction force necessary to maintain a constant speed, this force therefore represents the resisting force. The analysis is repeated considering different scenarios in terms of: curve radius, uncompensated acceleration, gauge widening, friction coefficient between wheel flange and inner side of the rail, mass of the vehicle and longitudinal stiffness of the primary suspension.

In the second phase of the work, instead, a set of three vehicles is considered in order to analyze if the composition has an effect on the resisting force in curve. The forces exchanged in the coupling devices can in fact influence the dynamic behavior of the vehicle in curve and the wheel-rail contact forces. The purpose of this analysis is to understand if the resisting force in curve increases linearly with the number of wagons considered or if it is, instead, necessary to consider the effect of the composition.

3 Results

The results of the different simulations are therefore used to define a new law for the evaluation of the resisting force to motion in curve as a function of the main parameters considered. A more precise knowledge of the curving resistances is important to have a more precise estimation of the coupling forces and of the energy consumption of the vehicle.

4 Conclusions

The work describes a numerical analysis for the determination of the curving resistances of a freight railway vehicle equipped with Y25 bogies. The results of the numerical simulations allow the definition of a simplified law for the estimation of the curving resistances as a function of the main parameters. The analysis is not limited to the analysis of an isolated wagon, but it includes an analysis for the evaluation of the effect of the composition and, therefore, of the coupling forces.

References

[1] IRS 40421:2021. Rules for the consist and braking of international freight trains: new IRS 40421.

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