METHODS FOR RUNNING STABILITY PREDICTION AND THEIR SENSITIVITY TO WHEEL/RAIL CONTACT GEOMETRY

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EXTENDED ABSTRACT

1. INTRODUCTION

Bogie instability or *bogie hunting* is a safety criterion. The bogies are unstable for all speeds higher than the critical speed. If the low frequency bogie movement is coupled to carbody movement, a deterioration of the lateral comfort behaviour by low damped carbody modes or by *carbody instability* can be observed. In comparison to bogie hunting, carbody instability can usually be suppressed with increasing speed.

The paper concentrates on bogie stability. Methods are presented of nonlinear stability analysis as they can, or may be used in industrial applications as well as the comparison of their results for different wheel/rail contact geometries.

2. METHODS FOR NONLINEAR STABILITY PREDICTION

Various non-linear methods are feasible in regard to stability design during the development of the vehicle. According to the type of excitation, differentiation can be made between analyses with no excitation, with excitation by a singular irregularity input (with certain one or with several amplitude values), or by excitation with stochastic (measured) track irregularity.

These methods were compared with the aid of two differing examples of wheel/track contact geometries. At a wheelset lateral movement amplitude of 3 mm, both contact geometries demonstrate the same equivalent conicity of 0.4. As can be seen in Fig. 1, one of the combinations (04A) demonstrates lower conicity for wheelset movement with amplitude below 3 mm, whereas the other (04B) demonstrates higher conicity. A four car articulated vehicle was investigated for comparison of the methods. The results are given for the trailing wheelset of the first bogie, at which the stability limits are first reached.

Method without excitation:

In this case a high speed during which the bogie moves in a limit cycle is used as initial condition and a continuous speed reduction takes place. The speed at which the vibrations subside is designated as being the critical speed, see Fig. 2. In one case (04A) the vibrations stop abruptly whereas in the other case (04B) the wheelsets continue to vibrate in a small limit cycle, only stabilising at a significantly lower speed, which subsequently leads to differing critical speeds at the same conicity.

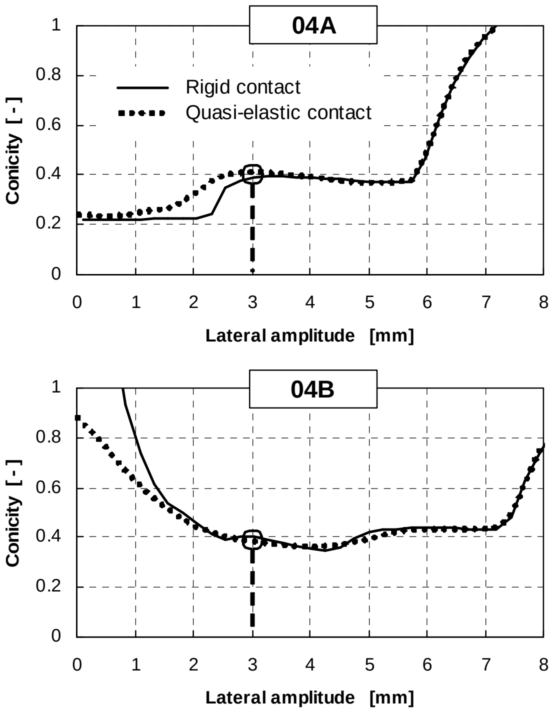

Fig. 1 Conicity diagram of examined combinations wheelset/track

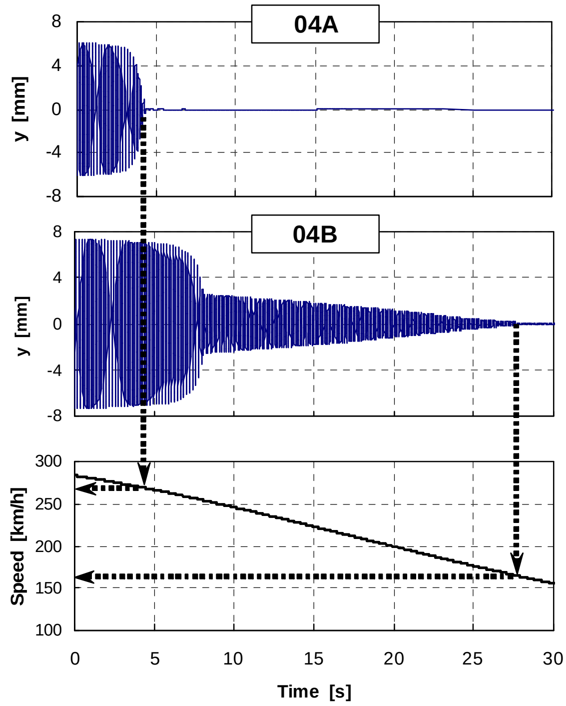

Fig. 2 Simulations of run with decreasing speed

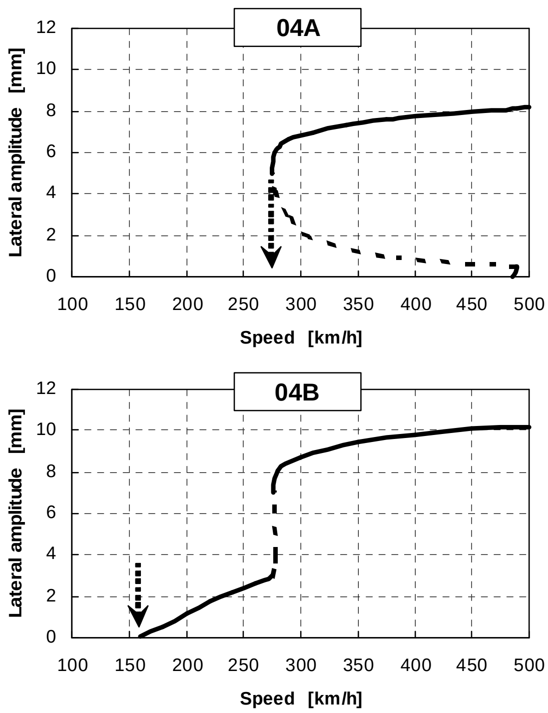

Fig. 3 Bifurcation diagrams

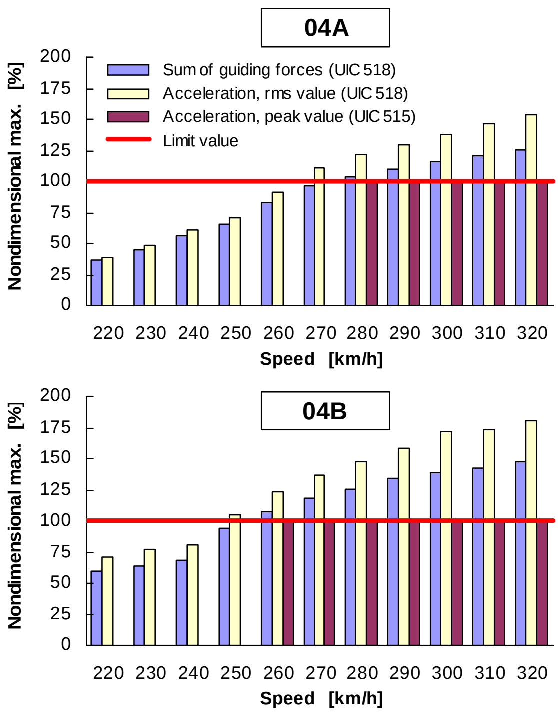

Fig. 4 Simulations of run on track with irregularities

Methods with single excitation:

Investigating damping behaviour following a single lateral track excitation, stability can be assessed; however the damping behaviour at the same conicity can differ for various contact geometries. If the amplitude of the stable limit cycle is presented in function of speed, a bifurcation diagram results, see Fig. 3. In certain cases the solution can vary – depending on the excitation amplitude – between a damped movement and a limit cycle. Differing forms of the bifurcation diagram can evolve depending on the profile combinations used.

Methods with stochastic excitation due track irregularity:

In order to predict bogie stability, methods specified for measurements and acceptance tests can also be applied. Running on straight track with measured irregularities is simulated and criteria for measurements and vehicle acceptance [1], [2] are applied for assessment:

- rms value of the sum of guiding forces (track shifting force)
- rms value of lateral acceleration on the bogie frame.

Another criterion still applied for on-line surveillance is the peak value of lateral acceleration on the bogie frame, as defined in the (now invalid) version of UIC 515 [3]. The limit value is seen to be exceeded when the value 8 m/s² occurs during more than 6 consecutive cycles. A comparison of the simulation results is given in Fig. 4. The criteria investigated are comparable against each other; however the criterion of the rms value of lateral acceleration on the bogie frame leads to a slightly lower permissible speed. In contrast to the method without excitation, the results for both contact geometries lie close to each other in this case.

Further examples of the results and discussion will be presented in the paper.

3. CONCLUSION

The non-linear methods enable a detailed stability analysis, but may lead to a partial differentiation in the results amongst each other, or with respect to the measurements during the vehicle acceptance tests. The results of the non-linear methods and the limiting values for the vehicle acceptance are similar if the potentially occurring limit cycles with low amplitude are not considered as a deviation from the stability limit. The best comprehension of vehicle behaviour on the stability limit is possible on the basis of a bifurcation diagram. The analysis of the linearization of wheel/rail contact can contribute to a better assessment of the non-linear analyses.

4. REFERENCES

[1] UIC Code 518: Testing and approval of railway vehicles from the point of view of their dynamic behaviour – Safety – Track fatigue – Ride quality. International Union of Railways, 2nd edition, Paris, April 2003

[2] prEN 14 363: Railway applications – Testing for the acceptance of running characteristics of railway vehicles – Testing of running behaviour and stationary tests. Draft. CEN, Brussels, June 2002

[3] UIC Kodex 515: Reisezugwagen Laufwerke (1), 2. Ausgabe, 1.1.1984