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MEASURING OF WHEEL–RAIL ADHESION CHARACTERISTICS AT A TEST STAND

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Abstract: *The properties of the adhesion contact of wheel and rail, expressed by the adhesion characteristic (dependence of tangential force on creepage), are of great importance for rail vehicle dynamics and drive regulation systems. The paper deals with the results of measurements of adhesion characteristics on a tram wheel test stand. The measured characteristics are described, special attention being paid to the transitions which show influence of changes of friction conditions during the sliding.*

Keywords: ***adhesion, adhesion characteristic, experimental measurement, wheel–rail contact, sliding***

1. Introduction

The transmission of tangential forces through the wheel–rail contact area is, due to the flexibility of the bodies, inseparably connected with creep. The dependence of the transmitted forces upon creepage is expressed by adhesion characteristics – see e.g. Čáp (1995). Several theories with various degree of simplification are available for description of the dependence; even the most accurate ones cannot, however, do without parameters, the values of which cannot be calculated but have to be measured. Therefore, experiments play an important role in this field of research. The paper describes the course and results of experiments conducted at the tram wheel test stand of the Jan Perner Transport Faculty in Pardubice.

The test stand on which the experiments were performed has a main frame bearing a tram vehicle wheel and a rotating rail rolling over each other. The wheel is powered by a permanent-magnet synchronous motor, and the rotating rail is connected with an asynchronous motor. The aim of the experiments is to measure the adhesion characteristic – the dependence of the tangential force acting between the wheels on the creepage or creep velocity not only during the effective slip (micro-slip), but also in the mode of full sliding.

2. Evaluation of the measured adhesion characteristics

Quantitative description of the measured characteristics is made upon the base of the Freibauer adhesion theory – see Freibauer (1983). The measured dependence is fitted by the theoretical function, whereby values of its parameters are obtained. Five parameters are used in this work: initial steepness of the adhesion characteristic $c_{\mu s0}$, initial steepness of the friction characteristic c_{fw0}, static friction coefficient f_0 and two additional parameters, A and λ. The latter introduces Polách's extension of the Freibauer theory.

3. Changes of friction conditions during the measurement

Some measured characteristics may be well approximated by the theoretical function; a majority of them, however, has different shapes. The approximation may be used, but it is suitable only for a certain part of the characteristic. In our opinion, these observations do not disprove the adhesion theory but document the changes of adhesion conditions. Owing to the sliding, the running surfaces

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may be cleaned, worn and warmed, which changes the friction conditions even during a single measurement. Therefore, the measured adhesion characteristics are not approximated by a function with one set of parameters but by a zone defined by ranges in which the parameters vary, the formula itself remaining unchanged.

The influence of the changes is more significant under bad adhesion conditions – the contaminant is being removed during the sliding. The change may then be expressed by an increase of the parameter f_0 in the model. The consequence is that the descending branch of the adhesion characteristic falls more slowly or even may rise and form another peak. Under good adhesion conditions, too, certain changes are encountered. They may be expressed by changes of the parameters $c_{\mu s0}$, λ, or c_{fw0}.

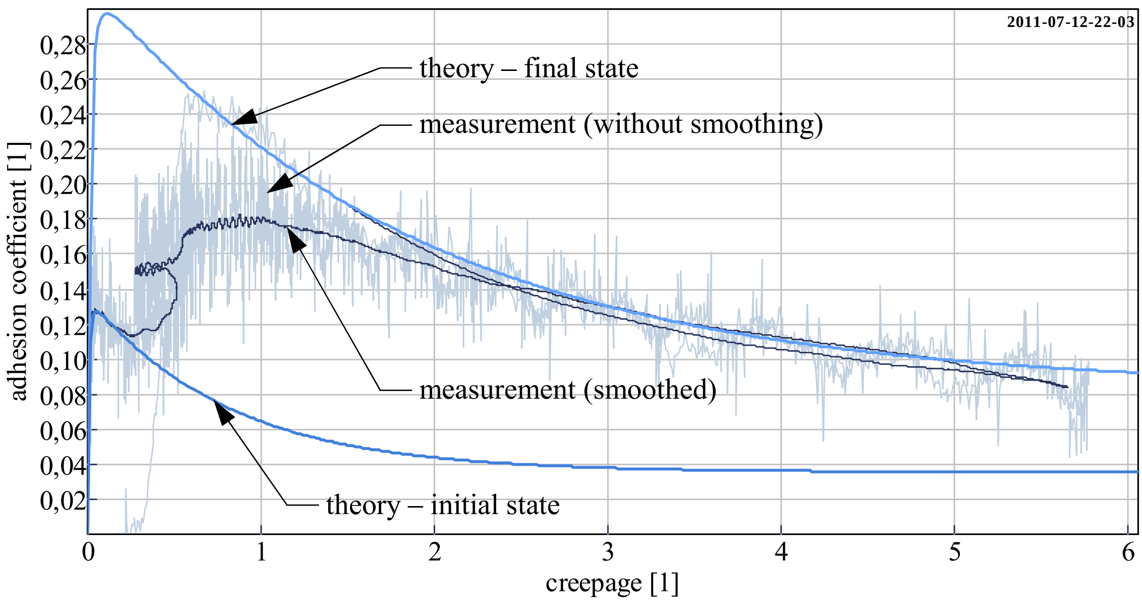

Fig. 1 A representative example of a measured adhesion characteristic under degraded adhesion conditions, showing a strong influence of changes of friction conditions during the sliding.

4. Conclusions

The measurement results provide values of the parameters appearing in theoretical formulae and can be used in calculations. In the first place, however, substantial qualitative results are obtained as to the changes of friction conditions during the sliding which should be taken into account if adhesion behaviour at full sliding is concerned. It may be stated that unexpected adhesion characteristic shapes (e.g. double peaks) are not a property of the μ–s dependence but a consequence of change of friction conditions in time.

The observed changes of friction conditions during sliding imply suggestions for further work: it might be possible to express the changes mathematically e.g. in dependence on friction force work/power, see Pugi et al. (2011).

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