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DYNAMIC ANALYSIS OF INTERACTION BETWEEN VEHICLE WHEEL WITH A METAL PROTUBERANCE AND RAIL

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ABSTRACT

A new mathematical model "Vehicle - Track" developed from other mathematical models is used in the research to determine the interaction between the wheel with a metal protuberance and rail. Fourier series are used to mathematically describe the geometry of vehicle wheel with a metal protuberance. Calculations and analysed results, obtained by using the newly developed method, when a wheel defect has a metal protuberance, are presented in this work.

Keywords: rail, wheel, interaction, metal protuberance, impact force, dynamics modelling.

INTRODUCTION

Wheel with damage causes a significant dynamic effect to the system Vehicle-Track (Bogdevicius et al 2016). Damages are formed on the surfaces of wheel and rail during the exploitation due to interaction between wheel and rail. Wheel damages may also be formed by poor parts machining quality and inaccuracies in production. Damages of wheel and rail are rarely detected at the initial stages of exploitation and the damages increase over time.

Protuberances in metal are dangerous, because they cause impact forces to rail and wheel. The metal protuberance often creates flats on wheel tread. It is forbidden to exploit the wagon when the wheel-set wheel has a metal protuberance of 0.5 mm height in passenger vehicles and of 1 mm height in freight vehicles. The wheelsets of the wagons are replaced in the intermediate station if metal protuberances are above permissible norms (TNN,1996).

When solving the problems of wheel and rail wear, special attention is paid to friction forces, which are caused by interaction between the wheel and rail

Metal protuberances are rarely included in the mathematical models of system Vehicle -Track due to complex and different geometric shapes. The authors have failed to find other articles about metal protuberance of the wheel and its effect to the system Vehicle- Track. A newly developed mathematical model of system Vehicle-Track is presented, which allows determination of interaction between a wheel with metal protuberance and rail, and shows its effect to dynamic loads.

RESULTS AND CONCLUSIONS

In Figure 1 (a) variation of friction force $F_{fric}(t)$ in the contact, caused by interaction between wheel and rail, is shown at time interval from 1 s to 1.7 s, when the vehicle movement speed is 100 km/h and metal protuberance length is 100 mm and height is 0.5 mm.

In Figure 1 (b) the same force is shown at time in from 1.395 s to 1.41 s (this time interval was chosen due to highest impact of negative force found in the first interval). Sleepers are marked as squares and can be seen on the time axis.

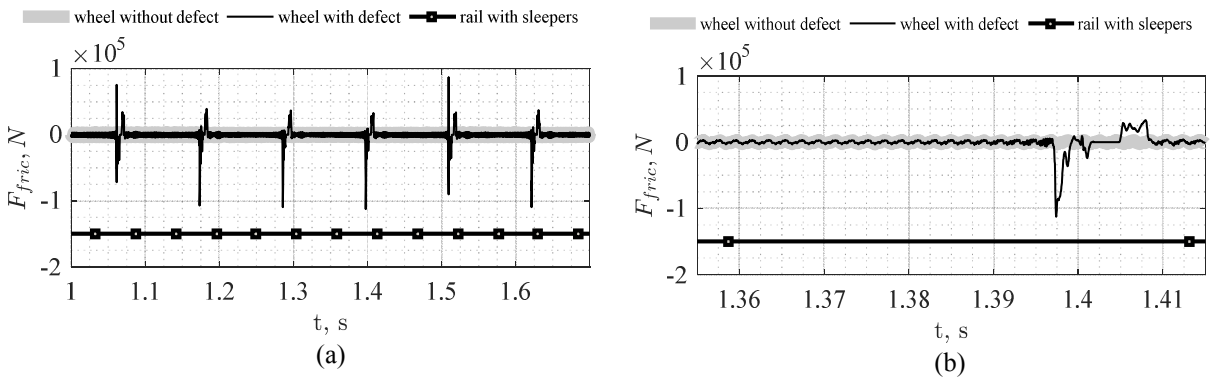

Fig. 1 - Variation of friction force $F_{fric}(t)$, when vehicle wheel is with and without metal protuberance and at time intervals: a) from 1.0s to 1.7 s, b) from 1.395 s to 1.41 s.

The friction force appears when wheel interacts with rail at support points. It works at direction opposite of the vehicle wheel slip direction. Friction force is a vector, whether its value is positive or negative depends on other vectors in the system Vehicle-Track.

Results obtained after the calculations allows to a thorough analysis of the interactions between elements in the system Vehicle-Track, when vehicle wheel is with a metal protuberance.

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