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Research of System Vehicle-Track when Wheel is Scaled

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Abstract

The interaction between wheel and rail is still a great problem of railway engineering. A mathematical model of the system Vehicle-Track, previously developed by the same authors and a newly developed model of vehicle wheel that is scaled, are used to create a new mathematical model. This model allows to determine changes of dynamical characteristics in rails and to evaluate physical and mechanical properties of the system Vehicle-Track. Results, obtained when rail is in contact with vehicle scaled wheel are compared with results obtained when the wheel is without scales.

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Keywords: rail, wheel, interaction, flat, impact force, dynamics modelling

1. Introduction

Damages in vehicle wheels occur due to interaction between wheel and rail and may also appear due to inaccuracies while manufacturing, poor part machining quality or due to appearance of a third body between wheel and rail [1]. Most off vehicle wheel damages are caused by braking, surface roughness, temperature differences and other factors.

Dynamic hardness methods [2] are used in order to assess the mechanical state (determine strength and plasticity characteristics) of vehicle's solid casting wheels.

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Theoretical angular speeds of loaded wheels are different because of uneven loads, and even though they are forced to move in at the same speed, the wheels slip and skid unevenly.

The most common damage in a wheel is a flat, which appears due to wheel slips or stuck brake pads [3].

Damages in the wheels are likely to increase during exploitation, the increase in wheel damages are examined in the article [4].

Many authors describe the contact zone of the wheel and the rail as a point or describe the wheel geometry as an analytical function in mathematical models of interaction between the wheel with a flat and the rail [5–9]. Results of forces appearing due to interaction between wheel with a flat and rail are presented [10]. These forces depend on different rail affecting forces and different vehicle movement speeds. It is determined, that the amount of maximum impact force appearing between the wheel and rail differs when static wheel loads are different and the wheel loses its contact with the rail when the wheel flat is in the zone of the contact between wheel and rail, and when the speed is high.

A developed mathematical model of the system Vehicle-Track is presented in this article. This model allows determining the interaction between wheel with scales and rail, model also shows its effects to dynamical loads.

2. Calculation model of wheel with metal scales

Scales can take different forms during the exploitation of a vehicle. Scale of a wheel, used in the article is shown in Fig. 1a, its position on the wheel surface is shown in Fig. 1b.

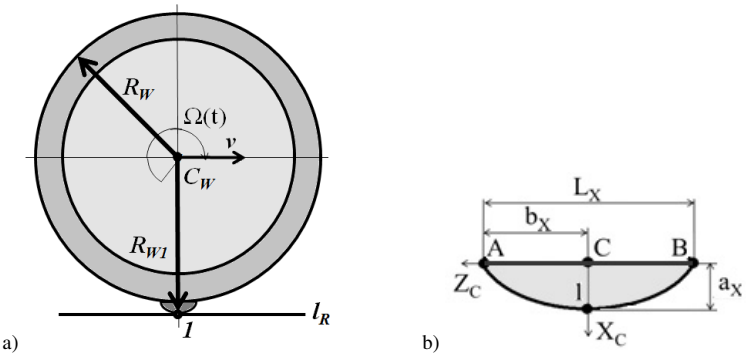

Fig. 1. Metal scale: its position in vehicle wheel (a); geometrical parameters of scale (b).

In the Fig. 1a, R_W is the radius of the wheel, R_{W1} is the radius of the wheel when the wheel is scaled, l_R is rail length, v is the speed of vehicle wheel, $\Omega(t)$ is angular acceleration, C_W is the centre point of the wheel, point 1 (in Figure 1a and Figure 1b is the peak of a scale in wheel.

In the Fig. 1b, a_x is a section between peak of a scale and a chord, which length is $L_x = 2b_x$.

Different height scales can be obtained by changing a_x. Points A and B are the beginning and the end of wheel damage, C is the middle of the cord, X_C and Z_C are the axis of coordinates.

A developed mathematical model [1, 11–13] has been used in the dynamic analysis of system Vehicle-Track, which consist of few mathematical models and is designed to determine forces occurring due to interaction between the wheel with a damage and rail.

3. Calculation results

The calculations are carried out and the results are obtained, when the vehicle movement speed is 100 km/h, when scale length is 100 mm and 0.5 mm height. Static load on the rail is 100 kN. The rail R65 which is 16.2 m long is analysed. The distance between sleepers is 0.5435 m. That distance is divided into 10 beam finite elements.

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