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Vibration analysis of a coach with the wheel-flat due to suspension parameters changes

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Abstract

This article is focused on the vibration analysis of the coach, which wheel is damaged by the wheel-flat. Analyses are carried out in multibody software and results are evaluated in terms of influencing suspension parameters change on accelerations output signals. The article consists of two parts. The first part is aimed on the problem of damaged wheels origin and its consequence during rail vehicle running on tracks during real operation. There is also included the system of forces and accelerations measurement during rail vehicle running on the given track section. The second part is focused on the assessment of selected measured parameters of a rail vehicle with wheel-flat which are obtained from computer simulations. As evaluation parameters signals accelerations in the selected location during passenger car running on the straight track for various stiffness of coil spring of the primary and secondary suspension were assessed.

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Keywords: rail vehicle ; damaged wheel ; multibody system ; computer modelling

1. Introduction

With a train moving on rails, a phenomenon of wheel-set stroke against the rail head occurs inevitably. This phenomenon is mainly caused due to the wheel rolling surface derailment, i.e. loss of contact [2]. This occurs as a result of the surface roughness on the wheel and rail. Roughness often is of jumping type: wheel flats, cracks and rail

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couplings. This type of wheel damage occurs when the wheel locks and slides along the rail because of malfunctioning brakes or because the braking force is too high in relation to the available wheel/rail friction [11]. Not so abrupt roughness also occurs, including uneven wheel wear, corrugated rail cracks and roughness due to wheel slippage. They also, at certain speeds, may create conditions for wheel derailment. With the emergence of strokes at the wheel and rail contact, the vertical forces may greatly increase (even up to ten and more times), thus causing serious damage of rail vehicles and the track and enhancing risk to the safe train traffic [20]. With increasing vehicle velocity, the dynamic forces caused by these disturbances increase as well. Therefore, it is necessary to identify the said faults of the rolling stock in due time and as much precisely as possible and to eliminate them.

2. Installation for damaged wheels detection

The Wheel Impact Load Detector (hereinafter – WILD) is a system for the constant measurement of vertical wheel and rail interaction forces of running rail vehicle through the overall wheel perimeter [4].

There are two basic types of sensors, the original sensors are based on strain gauges and measure force and the new type is based on accelerometers and measures rail motion [4].

Using rail mounted strain gauges as the wheel sensors, it can weigh each wheel of a train as it passes over, and detect skid flats in the wheels. A wheel with flat spots can create impact loads many times higher than the fully-loaded weight of the wagons it carries and cause serious damage to the railroad.

New WILD systems use an array of accelerometers to measure the change in motion. Air bags in wagons are released when an accelerometer senses sudden extreme changes. When the wheel goes over them, they read positive and as the wheel rolls past, they read negative. Any irregularities in the wheel cause the signals to go both positive and negative as the wheel rolls over them.

The array of sensors is mounted on track, together with an Automatic Equipment Identification (AEI) tag reader which determines the wagons ID when a train passes, identify and trace every wheel in the fleet for as long as that wheel is in service. The data gathered for each axle is automatically recorded on a database by the signal processor and the control PC. It is then transmitted to the railway control centre or depot maintenance centre for remote monitoring and diagnosis [6,15].

It is the beginning and the end of a measuring strip. The dynamic coefficient (hereinafter the DC), which to be drawn from the following formula, provides information on the status of the wheel, the higher the DC, the higher the degree of wear of the wheel.

The dynamic coefficient is calculated from the following formula:

$$DC = \frac{Q_{\max}}{Q_{stat}} \tag{1}$$

In equation (1) Q_{max} is the highest indicated dynamic vertical force on the wheel and Q_{stat} is the static vertical force on the wheel.

The dynamics are referred to as semi-normalized impact forces as they cancel out the effect the weight has on the impact reading. For example, a wheel carrying bigger weight will have a higher peak load simply because of the greater static force on the wheel. Similarly, a train moving at a higher speed will have a higher peak load just because of the higher dynamic forces on the wheel. Since the DC cancels out the effect the vehicle weight has no impact on a reading, but the speed of the train still affects their readings-out, these are considered only semi-normalized impact values. Rail vehicle properties as mechanical system can be designed [22], studied, evaluated and verified by means of experimental methods and measurements [9,16,21], simulation calculations and optimization by using computer software [3,23,24] or also by special equipment in laboratories [7,10,12].