Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 187 (2017) 235 – 241

Procedia Engineering

www.elsevier.com/locate/procedia

10th International Scientific Conference Transbaltica 2017: Transportation Science and Technology

Examination of Vertical Dynamics of Passenger Car with Wheel Flat Considering Suspension Parameters

Stasys Steišūnas[a,*], Ján Dižo[b], Gintautas Bureika[a], Vidas Žuraulis[a]

[a]*Department of Railway Transport, Vilnius Gediminas Technical University, Lithuania*
[b]*Faculty of Mechanical Engineering, University of Žilina, Slovak Republic*

Abstract

This paper describes the analysis of the vertical dynamics of the passenger car motion considering the vertical forces of wheel/rail interaction. The aim of this study is the assessment of the smoothness of passenger car running while one wheel is with a flat. The mathematical models of wheel flat impact on the rail and entire passenger car dynamic models are defined. In order to evaluate smoothness of rail vehicle movement by computer simulation means the software package Simpack was used. In this case, the wheel-flat was modelled considering the deviation of wheel rolling radius. On the base of the theoretical analysis, the vertical accelerations of passenger car with wheel flat running on the tangent track were evaluated. The analysis of passenger carbody oscillations was performed, while the vertical damping and stiffness of the car primary/secondary suspension changed within the specified range. The values of acceleration signals were measured and clarified. Finally, basic conclusions are given.

Peer-review under responsibility of the organizing committee of the 10th International Scientific Conference Transbaltica 2017

Keywords: rail car, wheel flat, suspension damping, running smoothness, computer simulation

1. Introduction

Seeking to attract the larger flows of passengers, the train running speed and frequency of routes should be increased, and a still broader range of services should be offered to passengers. Moreover, it is important to assess

* Corresponding author.
E-mail address: stasys.steisunas@vgtu.lt

Peer-review under responsibility of the organizing committee of the 10th International Scientific Conference Transbaltica 2017
doi:10.1016/j.proeng.2017.04.370

constantly the passenger travel comfort (convenience) which is significantly affected by the vibrations of the passenger carbody. These vibrations are generating due the interaction between the railway track and the vehicle wheel-set during train movement. Modern rail vehicles are quite comfortable, though, during their exploitation, defects of wheel running surface and track (rail) irregularities occur. While rail vehicle are running on the track, the interaction of these defects generate extra vibrations of the carbody and noise. These factors cause unpleasant feeling of passengers.

While operating the railway vehicle, the technical condition of the upper railhead and rolling surface of wheel should be periodically inspected in order timely to eliminate or to decrease the dangerous effects caused due to the wheel-set & rail influence on the car suspension, carbody and passengers [2, 3]. On the other hand, in the case of occurrence of considerable defects of wheel rolling surface, when rail vehicles are moving at too high velocity, the rails may get damaged (broken) and a traffic accident may take place [9]. Wheel damage occurs when the wheel locks and slides along the rail because of malfunctioning brakes or because the braking force is too high compare to the available wheel/rail friction [1, 4, 9]. With increasing vehicle velocity, the dynamic vertical forces caused by these disturbances increase as well [10, 12]. Therefore, it is necessary to identify the said faults of the rolling-stock in due time and as much precisely as possible and to remove them. Special methods are used for exploring the vertical interaction of wheel and rail, since the processes of shocks are becoming of high frequency. Duration of the highest momentary force action in the wheel and rail contact depending on the train motion velocity covers several milliseconds or even less.

2. Mathematical models of approaching assessment of wheel-flat impact on the rail

Not all dynamic models of wheel and rail contact take into account a degree of wheel wear and size of damage. To estimate wheel flat shock force on the rail, the following equation is used [2]:

$$Q_{\max} = v \cdot \frac{Z_n}{r} \sqrt{\frac{c \cdot m_{un} \cdot m_r}{m_{un} + m_r}}, \qquad (1)$$

where v is the train speed, m/s; Z_n is the wheel flat length, m; r is the wheel rolling radius, m; c is the stiffness at the wheel and rail contact, N/m; m_{un} is the unsuspended mass, t; m_r is the rail mass, t.

It is notable that the Formula (1) does not estimate the suspended mass, impact of primary and secondary suspension, track roughness, etc. Mathematical models of wheel flat dynamic impact on the rail are usually formulated using the inverse Laplace transform, which was studied in the works by the Russian scientist Kogan [6, 7]. Later these models improved by the scientists from Russia and other countries [5, 14]. Geometry scheme of wheel flat and rail contact is presented in Fig. 1a.

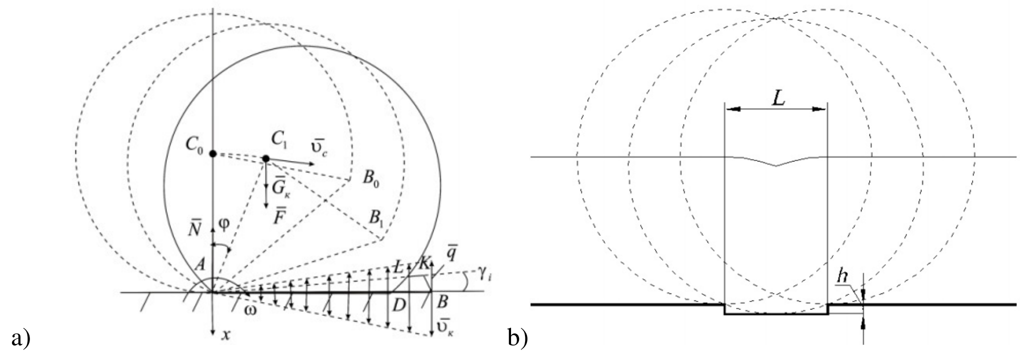

Fig. 1. a) Wheel flat and rail contact diagram; b) track irregularities for the „ideal“ wheel flat simulating.