EAN 2014
52nd conference on experimental stress analysis

Measurement of Wheel and Guiding Forces on the Tracks

PAZDERA Lubos[1,a], TOPOLAR Libor[1,b] and SMUTNY Jaroslav[2,c]

[1]Brno University of Technology, Faculty of Civil Engineering, Department of Physics, Czech Republic

[2]Brno University of Technology, Faculty of Civil Engineering, Department of Railway Construction and Structures, Czech Republic

[a]pazdera.l@fce.vutbr.cz, [b]topolar.l@fce.vutbr.cz, [c]smutny.j@fce.vutbr.cz,

Keywords: Guiding force, strain gauge, stress, dynamic load, wheel, train, dynamic.

Abstract. Force interaction between a railway track and a vehicle affects the safety, comfort, and last but not least, economical maintenance. Train of wagons incidence on track in both transversal and vertical direction is simplified by qualifying of force wheel (F_Q), guiding (F_Y) and perpendicular and transverse acceleration. Force action of vehicles on track can be directly measured, nevertheless those measuring are technically and organization wise very demanding. Generally, measurement method based on detection plate wheel deformation is used by the help of strain gauge on surface plate wheel. This method requires using specific wheel sets. Therefore, these methods are applied only at homologation vehicles. Limit values are given by regulations and standards. Sometimes it is advantageous with respect to long-term monitoring of dynamic characteristics of railways superstructure, to use another method applied directly on superstructure.

Introduction

An experimental basis for dynamic determination of vertical, F_Q, and lateral, F_Y, forces at the wheel using strain measures in the foot of the rail is given. Measurements of the dynamic forces during passing train are normally very costly and uneasy. These method consists of measuring strains at selected points of the rail profile is very simple and therefore interesting.

Experiment on the Turnout

This article is devoted to measurement of wheel and guiding forces on railway superstructure. The relative deformation measuring method evoked on rail cross – section by those forces was used. Sensors were placed on the base of rail. There is one part of cross - section rails, where relative deformation is in direction of normal tension. Guiding and wheel force ratio describes on important mode of against derailing. One part of article is a theoretical analysis of the problem and further analysis of measuring procedure and evaluation. Conclusion contains evaluation and recommendation for practice.

Measuring was implemented in frog turnout No. 3 J60- 1:26,5 - 2500 -PHS in railway station Poricany. Turnout is rolling mainly opposite frog, in direction Kolin–Praha. Turnout No. 3 is held on rail fastening system UIC 60 on concrete sleepers. Rails are fixed by elastic fixation Vossloh.

It should be noted that the mentioned method was a part of a complex measurement kinetic behaviour and transmission of vibrations by turnout construction [1].

Strain gauge sensors of relative deformation were placed in points C and D according to Fig. 1 [2]. Vertical load at the wheel is given

$$F_Q = k_1 \cdot (\varepsilon_C + \varepsilon_D) \tag{1}$$

and lateral load at the wheel is given

$$F_Y = k_2 \cdot (\varepsilon_C - \varepsilon_D) - k_3 \cdot (\varepsilon_C + \varepsilon_D) \tag{2}$$

where k_1, k_2 and k_3 are parameters gained by adjustment measurement, ε_C, ε_D is strain at point C, D respectively (see Fig. 1) [3]. Theoretical computing parameters k_1, k_2 and k_3 is also possible, but it can be more complicated. Relationship between stress, σ, and strain, ε, is given by Hooke's law

$$\sigma = E \cdot \varepsilon \tag{3}$$

where E is modulus of elasticity [4].

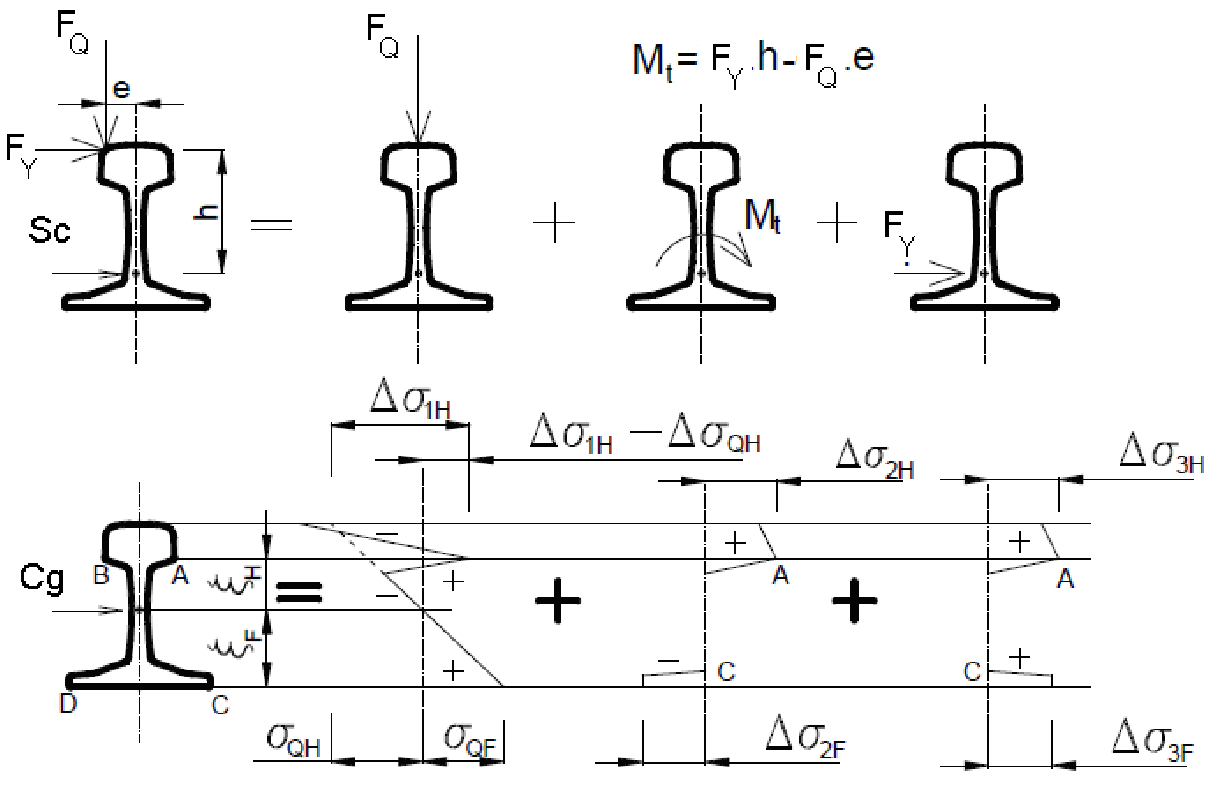

Fig. 1. Analysis of method for sensors placing (Sc – shear centre, Cg – centre of gravity) [2].

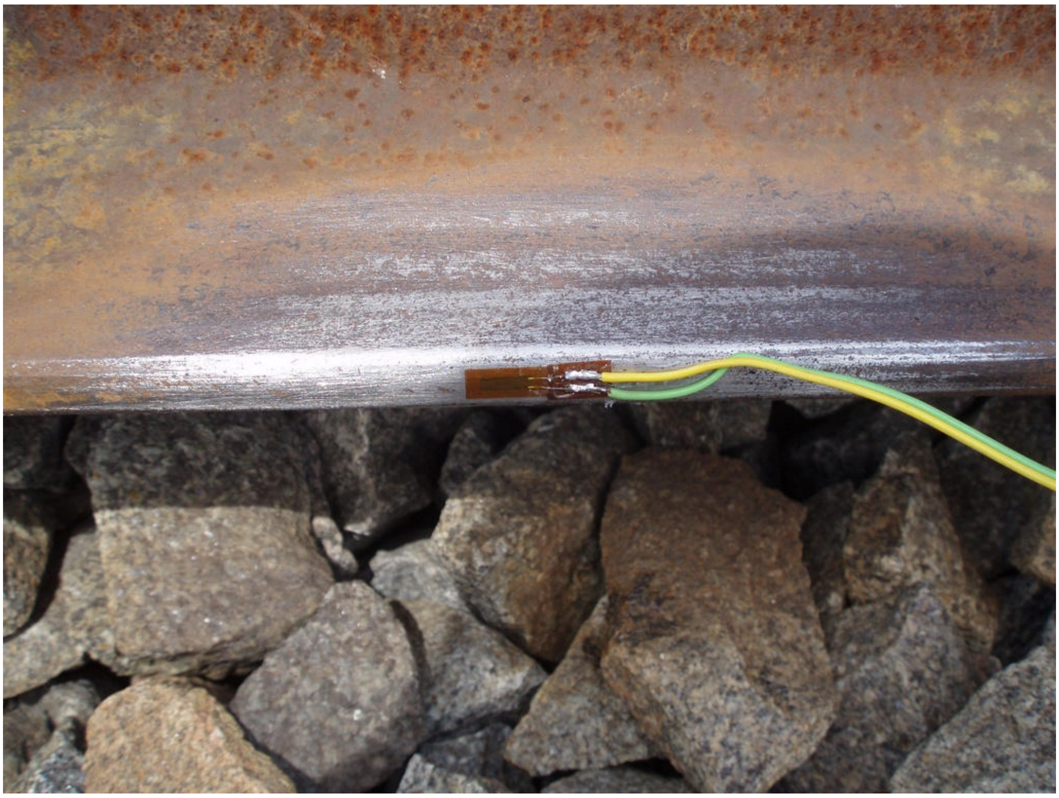

Fig. 2. Strain gauge placing.

Current measurement of wheel and conducting forces proceed in both running rails of turnout. Strain gauge placing on given structure is shown in Fig. 2. Joint time and frequency analyses were used for evaluation. Wheel forces in monitored seats came up to expected values and guiding forces were mostly very small. In all cases, largest values were recorded for the engine, smallest for the carriage. Values of wheel and guiding forces in both running rails of turnout were evaluated.

It is clear that forces on different parts of turnout will be different. Dynamic loading courses, when train SC-1600 passed over monitored turnout, are shown in Figs 3 and 4. Vertical loads at the wheel attain similar courses and values. However lateral load at the wheel are different. Lateral forces on the heel of crossing (Fig. 3 bottom) contain a half values of maxima lateral forces on the frog rail. Attenuations both forces on the heel of crossing are greater than on the frog rails [5].

Forces wheels on the hell of crossing (F_{QH}) and on the frog rails (F_{QF}) are shown in Figs. 5 and 6 and forces guiding on the hell of crossing (F_{YH}) and on the frog rails (F_{YF}) are shown in Figs. 7 and 8.

Conclusions

Time records of corresponding forces and their analysis by non-traditional methods will be described in the article. Monitoring strain gauges mounted on the rail profile foot is very simple alternative for determination of wheel forces on the rail. This measurement uses simple equations (Eq. 1 and 2) for determination vertical and lateral forces expressed as function of the measured longitudinal strains on the outside and inside of the rail foot midway between sleepers.

Application of neural network or wavelet transformation can help to analyse measured record [6, 7].

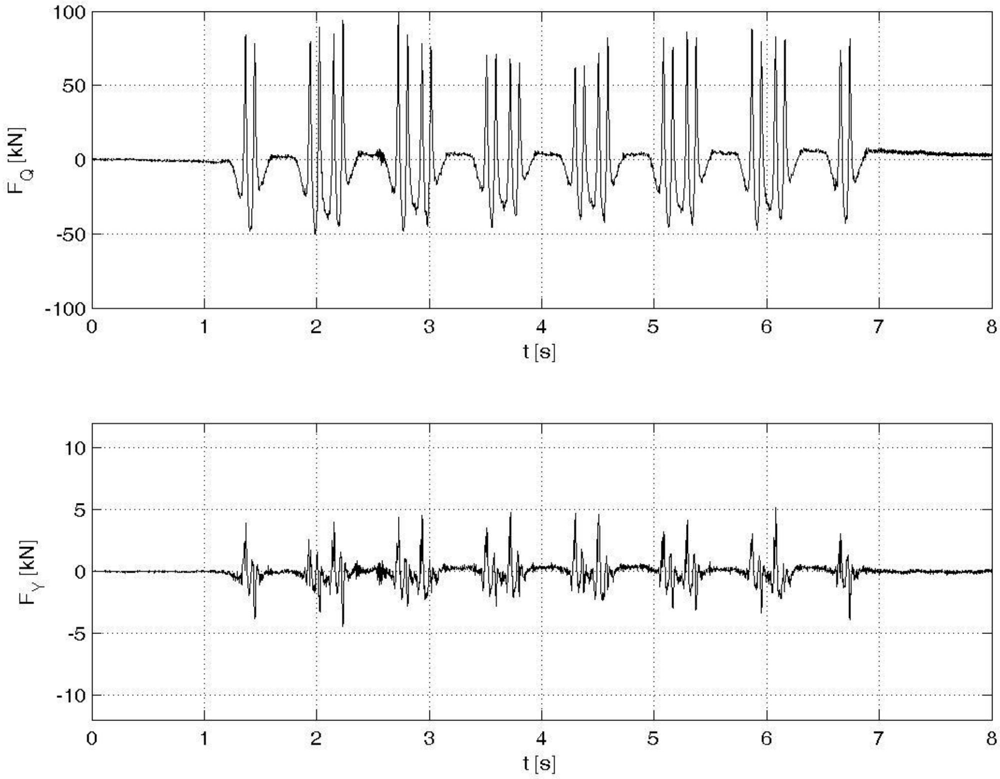

Fig. 3. Forces on the heel of crossing.

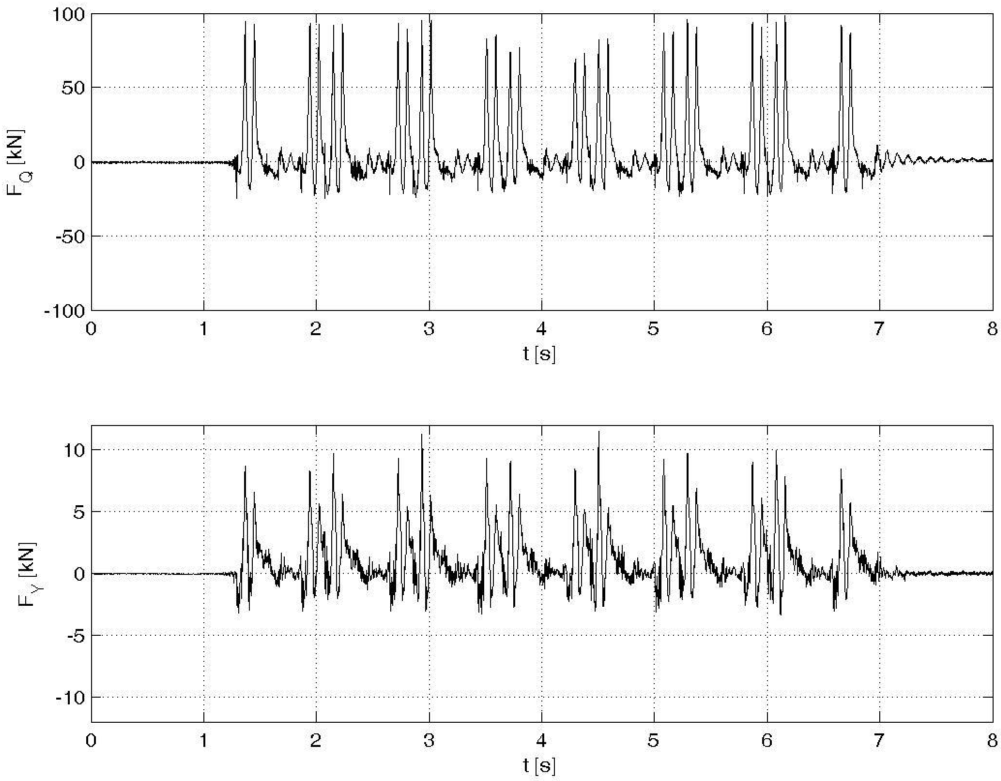

Fig. 4. Forces on the frog rails.

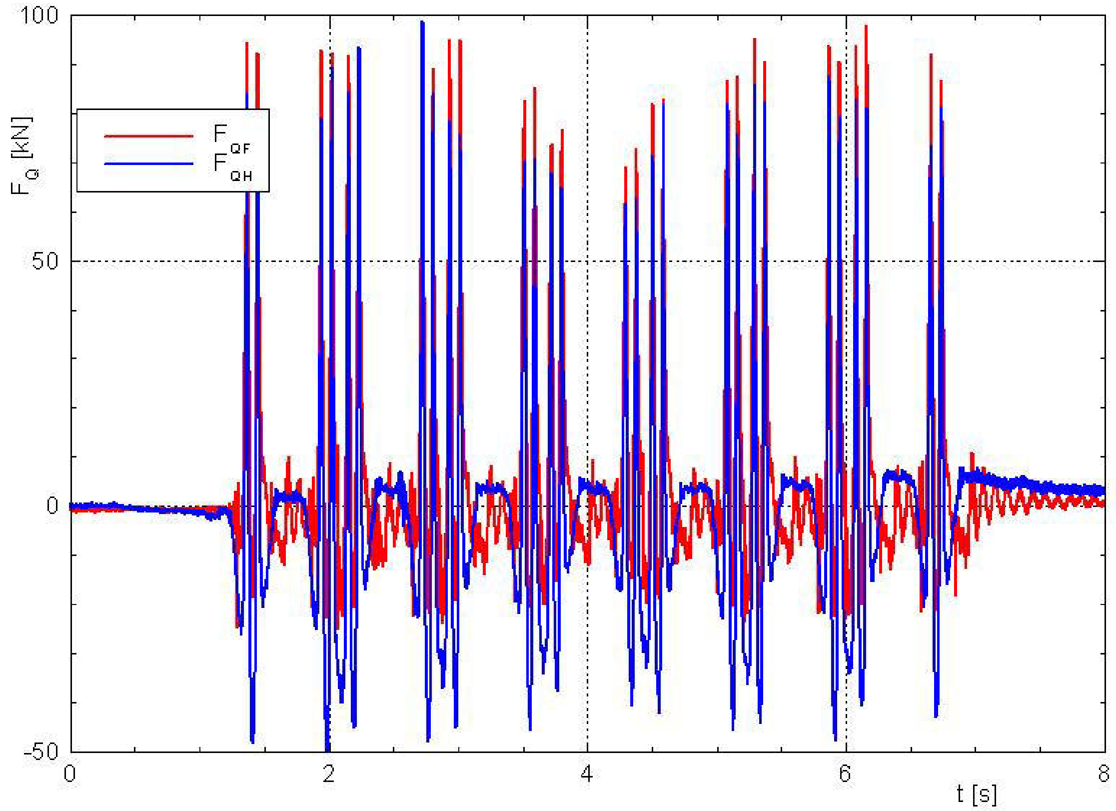

Fig. 5. Wheel forces.

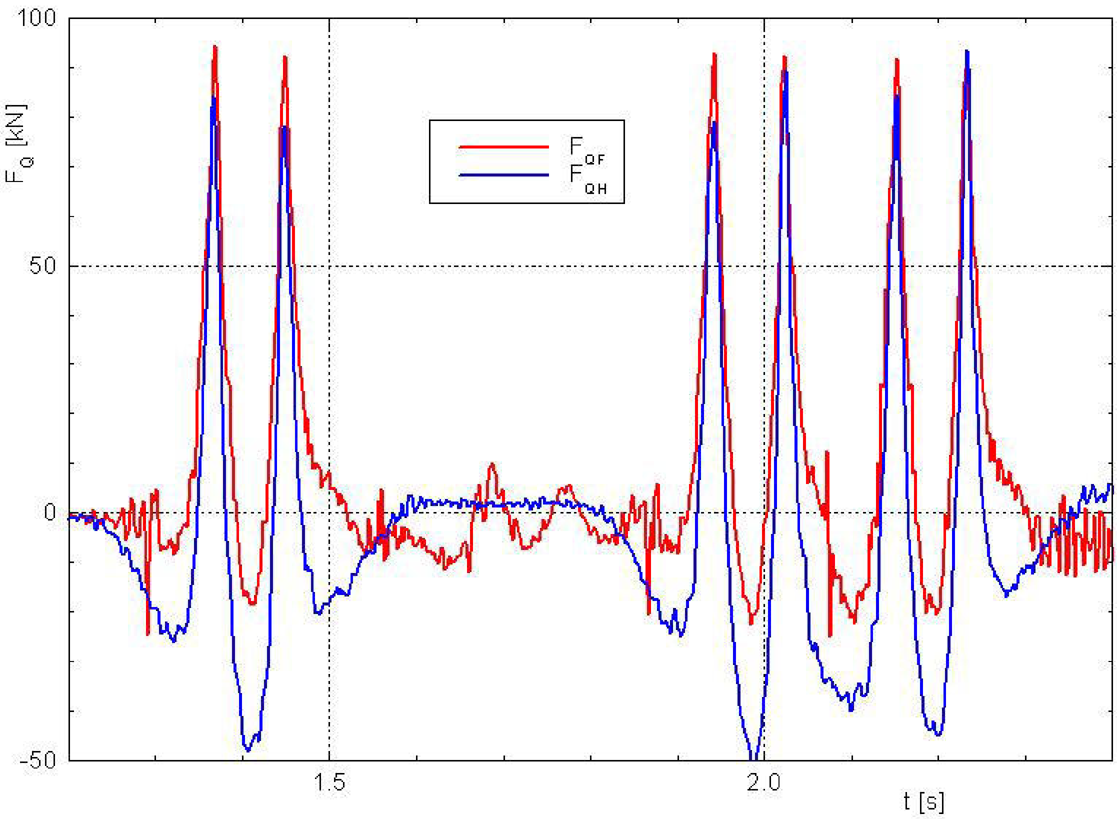

Fig. 6. Wheel forces – detail of Fig. 5.

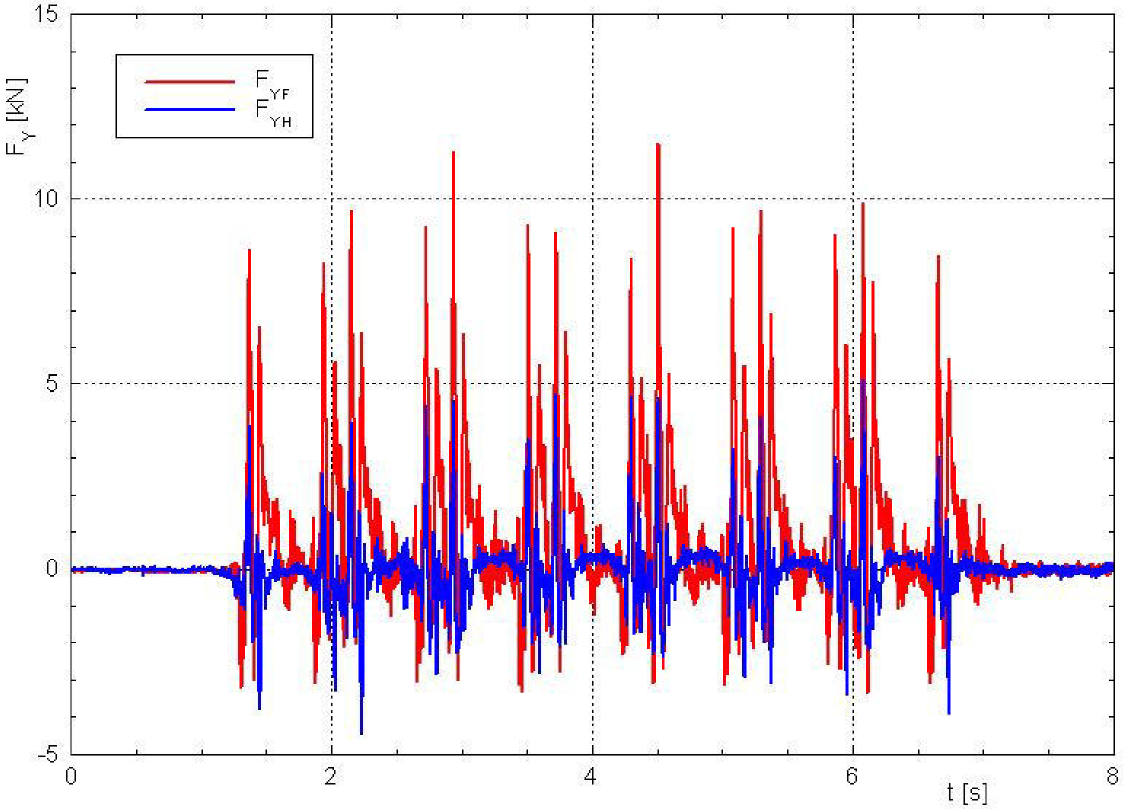

Fig. 7. Guiding forces.

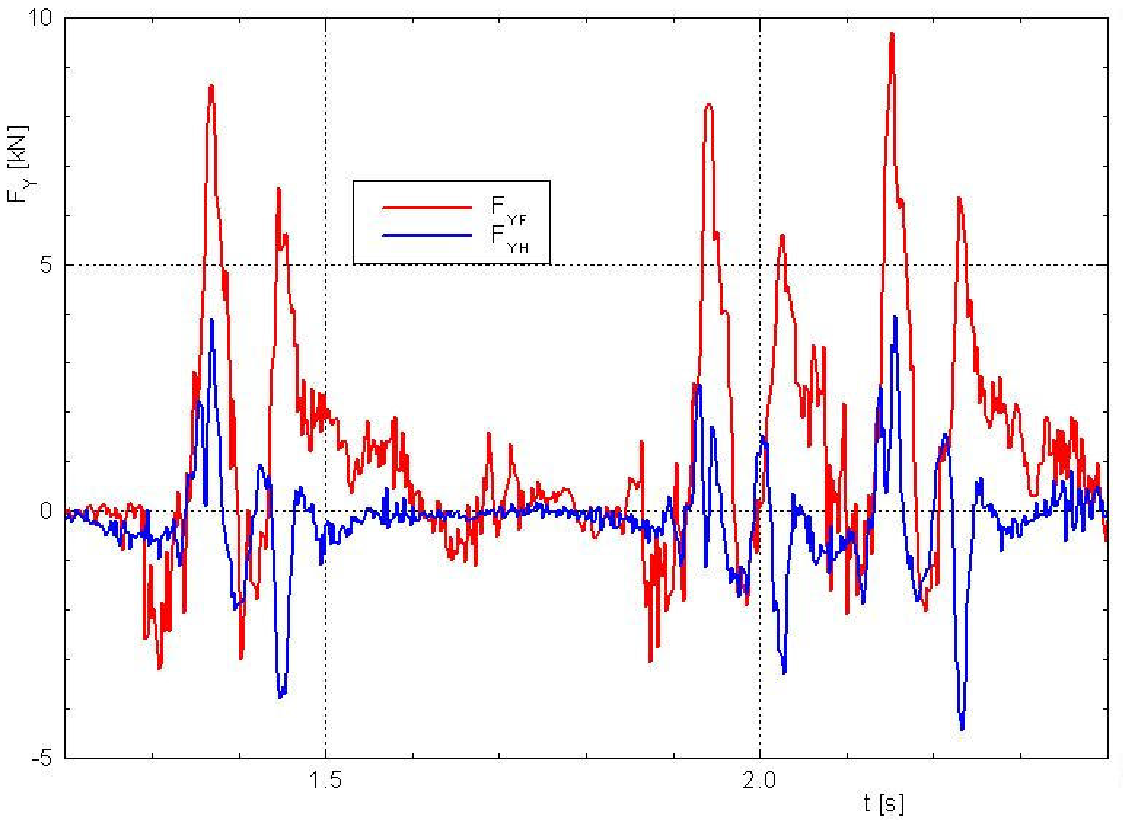

Fig. 8. Guiding forces – detail of Fig. 7.

Acknowledgement

This paper was elaborated with the support of the European Union's "Operational Programme Research and Development for Innovations", No. CZ.1.05/2.1.00/03.0097, as an activity of the regional Centre AdMaS "Advanced Materials, Structures and Technologies", and of the Technology Agency of the Czech Republic "Increasing the quality of track in switches by flexibility" No. TA01031297.

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