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Jaromír ŠIROKÝ[*]

THE METHODOLOGY OF DIGITISING OF THE TRACTION VEHICLE MOTION MECHANICAL RECORDING

METODIKA DIGITALIZACE MECHANICKÉHO ZÁZNAMU JÍZDY KOLEJOVÝCH HNACÍCH VOZIDEL

Abstract

This contribution deals with the partial procedure at the analysis of the traction vehicle motion recorded by a speed tachograph on a paper strip and also shows the possibilities of the digitising the record and its use for analysis of the traction vehicle motion.

Keywords: the motion record, digitising of the record, analysis of the record.

Abstrakt

Tento příspěvek se zabývá několika postupy při analýze jízdy kolejových vozidel, zaznamenané pomocí registračního rychloměru na papírový proužek. Ukazuje možnosti využití digitalizace záznamu a jeho zobrazení pro analýzu pohybu vozidla.

Klíčová slova: záznam jízdy, digitalizace záznamu, analýza záznamu.

1 Introduction

Currently there are still more than half of traction and special-purpose rail vehicles of all operators equipped with tachographs registering the data on a paper strip.

Such recording tachographs installed in those vehicles have either mechanical or electrical transmission of the wheelset angular velocity and record prescribed parameters mechanically on a sensitive layer of the paper strip. The recorded values are specified by MD 173/1995 Sb. standard. The values are [ČD, 2001]:

- principal parametres (instantaneous speed in relation to the distance moved, time, driving and stopping times, operation of a vigilance button by the driver, illumination of the red signal on the on-board signal repeating device);
- additional parametres (e.g.: use of a horn, pressure in the air piping, driving direction etc.).

[*] Ing. Jaromír Široký, Ph.D., Institute of Transport, Faculty of Mechanical Ingineering, VŠB-TU Ostrava. jaromir.siroky@vsb.cz

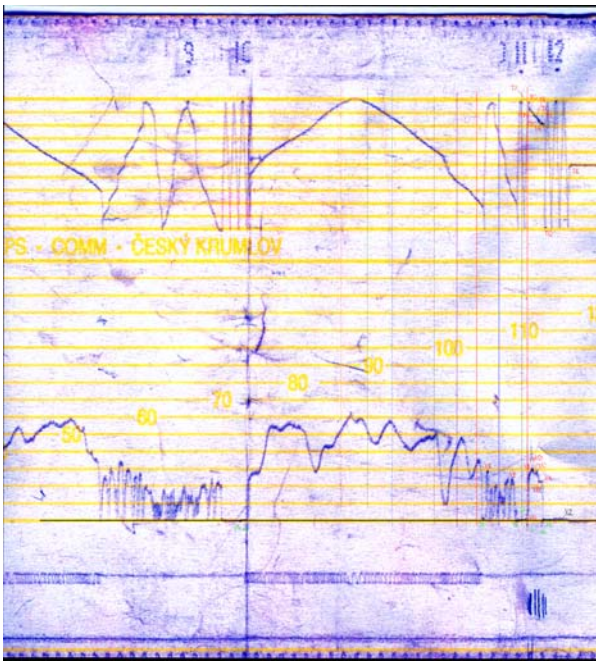

Fig.1: Sample of the record (the tachograph paper strip).

2 Requirements for the analysis realisation

The basic requirement for the analysis realisation is digitising of this record by scanning. For this further step it is necessary, however, to ensure so that the output bitmapped file is not compressed or changed in any other way. Then, such a file serves as a groundwork for further analyses where the course of monitored values can be replaced by a set of points described in the system of coordinates of the scan grid. For processing of the described course, a numerical method can be used, such as numerical derivation, interpolation etc.

Results from this analysis of testing on the digitised record in practice confirm that use of 600 dpi resolution will be suitable to achieve sufficient accuracy. This resolution is attainable with commonly used scanners.

2.1 System of coordinates

The direction which is parallel to the strip movement is specified as ***x***-axis, that vertical as ***y***-axis. The basic unit for the reading is a pixel (1 pixel = 1px). Origin of the system of coordinates is in the upper left corner of the digitised part of the record (see the sample in Fig. 4).

2.2 Rectification of the record presentment

To ensure correct and precise reading of the coordinates of individual points, it is necessary to carry out correction of the record presentment so that the course of the pre-printed grid of the tachograph paper strip is parallel to the used system of coordinates (see Fig. 2). The parallelism is documented by construction of adjustment straight line designated **V.P.** which is parallel along the ***x***-axis of the system of coordinates and to the grid presentment of the zero speed.

2.3 Setting of scales

The scale of the paper strip movement

Setting of the scale comes out from statistical evaluation of the positions of track marks by methods of the descriptive statistics:

$$a_p = \frac{l_z}{x_z} \text{ m/px} \quad (1)$$

where:

l_z [m]....distance between two track marks in the record (specified)

x_z [px] ..mean distance of track marks in the scan

The scale of speed record in the paper strip

Setting of the scale comes out from the statistical evaluation of the record field width for the specified tachograph range.

Mean value of the calculated scale of speed is:

$$b_V = \frac{V_z}{y_z} \text{ km·h}^{-1}\text{/px} \quad (2)$$

where:

V_z [m]..range of the tachograph (of the record) (specified)

y_z [px]..mean distance of speed limits in the scan

The scale of the time record

Setting of the basic scale of the minute record comes out from the field width of the minute record and from the statistical evaluation.

Mean value of the basic scale of the minute record:

$$b_{mz} = \frac{y_{mz}}{t_{10}} \text{ px/min} \quad (3)$$

where:

y_{mz} [px]..... mean distance of minute limits in the scan

t_{10} [min] ..... range of the minute record (specified)

To set real scale of the minute record, it is necessary to determine real maximum range of the minute record. From this range it is possible to set the mean value of the real scale of the minute record:

$$b_m = \frac{y_m}{t_{10}} \text{ px/min} \quad (4)$$

where:

y_m [px] mean real distance of the minute limits in the scan

t_{10} [min] range in the minute record (specified)

Then the scale is used for evaluation of the time record.

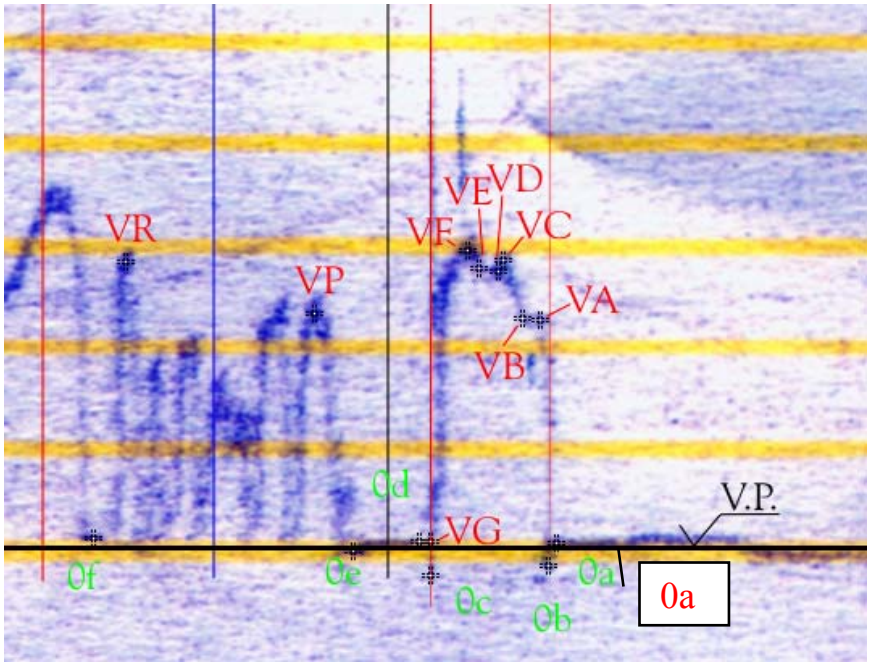

Fig. 2: Section of the speed record course.

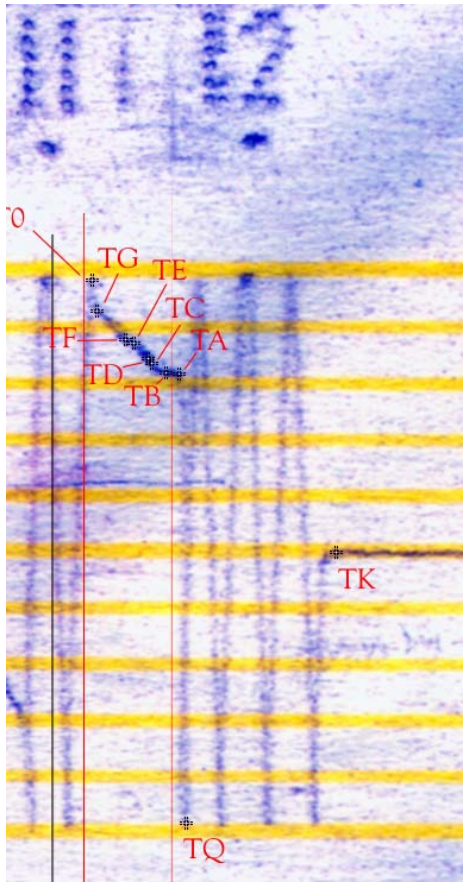

Fig. 3: Section of the time record in the tachograph paper strip.

2.4 Corrections of the record

Position of the zero speed

Position of the recording pin at the zero speed (the vehicle at rest) comes out from the established position of the pin. To set the position, it is necessary to select several reference points of this position (see the points **0a** to **0f** in Fig. 2). Then it is necessary to set mean value of a position Y_{V0} for V = 0 km·h^{-1}, including a tolerance field. This value is further used for setting of the speed value of individual important points in the speed record.

Limit position of the minute record

Limit position of the minute record Yms for reading of time is set by statistical analysis of limit point coordinates of the record. Further, this value is used for setting of time value of individual important points of the speed record.

Setting of the tachograph time correction

Position of the minute record at the moment of the paper strip taking out of the recording tachograph is defined by a value of a coordinate Y_{TK} of the point **TK** of the record (see Fig. 3). This point corresponds to the time which has been recorded by the tachograph $R^{t_{TK}}$ with the defined tolerance field. The time is compared then with official time of pulling out, signed on the paper strip, all that on the basis of statutory rules and railway operating regulations. The final correction of time is:

$$\Delta_R t = t_{V0} -_R t_{TK} \ [\text{min}] \tag{5}$$

Longitudinal shift of the record

At the analysis of the speed and time records, between important points of the speed record (e.g. VB and VA) and corresponding points of the time record (**TB** a **TA**), a longitudinal shift ΔX_T of the record can be found out along the x-axis with a tolerance field.

3 Setting of important points position

For further steps in the analysis, it is necessary to set coordinates of the important points including their tolerance fields in every single parameter. For this, characteristics of individual points of analysed parametres will be used (their colour characteristics). Value which describes the given point in the track of the recorded parameters differs from a colour of the paper basis. Width of the track is given by both shape and the pressure of the recording pin. These qualities are influenced by operating conditions of the recording device and the way of its maintenance.

Procedures coming out from the theory of dimensional limits (see Fig. 4) are used for setting of coordinates of necessary important points. Nominal value of the position is set as a pixel position $[X,Y]$ in the middle of the track. Limit values of presentments X_{DM}, X_{HM}, or Y_{DM}, Y_{HM} will be set by analysis of values change of the pixel characteristics along the both axis.

Within the analysis of distance between the points under consideration (eg. **VG** and 0**a** in Fig. 2) the values as follows will be set:

- nominal value of the distance along the ***x***-axis (presentment of the distance moved, in this case), i.e. providing that X(**0a**)>X(**VG**) according to the relation:

$$\Delta X = X(\mathbf{0a}) - X(\mathbf{VG}) [\text{px}] \tag{6}$$

- lower and upper limit of the tolerance field:

$$\Delta X_{min} = X_{DM}(\mathbf{0a}) - X_{HM}(\mathbf{VG}) \ [\text{px}] \tag{7}$$

$$\Delta X_{max} = X_{HM}(\mathbf{0a}) - X_{DM}(\mathbf{VG}) \ [\text{px}] \tag{8}$$

Nominal value of distance and of the lower and upper limit of the tolerance field along the ***y***-axis is set in the same way.

Subsequently, using the set scales according to the part 2, it is possible to determine numeric values of the characteristics under consideration, and to use them for further analyses of the traction vehicle motion record - see for example [Široký, 2007a].

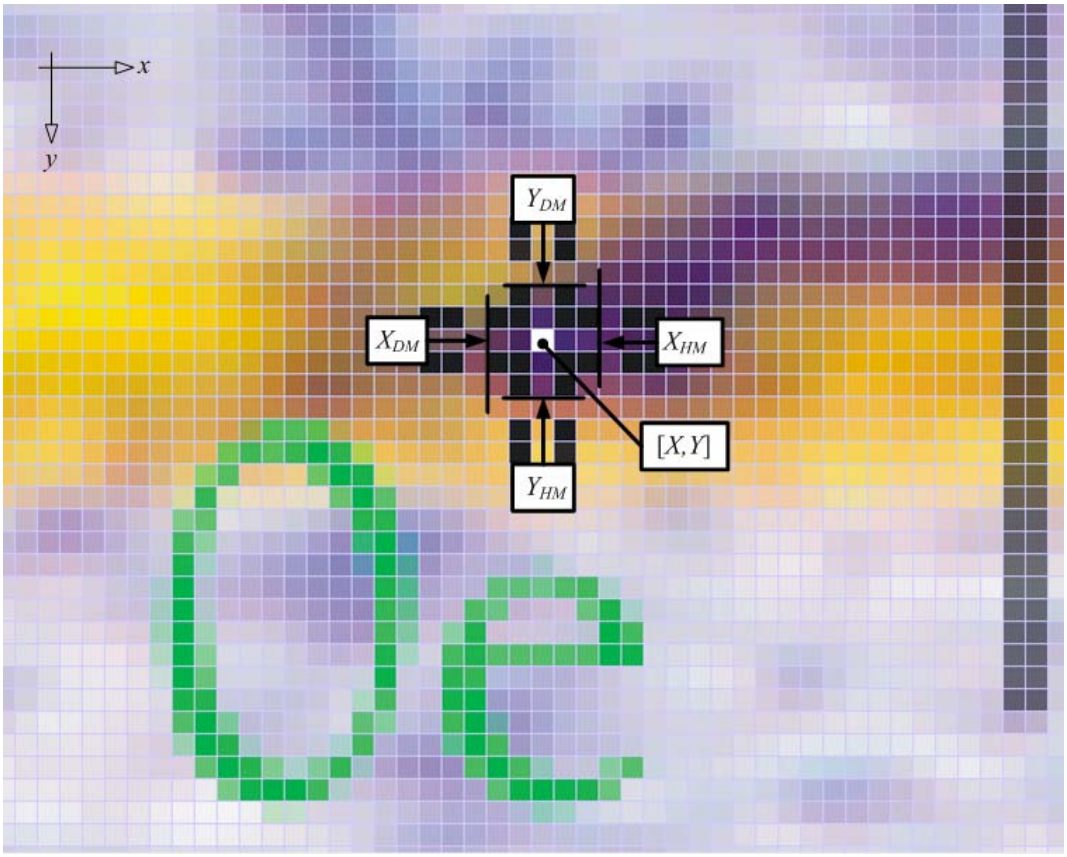

Fig. 4: Detail of the important point and its tolerance field.

4 Conclusion

Within this application it was confirmed that the use of the principles described above was fully suitable for definition of individual points of presentment in relation to the width of recording pins, accuracy of the recording device, [ČD, 2001] and scales of the real traction vehicle motion.

The procedure described in this paper as well as other procedures of the analysis described in [Široký, 2007b], which enabled digitising of the traction vehicle motion recording, were used in practice for speed profile analysis in the case of collision of a rail vehicle with a road vehicle at the railway crossing. This procedure has been accepted by practical experience, providing more precise results with high predicative value in comparison with a procedure of the analysis used up to now.

The contribution follows the text published in [Široký, 2007b] and the procedure was applied in the paper by [Široký, 2007a].

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