The Significance of Dynamic Detection of the Railway Vehicles Weight

Značaj dinamičke detekcije težine željezničkih vozila

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Summary

This paper is focused on the issues and aspects regarding the railway vehicle´s weight and its detection. Incorrectly indicated weight leads both to a reduction of the fee for using the railway infrastructure, but also the reduction of freightage (import fees). Damaging the transport infrastructure of the railway vehicles and safety threats of railway operations are other negative aspects.

KEY WORDS

static and dynamic detection of the weights
railway vehicles
railway infrastructure
safety

Sažetak

Članak se usredotočuje na problem i aspekte u svezi težine željezničnog vagona i njegovu detekciju.Netočno je navedeno da težina vodi smanjenju naknade korištenja željezničke infrastrukture, nego i smanjenju vozarine (troškova uvoza). Oštećivanje transportne infrastrukture željezničkih vozila i prijetnje sigurnosti željezničkim operacijama ostali su negativni aspekti.

KLJUČNE RIJEČI

statička i dinamička detekcija težina
željeznička vozila
željeznička infrastruktura
sigurnost

1. INTRODUCTION

The necessity to weigh the consignments intended for shipping is important for all modes of transport. Overloaded vehicles represent a serious danger for transport, for example, an increased risk for transport infrastructure users, deterioration of the traffic safety, severe impacts on the state of the infrastructure and unfair competition among different modes of transport and their providers can arise.

In most cases, the consignor indicates the consignment weight; therefore, the carrier has the right to check the declared weight whenever and wherever. The problem is that in most cases, it is not possible to carry out this act, because no railway scales are available. Therefore, it is necessary to minimize the number of overloaded vehicles. The application of vehicles' weighing while moving (weight-in-motion) represents a great potential. The introduction of new technologies aims to develop a comprehensive, fully-equipped and reliable system of dynamic weighing of vehicles, i.e. in motion. Such a system is certified as so-called "specified measure" and check-weighing results compare an actual weight with a permitted weight for a given type of transport infrastructure. For exceeding the maximum permitted weight, the sanctions are imposed [1].

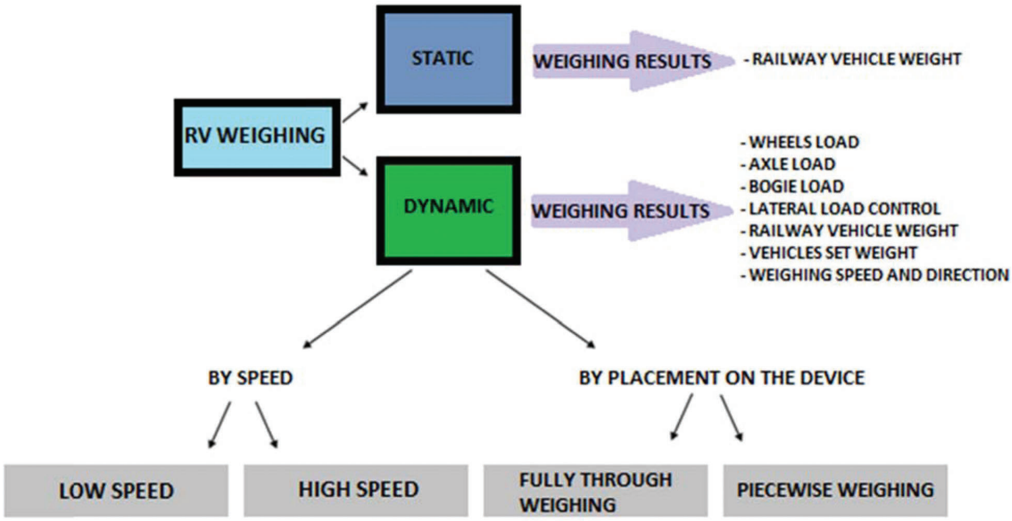
2. POSSIBILITIES OF DYNAMIC WEIGHING OF THE TRANSPORT MEANS WITHIN THE RAILWAY TRANSPORT

The real way of the weight detection is similar to the road toll and consists in the measuring the operational load, the number of passing railway vehicles, and possibly, the dynamic effects of traffic (operation) on the transport infrastructure. Subsequently, the process of elaboration and evaluation of the measured data to meet the needs of the railway transport infrastructure administrator and its charging. This method requires - similarly as for the road tolls - the installation (implementation) of measuring points on each railway track section that is a part of the charged transport infrastructure. The measuring points consist of the measuring devices that can operate either on the principle of dynamic weighing, or can detect the dynamic effects of passing railway vehicles. The advantage of this system is that it records all the burdens which pass along the installed measuring point [2], [3].

To define the expression "weight-in-motion (weighing in motion)", the following definition can be utilized. "It is such a weighing when the object of weighing (railway vehicle, hereinafter RV) moves on the rack of load (burden) with a uniform motion. The basic division is shown in Figure 1 [2], [3].

Static weighing has a lot of limitations. Above all, it requires a service and a time for its own weighting. Parameters of the railway scales and their improper placement after the valid time of their construction, in most cases on the sidings (sidetracks), are other limitations. Such a placement increases a time consumption (duration), i.e. an extension of the total transportation time. A total RV weight is the result of weighing [3-5].

The weighing in motion at low speed (up to 10 $km.h^{-1}$),



Source: authors

Figure 1 Basic division of weighing of the railway vehicles and weighing results

eliminating the partial disadvantages of the static weighing, is another "evolutionary" step. It is possible to weigh both the individual RV as well as the RV sets. It results in reduction of time for its own weighting and the result of weighing in time, i.e. before stopping, is the main benefit. It is also important to determine the scale of the weighing results which are bought by modern technologies [5], [6]. Weighing in motion at high speed (up to 140 km.hod^{-1}) represents the last, in the world used, technical solution. It is the railway track control device that allows, besides the train-sets weighing at high speeds, to detect an incorrect load distribution as well. All the acquired information is made available to users in real time [1-3].

3. LEGISLATION REGULATING THE DETECTION OF THE CONSIGNMENTS WEIGHTS

In the Czech Republic, the railway vehicles' weighing is regulated by the Railways Act 266/1994 Coll. as amended (Zákon o dráhách 266/1994 Sb). It regulates the conditions for the construction of railway tracks and buildings regarding these tracks, the conditions for the operation of railway tracks and railway transport operation, as well as the rights and obligations of natural and legal persons associated with it and the performance of the state administration and state supervision in the matters of railway transport.

The Act incorporated the relevant EU rules. The conditions under which goods are transported in public rail transport provides transportation orders. Government publishes regulation transport regulations for public rail freight transportation. Details conditions of carriage may be specified in the contractual conditions of carriage

The Czech Government Regulation No.1/2000 Coll. on transport rules for public rail transport (according to § 37 of the Railways Act) determines the conditions for the carriage of wagon consignments in domestic public railway transport. For the international carriage, the Convention concerning International Carriage by Rail (COTIF) mentioned in the Collection of International agreements under No. 49/2006 Coll., including connections is applied. Contractual transport conditions of the carrier are announced by the carrier in the Transport and Tariff Bulletin, issued by the Department of Transportation, or are issued on the usual venue for submission of information to the public [5-8].

If the carrier detects the weight of the consignment content at the request of the consignor, it will be determined in such way that from the total weight of the loaded RV will be counted out the tare indicated on the wagon. When using any method of determining the weight of the consignment content, this weight must not exceed the load limits specified in the load tables that are indicated on the wagon.

If the carrier detects the cargo overloading, he will proceed in accordance with the provisions of the transport conditions. The consignment part is indicated as an overloaded in such conditions when the part exceeds the loading weight of the RV for the intended route or other weight limitations of the RV. The consignment part must be unloaded; overloaded consignment belongs to the category of load failures. For exceeding the maximum permissible loading weights and other weight limitations, the carrier calculates the extra-amount, as a traffic (operation) safety threats, by tariff.

The RV weight is regulated by the Decree no. 177/1995 Coll., which issues the building and technical regulations of the Czech railways, here, the tracks are national, regional and railway sidings classified into track load classes. Track load classes are defined by the maximum parameters of the model RV: axle load, weight per unit length and the configuration of the drive axles [9], [10].

The tracks are classified into the track load classes A, B1, B2, C2, C3 (C4, D2), D3, D4, E4 and E5 shown in Table 1. For operational reasons, the tracks, without justification, are not classified into the classes C4 and D2. The weighing system within the railway transport is unresolved field of railway transport in the Czech Republic. Abroad, the modern technologies regarding the weighing in motion have been already commonly used. Therefore, it is necessary to apply these systems in the Czech Republic as well [3], [11].

Table 1 Table of the track load classes

Dividing bounds of track classes		Axle load				
Weight per linear meter of the vehicle length		A 16.0 t	B 18.0 t	C 20.0 t	D 22.5 t	E 25.0 t
1	5.0 t/lm	A	B1			
2	6.4 t/lm		B2	C2	(D2)	
3	7.2 t/lm			C3	D3	
4	8.0 t/lm			(C4)	D4	E4
5	8.8 t/lm					E5

Source: Annex no. 6 to Decree no. 177/1995 Coll.

4. PRACTICAL RESEARCH IN THE FIELD OF CORRECT USING THE CONSIGNMENTS WEIGHTS WITHIN THE RAILWAY TRANSPORT

Detecting the correct consignments weight transported by the railway freight transport was performed on the railway scale - TRAPPER DRS, placed at the train station Horní Dvořiště, which is located in a circuit of the operating units of the ČD Cargo - České Budějovice.

Electronic railway scales - TRAPPER DRS are designed for weighing the RV in motion (while they are moving = dynamic weighing). Individual railway vehicles are fully automatically weighed when passing the train set through the weighing bridge. Scales - TRAPPER DRS may be designed as a single-bridge (with a short weighing bridge with a length of 4.5 meters to 6 meters) for weighing the RV with a solid substrate.

Each RV is weighed piecewise = separately (by chassis or by axles) when it is passing through the weighing bridge. The superstructure of the railway scale weighing system consists of a personal computer with weighing and data-processing software - ScalexPC in a graphical environment of the MS Windows.

Due to the dynamic fully automatic weighing, this operator station can be located as a remote working place with the data transmission from the scale using the link modems or as a wireless system. For the static weighing, it can be mediated the visual contact of the operator with a weighing bridge using the industrial camera system [11-13].

The basic parameters of the railway scale are as follows:
- load of scale - 100t,
- scale length - 22.5 m,
- traveling (passing) speed - up to 40 km.h^{-1}.

In 2015, 11 027 of freight RV were weighted at the railway station Horní Dvořiště. This amount represents 62.2% of the total number of freight RV. The results of the weighing the railways wagons are shown in Table 2. Table shows the number of railway vehicles with an incorrectly declared weight, while the numbers are listed according to the exceeding weight in percentage.

From this analysis, it was found that 30% of the total number of weighted railway vehicles, for which the incorrect weight has been declared, were overloaded. The difference in declared weight and actually detected weight in the case of overloaded vehicles was 2 718.5 t. Graphical illustration of identified differences in declared consignment weight and the actual consignment weight is indicated in Figures 3 and 4.

Figure 3 shows the share of the percentage differences between the declared consignment weight and the actual consignment weight of the total number of identified differences in consignment weight. Figure 4 shows the total difference in weights in kilograms according to the range of percentage differences [5], [14-18].

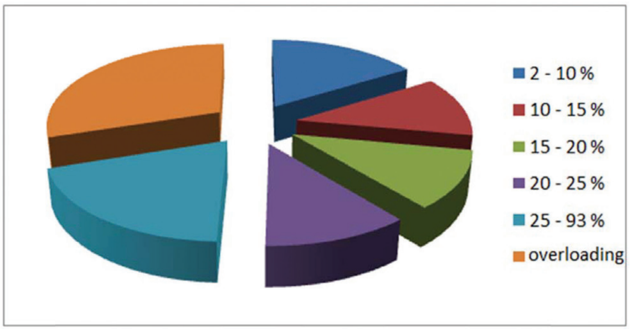
Source: [14]

Figure 2 Railway scale - TRAPPER DRS

Table 2 Weighing results from the Horní Dvořiště railway scale

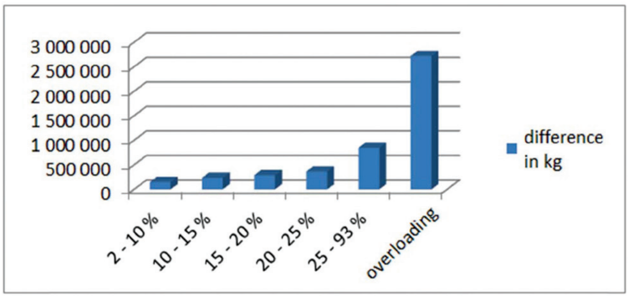
Range of excess weight	The number of RV with an incorrectly declared weight	% of the total number of RV with an incorrectly declared weight	Total difference in kg	% of the total detections of incorrectly declared weight
2 - 10 %	54	16.2	148 662	3.2
10 - 15 %	39	11.8	234 741	5.1
15 - 20 %	37	11.1	286 269	6.3
20 - 25 %	38	11.4	362 900	7.9
25 - 93 %	65	19.5	845 390	18.4
Overloading	100	30.0	2 718 500	59.1
Total	333		4 596 462	

Source: authors



Source: authors

Figure 3 The share of individual differenc,es in consignments weights in percentage



Source: authors

Figure 4 The total difference of declared a detected consignments weights in kg

5. CONCLUSION

Practical importance of detecting the consignments weight, whether the static or progressive dynamic system, lies mainly in the proper calculation of price for using the transport infrastructure. Detecting the incorrect weight of the railway vehicles can occur at the railway operator´s infrastructure. This may cause the reduction of the fee collection for using the railway infrastructure. Revenues for using the railway infrastructure are considered to be the remuneration for its using by the carriers. For the operator of the railway infrastructure, it is considered to be a major revenue items of financial incomes to cover the costs related to the railways operating and railway transport organizing [12], [13], [19]. For example, in 2013, revenues of the Railway Infrastructure Administration in the Czech Republic (SŽDC), for using the railway infrastructure, were 4 212 million CZK, which means that the «average» prices per train-kilometers and per 1000 of gross-tons-km are actually higher, which corresponds to a higher share of operation on railways with the higher fees.

If we take into account the «average» price per 1 train-kilometer = 40 CZK and the «average» price per 1000 of gross-tons-km = 50 CZK, we will get, in annual terms, the incomes at the level of 1.5 billion CZK for the infrastructure operation (train-kilometers) plus 1.7 billion CZK for ensuring the railway serviceability (1000 of gross-tons-km). Thus, for a total, the total revenues are at the level of over 3.2 billion CZK.

The above mentioned calculation is only approximate; it is based on a single rate per 1000 of gross-tons-km. In fact, on the tracks of the various categories, not just the fee per 1000 of gross-tons-km differs, but also the nature of the operation (shorter transport/travel distance, lower average weights of trains) [10]. As for the other negatives of incorrectly indicated vehicles weight, the damages of transport infrastructure, railway vehicles and traffic (operation) safety threats may be included [19-21].

From a practical research, it is also obvious that in the case of different declared consignment weight and the actual consignment weight also the overloading the wagon can occur at the same time. This fact significantly affects not only the economic side of the freight rail transport, but mainly the transport safety. The consignments weighing on the specific, above mentioned, scale has been performing since 2012, and according to the obtained data, the number of overloaded vehicles has been declining from year to year. Table 2 shows that, from the overall weighted railway vehicles, 333 vehicles had the incorrectly declared weight, and of which 100 vehicles were overloaded. This number represents only 3% of the total weighed railway vehicles. In 2012, the distinction between the declared weight and the actual weight was identified for 12.6% of railway vehicles of the total number of weighed RV [12], [21-25].

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