Smart techniques for technical conditions monitoring of railway wagons

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Abstract. An important part of the safe operation of rail transport is a quality of railway rolling stock and abidance the rules and standards applicable in rail transport. Just lawbreaking as well as neglect of the technical condition are frequent reasons for accidents, low security and subsequent non-compliance with the timetable graphics. For this reason it is necessary to ensure that only high-quality rail wagons with well-loaded loads can enter the transport load.
These conditions can be provided in two ways:

- Smart wagon, independent of the owner reporting its technical condition,
- Check points as part of a transport road, that will be monitored the technical condition and all necessary parameters independently of the freight wagon carrier.

In the first case, this is a conscious approach by the owners of railway wagons, and in the second case it is a form of restriction by the owner side and the rail transport controller too.

Keywords: intelligent wagon, dynamic control, RFID technology

1 Introduction

Today´s practice shows neglected technical control, there are often accidents, failures and delays in rail transport, which are largely caused by the poor technical condition of the wagons themselves, like poorly loaded cargo, overloaded wagon etc.. [1], [2] Furthermore, the first and underlying cause is the poorly controlled technical state of wagons, unsystematic maintenance and low prevention, resulting from the non-existent evidence of the technical and operational parameters of the railway wagons (speed, distance, loading or overloading of wagons, etc.). [3] In addition, it should be pointed out that even the basic technical state of wagons leaving production does not correspond to the current state of technical development, the possibilities offered by the state of the art in the field of their informatization and subsequent diagnostics. Frequent crashes in rail transport with varying levels of traffic-related wear addressed by incompetent restrictions of transport speed in critical sections only lead to a further slowdown in the transport process in rail transport as well as a negative impact on their competitive ability to road transport. [4]
In this way, there is unequal competition in the transport market between the significantly better equipped truck transport and the current rail transport, where, despite the various state and EU proclamations on the promotion and transfer of transport from the roads to the

MMS 2018, November 06-08, Dubrovnik, Croatia

DOI 10.4108/eai.6-11-2018.2279349

railways, the truck wins. [5] The "White Paper on Transport in the EU" recommended in section 1.3 / 9 "Railway Safety" is exactly as follows: "Strengthen the certification and maintenance process of important components used for the rolling stock production and the construction of railway infrastructure." [6]

2 Current state proposal solutions

In today's practice, there are two real possibilities to remedy this unbalanced situation from the point of view of a definitive solution to railway safety. [7]
The first proposal solution is smart wagon, that has been aware of its critical parameters and components and, in the event of a fault, reports to the operator as well as to the traffic controller. On the basis of the said signal, a solution is implemented that will help the owner of the railway rolling stock to avoid collisions or the emergency situation in the transport process.
The second proposal solution can be ensured by the traffic manager who used the diagnostic technique, monitors the technical condition on selected sections. Based on the measurement results, performs mostly restrictive interventions for wagonkeeper is most important focused on risk minimalize for restrictions by the transport operator.

2.1 Smart wagon proposal

Today, the application of RFID technology in railway transport [8], [9] is nothing special. In Slovakia, this technology is not used, but Slovakia neighbours use this technology to track shipments. The application of RFID in railway transport in our opinion would mean checking the technical condition of the railway wagon. Diagnosing the problem would alert you to the preventive check of the wagon to be commissioned. Used of RFID technology that would be part of the components, huge damage could be avoided by not checking the wagon's technical condition. [7], [8] An appropriate communication system is a prerequisite for the introduction of smart wagons, where sensors are connected to the system via a wireless connection. Intelligent wagon (or railway vehicle in general) is the use of sensors, control units, software, RFID technology and much other necessary equipment to establish such a wagon. This technology will allow tracking of specific components and parts in the wagon that could affect the operation of the truck. [10] The fault, as well as the overloading of the railway wagon, will then be signalled to the driver of the train concerned, but through the reading station and the nearest railway station. [11] Four axle open wagon type Eanos (Fig.1.) is destined for transportation of bulk goods that are resistant to bad weather during transportation. The box is a consolidated welded metallic construction, with four doors on the sidewalls.[16]
Loaded goods can be protected by a tarpaulin or net that is easily caught on fasteners located on the wagon body.

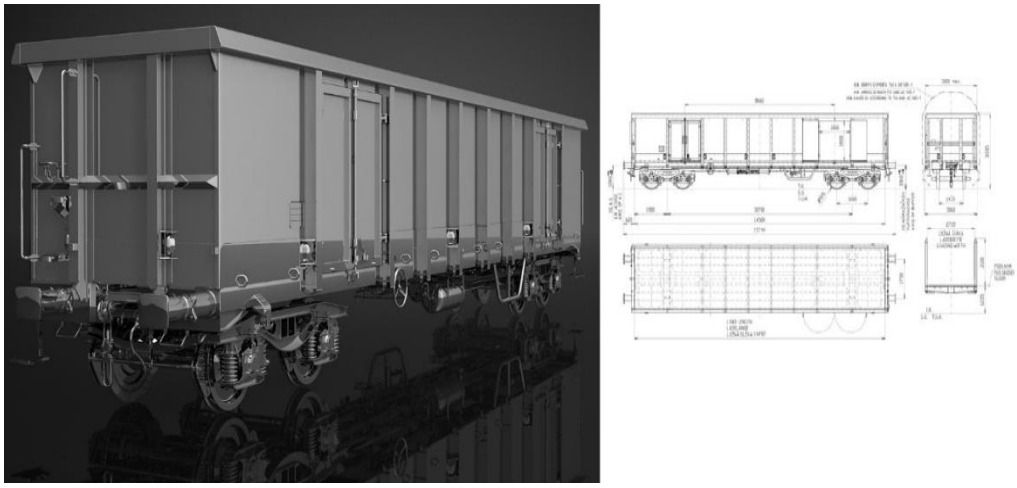

Fig. 1. Commercial wagon, type Eanos [16]

The system [8] can provide a transparent and intuitive advanced alert system that will allow users to identify new issues before something serious happens, which could affect the whole traffic and require remedial action. [13] Such an error in the technical condition of the wagon can cause big damage, which at the best causes only delay and damage in the logistics supply chain.

Fig. 2. Commercial wagon type Eanos, used a new technology [16]

2.2 Inspection (checkpoints) by the traffic controller

The beginnings of the use of continuous welded rails (CWR) on a large scale were in the 1950s, which led to the development of theoretical mathematical models. Due to the fact that it was not possible to verify the internal strength in the railway supply chain (RS) by systematic in-situ measurement, they were theoretical preconditions for the theory of continuous welding. [8] In a simplified form, it is possible to say that CWR's theoretical foundations did not notice a fundamental change in the years 1950-1992. On the basis of innovative technologies and methods of non-destructive diagnostics, a qualitatively new monitoring of physical processes was possible. This process is the basis for correcting and completing CWR knowledge in a truly revolutionary way and has come to its design and standards for installing, maintaining and assessing its safety. [9] The current trend of profitability at any cost and time-consuming transportation of material or goods causes many carriers to deliberately overload wagons. The overloading of the rolling stock itself is the cause of overloading of the rails, resulting in excessive wear of the rails, respectively, rail fracture, which is one of the most frequent reasons for the occurrence of traffic accidents in Slovakia. From the point of view of protection of railway infrastructure against intentional congestion of the railway, ŽSR Company has the right to control the observance of the specified weight limits and subsequently to recover financial compensation in the event of overtaking of the weights. Within the control stations currently used by ŽSR, there are no diagnostic devices that would monitor the weight parameters of rolling stock in dynamic mode. [14] The current wagon loading system is implemented by static but also dynamic balances in the form of large steel structures that are directly embedded in railway tracks. However, the main disadvantage is the marked slowdown in rail transport and thus the loss of competitive ability.

For this reason, the modern, simultaneously designed inspection system (checkpoints) must be fully automated and must take into account the following conditions:

- Wagon construction operating speed max. 160 km /h, is primarily a design solution that is easy to apply to the rail and does not require wheel terrain,
- Monitoring the total wagon weight,
- Asymmetric overload identification: The role of the system is to detect asymmetric rails due to improper storage of the goods,
- Monitoring the difference in weight of individual wheels, axles: different wheel weights represent one of the types of asymmetric overloads of the rails,
- Identifying the occurrence of technical irregularities in the form of wagon flat wheels [15]

The main function of the system is to identify the actual wagon weight, which will be compared with the data declared by the carriers listed in the central ERP database.

Uneven storage of the material, like a bulk good, causes uneven loads on each side of the wagon. The loaded wagon unevenly loads the rails and its asymmetric overloading type of the left / right side, the front / rear of the wagon, and the wagon twist. [6] Measurement of the weight of the wagon construction but also of the wagon flat wheels as well as the unevenness of the loading is possible on the strain gauge principle where, due to the piezoelectric phenomenon, the deformation is equal to the change in electrical resistance. [10] Thus, the load caused by the rail vehicle (wagon, locomotive) in the rails causes' deformation, which is the source of the output electrical signal, which is subsequently transformed into a digital form. The main component of the diagnostic sensor is a digital signal processor that includes A / D and D / A converters. [5] The digital signal process takes the signal, a digital pressure and mathematically modelling it on an output analogy signal in the form of a deformation curve. In the following Figure 3, is to shown a loading condition process by functioning properly wagon´s wheel. The weight of the separate wheel that caused the deformation is directly proportional to the plane of the upper deformation curve.

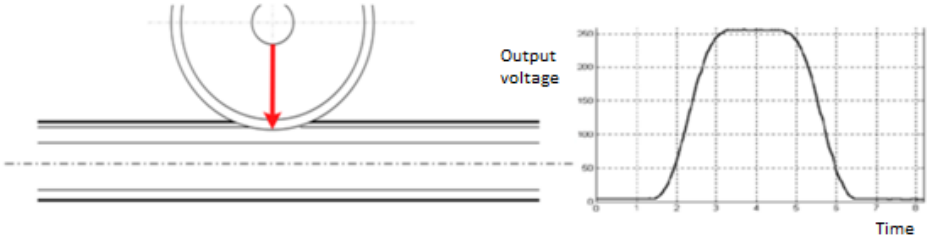

Fig.3. Loading condition process by functioning properly wagon´s wheel [5]

On this measurement principle, the occurrence of technical irregularities of wagon wheels is to shown on the the Fig. 4..

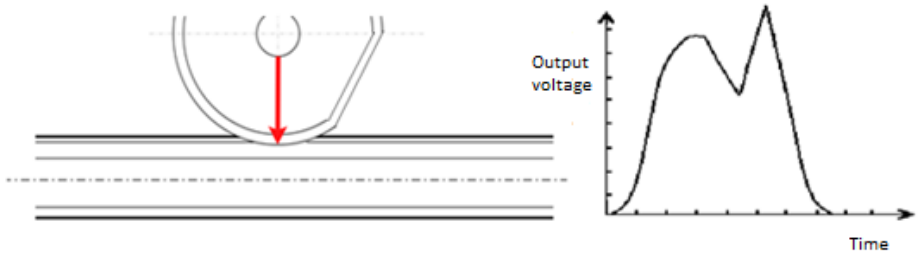

Fig.4. Loading condition process by non-functioning properly wagon´s wheel [5]

Conclusion

Above mentioned proposals are mutually compatible and suitable for deployment on a pan-European scale. The intelligent wagon-type solution assumes a conscious user, who is still living with the feeling that he saves the purchase of the wagon cheaper. In fact, its profits are questionable as the number of accidents on the railway has a different level of denunciation and proves to be the opposite. In addition, the Intelligent Wagon solution allows and envisages the creation of a mutually interconnected network, which will be monitored and managed by the Slovakian operator in dispatching mode. Also, in the situation that all EU countries reach this level, it is possible to create a fully monitored and real-time pan-European network. The diagnosis of the rail network administrator is just a compulsory way of monitoring that monitors potential intruders of rail transport rules and remedies in the form of restrictive measures. In any case, it is a prerequisite that, like the entire industry and road transport, the future of rail transport is inevitably directed towards intelligent transport, the necessary part of which will become intelligent wagons, control centres (dispatching centres) interconnected in national and pan-European network. As well as mutually compatible systems, their penetration, i.e., signalling failures and deficiencies of railroad vehicles complemented by intelligent railway traffic management will lead to the desired effect - reliable and safe rail transport.

Acknowledgments

Research reported in this paper was supported by EU Structural Funds within the project " Promotion & Enhancement of Centre for Research on Transportation" ITMS code 26220220160.

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