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AUTOMATIZATION OF OBTAINING INFORMATION AT INSPECTION OF TECHNICAL SAFETY OF RAILWAY VEHICLES

Abstract: *This paper presents some possibilities for improving the control of technical regularity of railway vehicles and pointed to the possibility of raising the level of technical characteristics. The introduction of automatic identification of irregularities, in railway car axle assemblies, allows improvement in the determination of the vehicle safety. Displayed consideration highlights the importance of automation in obtaining information for achieving quality of railway vehicles.*
Keywords: *Technical Characteristics, Automation of Railway Control*

1. INTRODUCTION

Transport services are a complex task [1] and it can not be regarded as a separate entity. An examination of demands for passenger services differs transport within: territorial units, type of transport and varieties of traffic companies. The offer of transportation services quality and price, determines the potential and also the carrier's position in the market.

It is indisputable a great importance of the railway transport. „The resurgence of railways worldwide is due to the recognition that this is the most sustainable form of land-based mass transport both for passenger and freight segments" [2]. Ortmeier and Schellhorn (2007) point [3]: „Safety is an important requirement for many modern systems. To ensure safety of complex critical systems, well-known safety analysis methods have been formalized. This holds in particular for automation systems and transportation systems."

As a consequence Hernández et al. (2009) emphasize the importance of the security system in this segment [4] „The current development of railway transport gives a significant importance to the design of suitable and reliable safety systems. Among them, the common track circuit can be improved to enhance its performance, by providing redundancy, immunity to noise and more information from the track circuit".

It is undisputed that "railway systems are also dependable systems and, considering their importance, it is vital to assure the application of adequate design techniques" [5]. Analysis and improvement of the system of rail transport was carried out by many authors, with different approaches:

- Analysis of high-speed and conventional rail systems [6]
- A rail simulation framework [7]
- An improved multi-route railroad problem by model [8]
- Simulation Techniques for the Detection of Risky Areas for Trains [9]

- Optimization in the management of transportation [10]
- A railroad simulator for distribution network [11]
- Models of rail transportation infrastructure [12]

Serbian railways with its offer deals behind the European railway administrations. However, the geographical position of Serbia in Europe, its size, observed regionally, and plans for development of European transport system, as defined by the White Paper (White Paper on Common Transport Policy) [13], giving hope for the international perspective and the chance to become a leader in the region. Today, railway traffic in Serbia is managed by AD "Serbian railways", with the following basic specifications shown in Table 1.

Table 1. Main specifications of the company AD "Serbian railways" [14]

Construction length of the railway network	4.092 km
Electrified lines (25 kV, 50 Hz AC)	1.724,100 km
Main routes	1.767,488 km
Industrial railway	772,568 km
Track wideness	1.435 mm
Maximum gradient	27.41´
Maximum axle load	22,5 t
Towing vehicles	417
Fleet of passenger vehicles	797
Fleet of freight wagons	7.528
Number of employees	18.651

Analysis of the current situation in railway traffic in the Republic of Serbia [15] indicates that the state of infrastructure and rolling stock is in a very poor condition and the maintenance of a very low level. It is a low quality of transport services, losses in business, lack of competitiveness in the transport market and also is a low level of technical development in relation to the characteristics of European Railways.

One way for improving rail transport in the Republic of Serbia is an improvement of organizational aspects of quality assurance in technical terms of trains [16].

This paper presents an attempt to point out the advantages and perspectives of railway companies of Serbia, which are reflected through:

- environmental acceptability and low cost of transport
- increasing the level of safety,
- the application of modern techniques for monitoring and control

The considered approach is primarily focused on detection and disclosure of non-compliance on brakes and axle assemblies, by implementation of measure stations. Such condition monitoring of railway vehicles, in addition to increasing level of safety of railway vehicles, also reduces the retention time for technical inspection of vehicles, discover inconsistencies of technical condition at an early stage and reducing maintenance costs. This improvement is based on the improvement of technical aspects in the operation of the railway transport.

2. CURRENT SITUATION AND PERSPECTIVES OF SERBIAN RAILWAYS FUNCTIONING

Transport policy, defined by the EU ([15],[13]), aims to develop a corridor in order to increase transport of goods by a rail and water traffic. This will contribute to the elimination of congestion on the roads and in the air, and getting faster, safer also more environmentally friendly transport. The concept of development is focused on the principles of modern transport technologies, measures aimed at the development of interposal transport systems and the application of environmental standards in the traffic. Geographical position of Serbia and the fact that its territory exceeds the Pan-European Corridor X, the shortest road and rail link between central and southern

Europe and the Middle East, is an advantage to attract transit traffic, Figure 1. From the foregoing, it can be concluded that the Serbian railways are included in the European railway system. For its better positioning in the European railway system, it is necessary to monitor the developmental EU transport policy [15]. Also, it is necessary to adapt legal regulations by European, restore and modernize its facilities, to be compatible with EU railways.

Figure 1. Pan-European Corridor X [17]

Management of Serbian railways must understand and accept the changes that are taking place in modern business. Its promotion should be oriented towards the implementation of a new marketing approach, in order to take advantage and pointed out the current ecological moment and enhance the value of transportation services. It is known that railways, at its major routes, use electricity for propulsion. This minimizes the negative impact on the environment (air, water, noise) [18]. Also, there are arguments in favor of railway transport, compared to other types of transport, in terms of energy savings and reduction of environmental impact.

By analyzing the cost and improving transport services, the railways are more competitive, compared to the road transport, on long distances. Studies [15], which was carried out 2006 year by the Community of European Railways CER and International Junior of Rail, indicates that the average cost of transportation on routes over 150 km, by rail is lower than by road. For distances over 150 km are lower by 22%, for the routes from 300 to 325 km are lower by 26%, and for distances over 500 km the transportation costs are lower by up to 30%. Also, the study [19] was conducted comparative analysis of freight rail and road transit traffic, by route Subotica-Belgrade-Nis-Dimitrovgrad. It suggests that the driving energy costs are six times higher in road, compared to rail traffic. Specific energy consumption, per unit of transported cargo, is four times less by rail in relation to the road transport. The mentioned advantages provide a good starting point for railways, to be positioned as an operator that can not be evaded. However, they are not enough by themselves. It should be accepted the concept of continuous improvement of the organization of work and apply technical achievements, in order to railways could meet the demands and interests of the market, increase competitiveness and market share in transportation.

Railways, as an open system, are in constant interaction with interested stakeholders [20]. In this way, we can get an answer to a question, which expectations have the users and society. Management should select a model that would meet the interests of stakeholders, in order to achieve the objective function of the organization. "If the external stakeholder is more important for organization, and environment turbulent, managers explicitly establish relationships with stakeholders" [21].

3. ORGANIZATION AND IMPORTANCE OF CONTROL OF TECHNICAL ACCURACY OF RAILWAY VEHICLES

Railway vehicles, which perform traffic, must be technically correct and periodically controlled. Technical inspection of the vehicles, in exploitation

perform vehicle viewers, on predetermined locations (review stations), in order to detect faults and defects. In order to determine the deficiencies and defects, viewers must visit and inspect trains by visual inspection, checking the sound, moving and putting into operation and in the event of doubt take measurements of the controlled circuit. Overview of technical condition of trains in exploitation is based on the assumption that viewers must perform technical inspection in a conscientious manner. In practice it is possible to overlook or detecting defects, depending on:

- whether the inspection is done during the day or at night,
- weather conditions (sun, rain, snow) or
- technical culture of employees themselves

Table 2. Defects, of the axle assemblies [22]

Descri-ption of defects	Year						Σ	Grade of defe-cts
	2006	2007	2008	2009	2010	2011		
Break of solid wheel	1	-	3	5	2	3	**14**	**5**
Heated axle bearing	6	7	8	6	5	3	**35**	**5**
Flat places of length > 60mm	17	9	16	29	57	62	**190**	**4**
Metal labels of length > 60mm	23	18	17	20	31	20	**129**	**4**
Flat area of length < 60mm	-	-	-	116	202	203	**521**	**3**
Σ	**47**	**34**	**48**	**171**	**297**	**289**	**886**	

In this case, vehicles can run with defects that could endanger safety of railway transportation. The described model of technical inspection has not changed much on the railways of Serbia in the last fifty years. By analysis of documentation [22], led by viewers on the Bar railway, in the period since early 2006. to end of 2011. year, we come to the data (Table 2) of the identified defects on axle assemblies because of them are vehicles disconnected from traffic, on the basis of defined technical criteria ([23],[24]). Defects, by its severity, are divided into [23] critical (grade 5 which can significantly affect the safety or traffic), major (grade 4, which significantly reduces capacity or which may endanger traffic safety) and secondary (grade 3 which significantly affect the usefulness - drivability).

From the table 2. it can be seen that in the observed period is registered 14 cases of solid wheel fractures - ruptured solid wheel (Figure 2) and 35 cases of heated axle bearings (Figure 4 shows a heated bearing, and Figure 5 fused - broken wrist axle assembly).

On the whole, the most critical defects were registered in 2008, but over the next three years the number of these defects recorded a declining trend. Because of flat places longer than 60mm on running surface of wheel, it is excluded 190 and that number is growing every year. Layers of metal labels on running surface, longer than 60 mm, was a reason for exclusion of 129 vehicles. Figure 3 shows a wheel in which are formed flat places on the running surface and metal labels. Flat places with length less than 60 mm, which occur from improper brake operation, are not recorded in the first half of the period. In the last three years were registered 521 cases.

Figure 2. Rupture of wheel

Alarming fact is that a number of major defects on vehicles constantly rising, but at the same time are encouraging that increasing number of detected irregularities on running surface is pointed in the early stages.

Practice shows that the reasons for occurrence of permanent deformation of the axle assemblies follows:

- Extreme (extraordinary) load of wheels
- Irregular handling of brakes and axle assemblies,
- -Low-grade review in the exploitation (untimely identification of phenomena that lead to damage),
- Low level of preventive maintenance,
- Of failure occurrence - failure in braking devices,

The effects caused by defective axial assemblies are:

- Abrasion and destruction of infrastructure (excessive shock by deformed wheels on rail)
- Exclusion of the vehicle from transport, repair or replacement of the damaged axle assembly, handling
- Extension of the driving time of passenger trains and delays in delivery of goods,
- Extraordinary events and interruption of traffic

Figure 3. Stickers and flat places

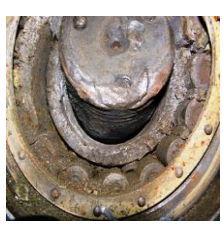

Figure 4. Heated axial bearing

Figure 5. Broken wrist axle assembly

These irregularities are unplanned costs which adversely affect the overall operation of railways. It can occur extraordinary events with the consequences, environmental contamination by outpouring of RID transported substances, accidents with loss of human life. Railroad companies in economically developed countries are more than two decades ago began to apply modern technical solutions. These are "monitoring stations" that are used for the earliest possible detection of non-compliance on the brakes and axle assemblies, with respect to the given parameters.

The experiences of these railways, which applied this method of technical control, are positive. Applying the "measuring stations" maintenance costs of rolling stock are reduced, it is increased the level of security and reduced time of retention for technical inspection ([21], [25-27]). Worldwide, there are many manufacturers who produce systems for condition monitoring of railway vehicles. The common characteristic is:

- exclusion from human error factor
- performance of non-contact measurement
- development of a database
- comparison of the obtained values with the given parameters of a moving vehicle and
- issuing warnings (to the train driver or operator) of the observed irregularities.

Significant manufacturer and distributor of this system is the Trackside

Intelligence Pty Ltd, based in Adelaide, South Australia. It has installed systems in Australia, North and South America, China, South Africa and Europe. Its main products are:
Bearing Acoustic Monitor (RailBAM) – acoustic monitoring of bearings (Figure 6),
-Wheel Condition Monitor (WCM) – monitoring of wheels (Figure 7)
-Wayside Monitoring System Database (WMS) - tracking system database

Trackside Intelligence PTY LTD emphasize that features of the WMS include [28]:

- Automated notification of faults
- User configurable alarm criteria
- Defect trending – by vehicle, bogie, axle and wheel/bearing
- Custom data export
- Many standard reports with spreadsheet output including;
- Alarms
- Wheel Quality
- Vehicle history
- Operator summaries
- Track loading summaries
- Axle mass
- Speed distribution

Figure 6. RailBAM - Bearing Acoustic Monitor [28]

Data are obtained during the passage of the train, by series of acoustic sensors, which are located next to the railway, by measuring the acoustic signals emitted by bearings and wheels. RailBAM system identifies the severity of damages of bearings and wheels, by the analysis of identified sound characteristics.

Detector for detection of impact pulses on the wheel (WILD), a company Salient System, Inc. from the North America, is the most widely used system in the world for detection of impact loads on the wheel, of railway vehicles. Until now there are over 300 installed systems worldwide. WILD technology is based on the measurement of vertical load of each wheel passing through sensor (strain gauge) that is placed on the rails.

System for detecting acoustic vibrations - Trackside Acoustic Detectors (TADS) or Bok detectors use a series of microphones, installed next to tracks, which are used for processing of sound signals and detection of faults of axle assemblies.

Institute "Nikola Tesla" is developing and improving measurement system, which is based on measuring the temperature of caps of axle bearings, on vehicles in motion [26]. Measuring is performing without contact, by infrared detectors, which are located within the measuring point on the railway. This device has already been installed and put into operation on the railroad in Obrenovac (on the unloading place of the power plant “Nikola Tesla" A).

Figure 7. Wheel Condition Monitor (WCM) [28]

AD "Serbian Railways" until now not implemented a system of measuring stations. Traffic Institute CIP has done a

general project [29] where are:

- described detection system for monitoring of vehicles
- defined a modern technology and equipment for diagnosis within the maintenance railway vehicles
- selected the most appropriate places for placement of detection systems.

Also is performs an analysis of the impact on the environment, from the justification of procurement and installation of monitoring stations. It is anticipated that the measuring station should be built in Batajnica [25] on both tracks. Measurements should be carried out by the infrared scanning and determining the temperature of rolling bearings. Setting the dynamic scales G-2000 will contribute to the detection of flat surfaces on places for rolling wheels, inequality in loading wagons and measurement of axle load.

4. CONCLUSION

This paper presents a proposal that would raise the safety of rail transport to a higher level, through the modernization and automatic identification of irregularities of railway vehicles in exploitation, using existing solutions on railway lines in of developed countries, harmonizing ways of monitoring technical condition of trains and towed vehicles in exploitation. This paper points out the perspective of Serbian Railways and the chance to increase competitiveness and market share of transportation services. A large number of excluded vehicles (886) from traffic due to the malfunctioning of the axle assemblies are worrying signal to the management of Serbian Railways, to modernize current practice.

Application of modern systems for detection of inconsistencies on axle assemblies is a step in obtaining reliable accurate data, regarding to the technical condition of trains. Errors in measurement and assessment of the status, which are characteristic for people, in this way are reduced to a minimum. However, modern systems and gained data by themselves are not enough, unless are taken steps for elimination of the cause of the malfunction. Processing and exchange of obtained information (between the owners of railroad cars) are important contributions to the quality of maintenance, safer, faster and cheaper transportation.

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