Measuring Points System for Wayside Dynamic Control of Vehicles on Serbian Railway Network

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Abstract **–For the purposes of the control of train weight status and the control of good wagons technical state SR developed the concept for wayside measuring stations system for rail vehicle dynamic control on the railway lines. This paper gives an overview of the two measurements: The first system is designed for monitoring the temperature condition of rolling bearings, wheels, and brake discs of all railway vehicles. The second system is a dynamic scale for measuring the axle loads, unbalanced loading, and detection of flat places on the surfaces of rolling wheels.**

Keywords – **dynamic control, railway vehicles, wheels, rolling bearings, flat places**

I. Introduction

An extraordinary event in railway operations implies an event which impedes or makes service impossible, endangers human lives and destroys railway property and goods in transportation. Extraordinary events can be classified according to their causes and consequences: crashes, accidents and natural disasters (Table I) [1].

By observing the accident database of one infrastructure manager, one can see a high number of small derailments at shunting yards and less on normal track between stations, but with high degree of loss (Table II, III).

Automation of wayside train monitoring leads to higher estimation accuracy and minimizes human necessity in railway operation. Consequently, the impact of human factors is becoming less important in case of extraordinary events. Current worldwide tendencies are to minimize the influence of human factors in extraordinary events which would be impossible without the application of modern systems for railway operation control and wayside monitoring equipment [2,3, 4]. The new system can dynamically detect 75% of the causes of cars' exclusion from railway network traffic (Table IV).

On the other hand, for railway vehicle maintenance it is also very important to act in a timely manner. Furthermore, from the aspect of safety and reliability, the wheel sets are the second most important assembly, just after the braking system. Poor wheel conditions can often lead to derailments, whereas early detection of wheel faults brings numerous benefits to infrastructure owners and also to railway operators. In order to increase safety, improve rolling stock maintenance and to protect infrastructure public enterprise "Serbian Railways" plans to create a system for wayside monitoring. Implementation of wayside monitoring on the Serbian Railways network will decrease the influence of human factors in vehicle inspection and faults will be identified in a timely manner.

The first installation for wayside train monitoring on Serbian Railways will be located near Batajnica station and will be a result of close collaboration with Austrian Federal Railways and the Vienna University of Technology. The installation will have two TK99 measuring groups for hot-box, hot wheel and hot disc detection and dynamic scale G-2000 for wheel set weighing, flat spot detection and detection of uneven loading of wagons. Both devices are developed and assembled by Infrastructure of Austrian Federal Railways (ÖBB - Infrastruktur AG).

In the scope of early defect detection, it is indispensable to have equipment capable for contactless recognition of overheating, flat spots and uneven loading, accurate data processing and transfer to remote places. Identification of freight cars which are loaded out-of-gauge should be left for the final phase of the project since such equipment is still in experimental use on the other railway networks (i.e. BLS, ÖBB) [5]. Equipment for detecting gauge overload should be restricted to locations close to border stations and before tunnels with lower contact wire where lorries are transported by Ro-La-trains [6]

II. Location and Equipment Displacement in Measuring Station at Batajnica

The installation location is going to be km 24+776 (from km 24+734 to km 24+818) on the left side of the double track line No. 5 from Belgrade to Šid - border line Serbia/Croatia will collect data from all railway vehicles coming from the West and North of Serbia (Fig. 1) [7].

The installation will consist of modules TK 99 (module 3) and G-2000 (module 4) placed on track and cabin (module 1) at km 24+776 on the left side of line 5, next to the left track. The outside installation part has axle counters RSR180 (2x3, 6 in all – Fig. 2), two TK99 modules (Fig. 3), one on each track, and one scale G-2000.

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TABLE I - EXTRAORDINARY EVENTS

Type of Extraordinary Event	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
Accidents	21	33	30	27	11	18
Operating incidents	435	447	430	383	349	375
Accidents and Incidents at Level Crossings	198	209	193	131	168	181
Total	654	689	653	541	528	574

TABLE II - TYPES OF ACCIDENTS

Types of Accidents	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
Collisions	1	1	1	-	-	-
Overtaking	1	2	4	-	-	-
Car Derailments	16	26	23	26	11	16
Derailments and Overtaking at Shunting yards	-	-	-	66	79	1
Collisions, Overtaking and Derailments of Maintenance Vehicles	2	3	1	-	-	-
Other Accidents	1	1	1	1	-	1
Total	21	33	30	93	90	18

TABLE III - TYPES OF OPERATING INCIDENTS

Types of Operating Incidents	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
Collisions Avoided	7	4	6	7	3	4
Overtaking Avoided	2	6	4	1	2	2
Signal Passing	15	12	14	11	10	8
Derailments and Overtaking at Shunting yards	76	83	68	66	72	86
Collisions, Overtaking and of Maintenance Vehicles	-	-	1	-	-	-
Other Operating Incidents	335	342	337	298	262	275
Total	435	447	430	383	349	375

TABLE IV–THE NUMBER OF CARS EXCLUDED FROM TRAFFIC IN 2010.

Passenger Freight	Overheated axle-box	Wheelset	Suspension spring	Frame and bogie	Buffer	Drawgear	Brake disks	Σ
P	89	581	29	352	288	54	1121	2514
T	148	1524	367	782	625	235	2447	6128
Σ	237	2105	396	1134	913	289	3568	8642
%	2.74	24.36	4.58	13.12	10.56	3.34	41.29	100

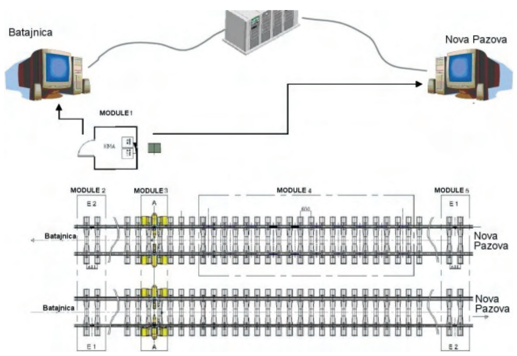


Fig. 1. Scheme of stationary installation Batajnica

All six axle counters are identical, only their positions are different (km 24+734 - module 2, km 24+776 - module 3 and km 24+818 - module 5, one on each position on both tracks). The mid counters will be positioned at the same locations as TK99 modules and the end counters will be at a distance of 42 m in each direction. The TK99 measures wheel set bearings temperatures, wheel body temperatures and brake disc temperatures.

Dynamic scale G-2000 will be positioned from km 24+779 to km 24+789,80 on the left track on railway line No. 5 Belgrade – Šid. Strain gauges are sensors which are used for measurements in rail deformations caused by vehicle wheels passing over them. Strain gauges are positioned at a distance of 1.2 m directly on the rail neck between sleepers, in total 10 strain gauges on each rail, 20 in all on that one track. A PC inside a cabin (module 1) which is connected to G-2000 (module 4) calculates the axle loading for each wheel set upon rail strain measured between sleepers and wheel flat spots from impulse forces exerted over the rails.

The cabin equipment (module 1) will consist of power supply electronics for TK99 sensors (scanners), 2 PCs for data storage, calculation and transfer, and UPS units for 15 minutes power supply in case of power supply interruption. The cabin will be thermally isolated and will have a base of 2.40x2.40 m. All electronic equipment will sit on two movable racks. The distance between the front of the cabin and the centre of the track will be 6 m. The power supply will be 5 kW max. power, 230V/50 Hz, from a catenary transformer. Connections between cabin PCs and train inspectors PC terminals in Batajnica and Nova Pazova stations will be done by modems.At Batajnica and Nova Pazova stations the computers will be located at movements inspector's office. They will be served by authorizes personnel from the Department of technical vehicle services of the ŽS.

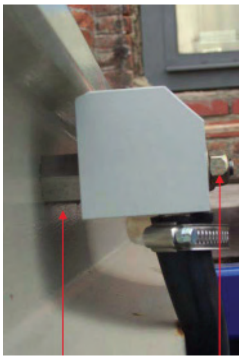


Fig. 2 Counter pick-up device.

III. EXPERIMENTAL METHODOLOGY

Generally, the trains are registered in both travelling directions; weighbridge axles' temperature is measured contactlesson the left and on the right side. Simultaneously, the wheel center and brake disks temperature is also measured. Every body that has a temperature above absolute zero emits electromagnetic radiation proportionally to its temperature. The wavelength of that radiation is within the range 0.7 – 1000 µm. The range of interest for technical measurements is 0,7 µm to 14 µm (Fig. 4). Since in this spectrum range vapor and carbon-dioxidecause transmission losts, only certain measurement windows can be used. Typical measurement windows are 1,1...1,7 µm, ...2,5 µm, 3...5 µm, and 8...14 µm (Fig. 5). However, these measurement windows have different radiation maximums depending on the object temperature (Fig. 6). The most suitable range for measuring axle and wheels' temperature (0-600°C) is 3 to 5 µm. For this range we use infrared (IR) detectors with thermo-electrical cooling, since they have response time shorter than 5 µs.

The most important characteristic of the device for detection of overheated axle bearing (HOA) is double checking of axle bearing' pair of wheels. Both bearings of the same axle are checked both vertically upwards and horizontally from the outside. By doing this, besides bearings of any construction kind opened downwards, any axle-bearing type with reconstructed bearing is certainly detected (ex. Y25, Y31). Modular structure of the devce allows for different layout of measurement points on wheels and disks (FOA and SOA). The temperature of disk brake is measured verticallydownwards. The temperature of wheels is measured by using a special sensor in the flange of wheel area.

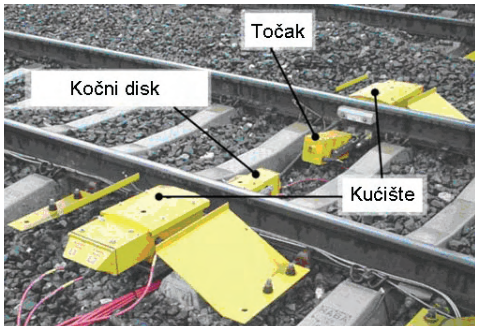


Fig. 3 –The device for axle weighbridge's wheel (axle), wheels and brake disks temperature measurement

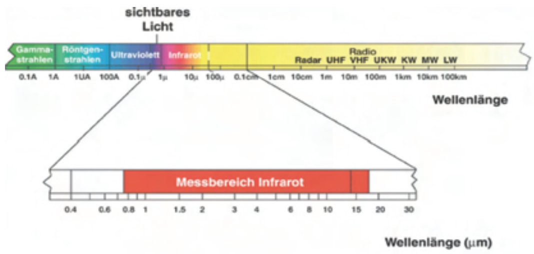


Fig4. Measurement area from 0,7 µm to 14 µm (Sichtbares Licht=Visible light; Wellenlange=wavelength; MessbereichInfrarot=infrared measurement area)

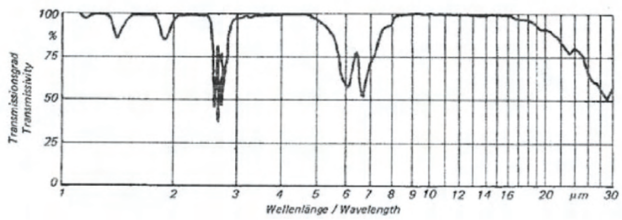


Fig 5. Transmission degree.

The G2000 system uses gauges which follow rail deflection caused by the wheel seating force. Sensors are put onto the rail, between sleepers (with axle distance of 1.2 m), so that one stretch of rails has ten sensor pairs. A computer loads measurement data when the train passes through measurement point and calculates axle loads of every wheel and the size of flat places, if there are any. Sensor device is mounted on the rail side, along neutral line. Gauges are welded onto the rail. The complete sensor device has four parts, mounted very near the measurement module (one pair on the inner rail side, and the outer pair on the outside, Fig. 7).

IV. WARNINGS AND ALARMS

In a case of any irregularity detected on trains passing over the installation, pictogram alarms will be shown on each monitor connected to the stationary system network (Fig. 8). Pictograms will be accompanied by exact values represented in data tables. In accordance to procedures, the train will be stopped and the faulty car will be removed from the train.

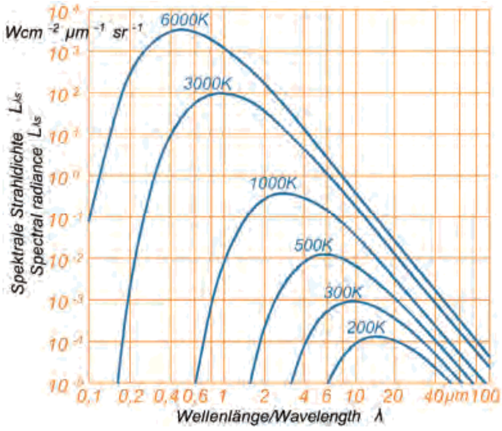


Fig.6 Spektraldensity of L ray λs

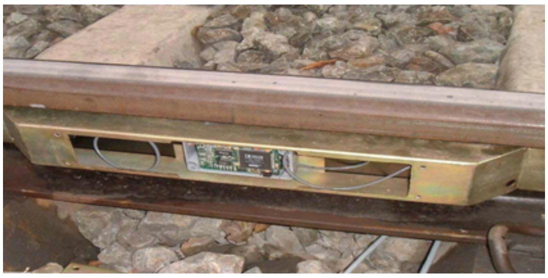


Fig. 7 Measurement device in protective box; sensors are on the left and on the right.

Displayed values will include train identification number, date and train time, direction, train speed, and mass, axle number, total number of axles, measured temperature, track number, fault identification and description, etc.

Timely detection of technical irregularities and avoiding additional damage offers diverse advantages in railway traffic flow: better security, avoiding traffic disturbances, lowering costs due to reduced number of traffic accidents, lowering risk in dangerous goods traffic, lowering the risk of tunnel accidents, better traffic quality, higher speed and axle load, longer periods between inspection and vehicle maintenance, optimization of traffic control, less frequent active railway maintenance, smaller superstructure load.

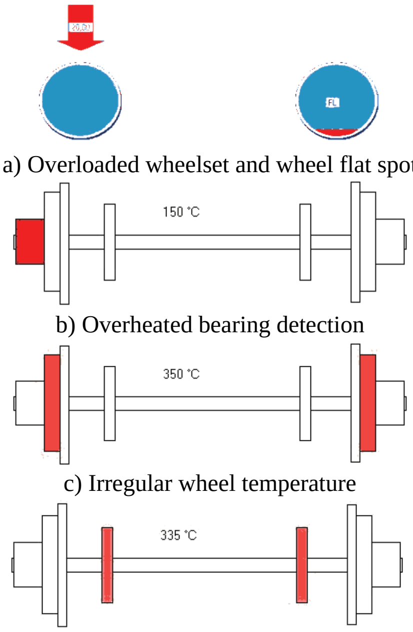
V. Conclusions

As it is clearly shown in the project sensitivity analysis, the project is highly resilient to all variations of input parameters and also to expected divergences. The facts indicate investment return and necessity of immediate project realization which should significantly reduce costs for both infrastructure and vehicle maintenance. Procena direktnih efekata od uvođenja ovog sitema ide i do 500.000 € godišnje. Results for the investment estimate are [8]:

Internal rate of return (IRR) = 11.99%,

Net present value (NPV) = 603.719. €

By embedding measurement stations for wayside dynamic control of the technical state of railway vehicles, Serbian railways will join current European transportation system by improving the reliability and quality of service. Batajnica measurement station is going to be one of the first steps in this direction.



a) Overloaded wheelset and wheel flat spot

b) Overheated bearing detection

c) Irregular wheel temperature

d) Irregular brake disc temperature

Fig. 8

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