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RESULTS FROM FIRST BULGARIAN WAYSIDE TRAIN MONITORING SYSTEMS AT ZIMNITSA

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ABSTRACT

Within the cooperation of NRIC and ÖBB Infrastruktur Betrieb AG (now: ÖBB Infrastruktur AG) a demand analysis for wayside train monitoring systems for NRIC was carried out under the scientific guidance of Vienna University of Technology. The aim of this study was to point out the specific needs of wayside train monitoring for the infrastructure manager NRIC. The specific demand was located at the failure states of overloading, faulty suspension and damaged boxes. The final recommendations lead to a prototype installation in the network of NRIC. This paper deals now with the results from two years of field experience in daily railway operation at Zimnitsa.

1. Introduction

As a result of the ongoing reduction of station inspectors, the railway system has lost a decisive link of well-established organisational and technical processes. The consequences of this development were compensated by the introduction of technical solutions. The new processes are subsequently less labour-intensive and more efficient. The role of the traditional train supervision is, however, a good example to demonstrate that technical solutions, currently available on the market, do not provide the whole solution.

Originally, station inspectors were not the only employees among those responsible for the operation of trains who had to deal with train supervision. Interlocking, block and/or level-crossing attendants had to monitor the condition of the rolling stock, too. The locations for this task had been defined alternately, thus enabling train supervision to be carried out on both sides of the track. The disappearance of mechanical signalling equipment led first to a

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reduction of posts for the supervision of trains. Technological progress resulted in a further acceleration of this trend. By introducing management operation systems, the network of posts to observe trains, which was initially very dense, was reduced again.

Technical systems for automatic train supervision are able to check both sides of the train at the same time. Their locations do not have to be set up according to the original locations for traditional train supervision. These advantages will result in a lower number of locations needed for automatic train supervision. In addition to that, the technical systems used for automatic train supervision are able to detect faulty conditions of the rolling-stock which can not be discovered even by well-trained station inspectors. Therefore, these technical systems are very important with regard to early accident identification and will bring about higher productivities, too. Checkpoints can be defined as trackside locations containing an accumulation of technical systems, which are required to enable the substitution of the traditional train supervision.

Based upon the experiences on wayside train monitoring which ÖBB made since the prototype of a checkpoint solution was installed in their network in the year 2003, this topic became part of the collaboration memorandum between NRIC and ÖBB. This paper is now dealing with the results from the experiences in daily operation at Zimnitsa.

2. Previous work

Before looking into possible measures to prevent accidents by wayside train monitoring systems it is recommended to estimate the economically feasible range for investments. This can be done by calculating the difference between the risk estimation for one fault state and the defined protection goal of NRIC. This specific amount is now available for investments to prevent accidents caused by each single fault state. This allows planning of possible measures in an economic feasible way. For NRIC three fault states have to be monitored by some equipment:

- Overload
- Wheel unloading
- Faulty boxes

After the identification of risks caused by car related fault states and the general check for the economic feasibility risk reducing measures have to be designed. Fundamental risk reducing measures can be divided by functionality:

- Event-avoiding
- Damage-reducing
- Rescue-supporting

Event-avoiding measures aim of preventing hazardous events. Important here is the coordination of the responsibilities of railway undertakings and infrastructure managers. But it is not possible to reach sufficient protection by preventative measures only, because it will not be financially feasible. Therefore damage-reducing measures also have to be planned, to minimise loss in case of an accident. After one accident has happened, rescue measures become important for saving people. Wayside train monitoring systems are related to the event-avoiding and damage-reducing sector of risk reducing measures.

For the three mentioned fault states the requirements were defined in the last workshop which can be used to prepare a tender. Basic requirements are:

- Costs (purchase, installation, maintenance)
- Availability, reliability
- Allowed passing speed

- Car identification
- Accuracy
- Applicable on different superstructures
- Short evaluation time

To share the experience on wayside train monitoring between NRIC and ÖBB components provided by ÖBB have been offered to NRIC which shall prevent accidents caused by car related fault states identified as critical for the Bulgarian infrastructure manager. As a result of the previous work [1] a hire contract between NRIC and ÖBB was signed which includes the installation of a hot box detection (incl. hot brakes) system TK99 [2] and an axle load checkpoint system G2000 [3]. This task was fulfilled in April 2009 and since then the first installation of a wayside train monitoring system is in daily operation.

3. Systems installed at Zimnitsa

3.1. Hot box detection system TK 99

The Hot Box Detection System used in Austria by ÖBB IKT GmbH consists of the following elements: track-side equipment (scanners), evaluation and control unit, data transmission equipment and visual display unit.

The track-side equipment includes (Fig. 1):

- The control and evaluation electronics accommodated within a cabinet
- The rail fastened measurement equipment with infrared sensors to record axle box and wheel temperatures and axle counters

Two hot box detection sensors, one provided at each side of the track, measure surface temperatures of the axle boxes, thus, meeting the requirements of UIC 501 and the latest version of the TSI Infrastructure. Simultaneously with the scanning of the axle box, a hot disk detection sensor scans the heating of the disk brakes. A hot wheel detection sensor measures the temperature of the wheel flange to detect critical temperatures of blocked brakes. In most locations, where a hot box detection system is positioned, there is also a hot wheel detection system and a hot disk detection system. The main reason for this accumulation of sensors is the installation costs for a single system. The technical solution is able to check the temperature even in a temperature range which cannot be seen by a station inspector. The visual check of boxes leads only to an alarm if the box is already glowing but in the beginning phase a box doesn't glow. So, a technical solution will recognise an initial hot box earlier than one station inspector ever can.

Figure 1. Hot box detection system TK 99 at Zimnitsa

3.2. Axle load checkpoint system G2000

Axle load checkpoints measure forces, which are exerted by the vehicles wheels on the rails. In general, this contact-based measurements use either the bending characteristic of the rail between the sleepers or load cells between rails and sleepers to determine the wheel loads. Also a combination of these approaches is sometimes applied. Thereby following aspects have to be considered:

- Type of sensors: the sensors for acquisition of the elastic deformation (of the rail or of the weighing element within the load cells) have to be robust against the harsh environmental conditions (climate changes, electromagnetic fields, etc.). Because resistance strain gauges fulfil these requirements, they have prevailed in the field of wayside axle load measurements. Other systems also use laser technology for measuring the bending of rails, but the practical application was not satisfying customer requirements so far. For instance, in Switzerland SBB tested several axle load checkpoints from different suppliers. Finally they decided to build up their own system based upon strain gauges (similar to Austrian G2000 system).
- Length of measurement section: for reliable detection of fault states regarding the running surface of wheels, always the whole wheel circumferences have to be examined. Thus, the measurement section has to cover at least one complete circumference of the largest diameter of the expected vehicle wheels (common wheel diameters are not larger as 1m, which yields minimum sections of approximately 3,2m). A further increase of the measurement section length often allows more extensive averaging of the measurement data, which may lower the influence of dynamic effects and which may reduce measurement errors of axle loads and of the running surface faults. Thus, many systems feature a section length of 8m and beyond.

Figure 2. Axle load checkpoint G2000 at Zimnitsa

The sensors systems have to detect following conditions, which are specified by user-definable threshold values:

- Quasi-stationary wheel load: measured wheel load exceeds an alarm threshold
- Quasi-stationary axle load: measured load exceeds an alarm threshold
- Ratio of higher to lower wheel load of an axle: measured load exceeds an alarm threshold

- Faults on the running surface: considering the protection of the infrastructure, the type of the defect on the running surface (flat spots, reweldings, metal bumps, out-of-roundnesses, material eruptions, etc.) is rather unimportant. It is much more a question of the peak forces, which are primary responsible for stressing the rails. Thus, the measurement system has to evaluate, if such peak forces exceeds an alarm threshold.

Additionally, for each of these fault states the system must be able to generate warning notifications, if warning thresholds are exceeded but before the alarm thresholds have been reached. For fast initiating of measures regarding the detection of dangerous situations and in the face of the high amount of measurement data, the calculation time for alarm or warning generation may last at most 90 seconds after the last vehicle of a 700m long train has left the measurement section.

Another crucial aspect is the setting of thresholds and executing of intervention as this measure directly influences the workload and the disruptions of railway services. Therefore the executed thresholds have to be discussed with the managers responsible for operation control. The successful implementation of axle load checkpoints in Switzerland at SBB shows that accuracy is not the most important key factor but the workload for daily operation in handling alarms is more essential [4].

4. Results from daily operation

For daily operation thresholds were applied to define when a train has to be stopped and the fault state had to be validated. For boxes temperatures over 100° were defined as hot ("alarm") and temperatures over 60° as warm ("warning"). For brakes temperatures over 270° were classified as hot ("alarm") and temperatures over 220° as warm ("warning"). The axle load checkpoint was primarily used to identify unbalanced loads in the left to right ratio but one alarm was validated as an unbalanced load front to back ratio among these 15.

Table 1. Alarms and warnings at Zimnitsa

Type of event	Alarm	Warning
Boxes	14	18
Brakes	1	3
Unbalanced load	15	-

5. Conclusions

The prototype at Zimnitsa could at least prevent one serious derailment due to railway expert's knowledge that every 10th hot box might lead to a derailment if it is not recognised in time. The low rate of alarms and warnings at the brake monitoring shows clearly that the wagon inspectors are doing their job in careful and reliable way. A serious problem seems to be the loading of open cargo wagons from type "Eaos" which caused almost all alarms at the axle load checkpoint. Therefore the loading of this type of wagons should be improved.

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