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IMPROVE OF RAILWAY VEHICLE MAINTENANCE BY WAYSIDE DETECTION

Dušan Stamenković
dusans@masfak.ni.ac.rs

Faculty of Mechanical Engineering,
Nis 18000, Aleksandra Medvedeva st. 14
SERBIA

Key words: *railway vehicles, maintenance of rolling stock, wayside detection system.*
Abstract: *In order to increase the efficiency of maintenance and availability of rolling stock, using the development of electronics, sensor technology and computer technology, on-board and stationary diagnostics are introduced. On-board systems are installed in a vehicle and used for continuous monitoring devices in use. Stationary diagnostic systems are used for a casual-periodic inspection of railway vehicles and these are installed directly on the track or very near track. Wayside detection system can achieve condition monitoring of vehicles in time of regular operation, without stopping. Using the collected information it is possible to analyze the condition of the equipment and to predict potential failures and errors that may occur in the future. This paper describes some of wayside detection system and points out that this approach can significantly improve the condition-based maintenance of railway vehicles.*

1. INTRODUCTION

Each transport means needs maintenance in order to keep its functional condition. Maintenance can be performed sometimes, very often or continuously, but the most important is not to reduce vehicle exploitation. Railway vehicles are complex technical means which consists of many different parts and each part should to be checked. Development of electronics, sensor technology and computer technology enabled development of on-board and stationary diagnostic systems which are in use in rolling stock service last years.

On-board systems are installed in a vehicle and are used for devices continuous monitoring in period of regular service. In that way, by condition monitoring can be planned maintenance activities and the out of service time can be minimize. But these diagnostic systems are very expensive because of the fact that each device need own diagnostic equipment. Installation of these systems is economically justified for locomotives and trains, or for traction units.

Wayside detection systems (stationary diagnostic systems) are much more reasonable in terms of economy. Wayside detection systems are used for a casual-periodic inspection of rolling stock and these are installed directly on the track or very near track and condition monitoring of vehicles is performed in time of regular operation, without stopping.

Basics of on-board and stationary diagnostic systems in railway are described in [1]. Description of different types of wayside detectors and evaluation of wayside condition monitoring technologies for condition-based maintenance of railway vehicles is presented in

[2, 3]. In the paper [4] author describes the implementation process of wayside detectors in North America, different detector types and the state of deployment and he points out the nature of the data and performance norms. The North American railroad industry is increasingly moving to wayside detection to reduce rolling stock inspection and maintenance costs. Currently, car inspection costs are a high percentage of the labor costs for car repair. It is anticipated that through automated performance measurement, a significant reduction in inspection costs can be achieved [4]. Achievements and results of the research carried out in the Safety IDEA Program project, especially in the area of rail vehicle bearing defects detection are presented in the paper [5]. In the paper [6] author dealt with development of diagnostic systems which can be used in wagon maintenance which are oriented to wayside detection. Authors in [7] describe the modern concept of freight cars maintenance and posibilities of its aplication in Serbian railways.

Improve of rolling stock maintenance by using wayside detection is pointed in this paper.

2. MAINTENANCE OF ROLLING STOCK

Regular maintenance of railway vehicles includes the constant monitoring, control inspections and emergency and regular repairs. Permanent monitoring is the basic maintenance of railway vehicles and it is the most important for the safety of service as it is done continuously during operation and represents the continuous monitoring system of the vehicles. Activities of permanent monitoring of rolling stock are carried by many of the participants in the railway transport organization, such as train drivers, train crew, the traction and station staff, as well as technical wagon unit.

Maintenance of vehicles on Serbian railways is divided into regular and emergency maintenance. Regular maintenance is the pre-prescribed by the scope of work and required replacement parts and equipment. This means that it is cyclically repeated in period of railway vehicles life. The regular maintenance includes:

- permanent monitoring,
- washing and cleaning
- disinfecting (for passenger cars),
- periodical control inspection and
- regular repair.

Emergency maintenance is one that is done in case of failure or malfunction of certain elements of the vehicle. Emergency maintenance includes: emergency repair of minor importance and emergency repairs to large scale.

The basic maintenance of railway vehicles comprises the interventions implemented on daily basis before, during and after the performed transport and it is called the permanent monitoring. Permanent monitoring includes the visual inspection of the technical condition of vehicles and their supply and it is done during the preparation of the vehicle for service, during operation and after it. During the preparation of vehicles for operating, the vehicle examiners perform the inspection of vehicle condition such as the visual control of condition of parts, components, devices and equipment of the vehicles, checking the proper condition of the devices by putting them in service, validation of regularity of the loading, both in terms of loading gauge and regularity of loading i.e. the arrangement of the load in the wagons, i.e. permissible weight per axle and linear meter etc.

The control inspections of vehicles are performed with the scope that is determined by the running distance. With the new types of railway vehicles, which are equipped with modern diagnostic systems, maintenance interventions are planned on the basis of processing of the signal from the sensor. After the long period of exploitation, the regular repairs are carried out on the vehicles and they have the aim to improve the condition of the equipment

and operation of vehicles in the next service period until the next regular repair.

3. WAYSIDE DETECTION

The first stationary detection systems on tracks were developed in sixties of the last century, but their expansion started last twenty years. Up to 2002 the Canadian National Railways had installed 452 wayside detection systems from the Atlantic to the Pacific coast. These detector locations consisted of hot box detectors, dragging equipment detectors hot wheel detectors. In USA there were installed different types of detectors like acoustic bearing detectors, hot bearing detectors, wheel impact load detectors and truck hunting detectors. In many European countries are developed wayside detection systems. Wheel-flat detection, axle load measurement system and weigh-in-motion system are installed In the Netherlands.

Most of the condition-monitoring systems for railway vehicles are focused on the wheel and bogies since these are the parts that have the largest impact on the performance and are also the mayor cost drivers in maintenance.

3.1. Wayside detector types

There are different types of wayside detectors as:

- Hot bearing detectors
- Wheel impact load detectors
- Overload and imbalanced load detectors
- Truck hunting detectors
- Truck performance detectors
- Wheel profile detectors
- Cold and hot wheel detectors
- Acoustic bearing detectors.

Hot bearing detectors are the most common wayside detectors in many railroads worldwide. The alarm is typically given to the locomotive engineer by radio from an operating center with an indication of the position in the train of the failure axle/bearing.

Wheel impact load detectors (WILD) comprise of a number of strain gages that measure vertical wheel loads as the vehicle passes across the site. An evaluation is made of both the static and dynamic load imposed by each wheel passing the site.

The overload and imbalanced load detectors are currently a derivative of wheel impact load detectors. Vertical wheel load information from WILD sites is integrated to provide information on vehicle overload and vehicle load imbalances that can be between one side of the vehicle and the other or between one end of the vehicle and the other.

Current truck hunting detectors used in North America are a further derivative of WILD. Measuring equipment is instrumented to measure lateral as well as vertical loads. A vehicle that is hunting exhibits a sinusoidal motion on the track (Figure 1) and imposes regular lateral and vertical load patterns on the track [4].

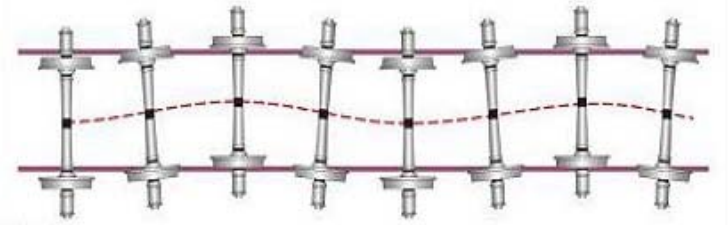

Figure 1: Wheelset hunting motion [3]

Truck performance detectors have been developed to monitor the tracking performance of vehicles, particularly on curved track. Measuring system, using strain gages, measures lateral as well as vertical loads. These measuring devices are located in two reverse

curves and the inter-leading tangent track, as Figure 2 illustrates [4].

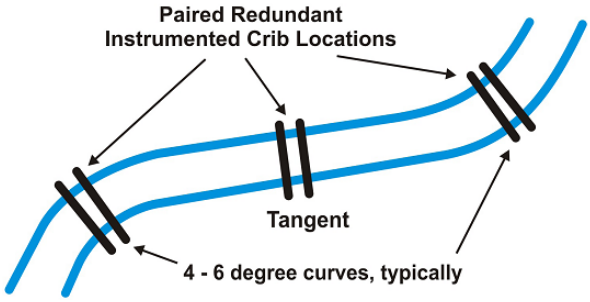

Figure 2: Truck performance detector [4]

Vertical and lateral loads on each passing wheel are measured on both high and low rail of the left- and right-hand curves, as well as the tangent track. Examination of the force patterns associated with each truck gives an indication of the condition of that truck and, in particular, the tracking misalignment errors associated with the truck [4].

Cold and hot wheel detectors measure vehicles wheels temperature. Train brake systems utilize the wheel to dissipate braking energy. Poor braking can lead to imbalances in energy dissipation between wheels in a train and cause the overheating of particular wheels. Excessive tread temperatures can lead to thermal mechanical fatigue. Wheel temperature measurement devices typically use infra-red sensors aligned at right angles to the track focused upon the wheel (Figure 3).

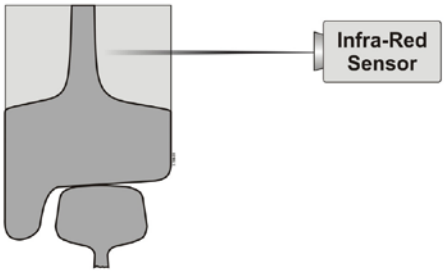

Figure 3: Infra-red sensing of wheel temperatures [4]

Acoustic bearing detectors comprise of microphone arrays (Figure 4) that are positioned alongside the track to detect the characteristic sounds emanating from bearings with defects on their rolling surfaces. The acoustic bearing detector allows railroad operators to detect defects long before they cause overheating. Due to the early warning capability of this detector, a large number of acoustic detectors are not required provided that individual bearings are monitored over a reasonable time or mileage interval [4].

Figure 4: Acoustic detectors [3]

3.2. Wayside detection in Serbian railways

The first wayside detection system in Serbia was installed on line Belgrade-Sid in 2013. This measuring station (Figure 5) includes hot bearing detector, detector of locked brakes, detector of flat areas on wheel thread and wheel load detector.

Figure 5: First Serbian railway wayside detection system [4]

Detection of overheated axle bearings is achieved by measuring temperature using IC cameras placed on both trucks (Figure 6).

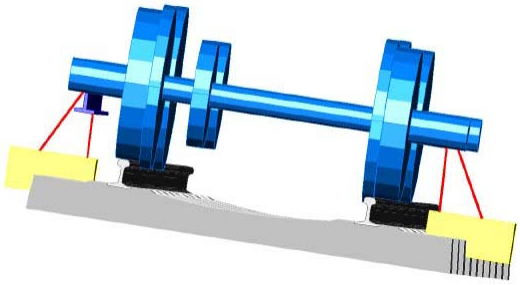

Figure 6: Hot bearing detectors.

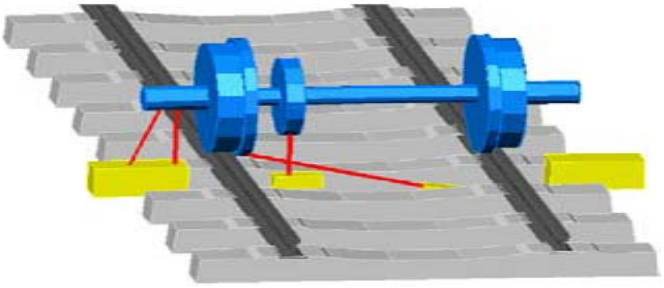

Figure 7: Locked brakes detectors.

Detection of locked brakes is achieved by measuring temperature on different points on wheels and brake disks using IC cameras. Figure 7 presents usually order of measuring points for detection locked brakes.

Detection of flat areas on wheel thread is achieved by measuring vertical loads on truck using strain gages. Strain gages are distributed along 10 meters on the truck. This detector presents the wheel impact load detector. Device for digital signal processing (Figure 8) is fixed on truck and its task is to download and transmit measurement values to the PC by the interface PC485.

Figure 8: Measuring device for digital signal processing

Transfer of measuring data from measuring station to the operational services is carried out by Ethernet or modem connection.

Train inspectors monitor technical malfunction of the train while crossing across modules of measuring system. There is installed alarm system with visual and audio signal stored on computers which signals:

- Overheating of axle bearing boxes

- Overheating of wheels
- Blocked brake
- Flat areas on wheels thread
- Weight of vehicle, axle and individual wheels larger than allowed.

All measuring and alarm information are stored in central memory.

4. CONDITION BASED MAINTENANCE USING WAYSIDE DETECTION DATA

With the help of a monitoring system, the data on rolling stock and rail infrastructure can be systematized and it is a significant to increase the efficiency of maintenance. With the ability to monitor the entire system, the railways can develop the concept of condition-based maintenance.

Most of the condition-monitoring systems for railway vehicles are therefore focused on the wheel and bogies. The wheel/rail interface is the one of the most important parameters in the vehicles' condition. This is where most of the cost for maintenance on both railway vehicles and infrastructure occurs. It is also important to monitor this condition to avoid accidents, as a derailment is very costly and may cause injuries [2].

One of the challenges with implementing condition monitoring is to find the right measurement technologies, since reliable and valid measurements are a necessity for an effective condition monitoring approach. There is the question of finding relevant and correct parameters that can be measured to provide the most relevant measuring data, because the measurement data must then be transformed into relevant and understandable information that can then be used as decision support in the maintenance management process. These are some of the corner stones that are needed to be able to arrive at a condition-based maintenance strategy [2, 3]. It is also important to develop a system for handling the collected data, so that appropriate maintenance activities are done thus creating continuous improvement in operation.

In the railway industry the maintenance intervals are often traditionally time-or mileage-based, and these intervals are often based on earlier experience or on the supplier's specification. This method of maintenance can be further improved by condition monitoring and based on the measuring data predict future maintenance activities.

To achieve the goal of bringing the railway industry from time/mileage-based maintenance to a condition-based maintenance, it should be set the condition monitoring system and according the measuring data set the system of prediction the remaining life length of the vehicle components. It is very complex and long-term task for railway engineers and managers.

5. CONCLUSION

After this description some conclusions can be established:

- The most effective maintenance of railway vehicles is a common control without interrupting operation.
- Testing of equipment and vehicle components is the most proper in service condition.
- On-board diagnostic systems are installed in a vehicle in order to carry out continuous monitoring of vehicle components in period of regular service. But this system is very expensive, because one diagnostic system controls only one vehicle.
- Wayside detection systems are installed on the track in order to carry out periodic inspection of vehicle components in period of regular service. Wayside detection systems provide frequently check, not continuously, but this system is cost-effective because one diagnostic system controls many vehicles.

Installing the wayside detection system on the railway lines can provide the most effective vehicle maintenance. Railway vehicles maintenance can be better planned with maintenance focused on specific systems or components directly related to the measured poor performance vehicle components. Consequently, a vehicle can be placed at a maintenance facility with minimum service disruption with appropriate labor and materials provided for necessary repairs.

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УСЪВЪРШЕНСТВАНЕ КОНТРОЛА НА ТЕХНИЧЕСКОТО ОБСЛУЖВАНЕ НА ЖЕЛЕЗОПЪТНО ПРЕВОЗНО СРЕДСТВО ОТ КРАЙПЪТНИ ДЕТЕКТОРИ

Душан Стаменкович
dusans@masfak.ni.ac.rs

Факултет по машинно инженерство,
Ниш 18000, ул. Александра Медведева 14
СЪРБИЯ

Ключови думи: *железопътни возила, поддръжка на подвижен железопътен състав, система за крайпътно детектиране.*

Резюме: *С цел да се повиши ефективността на техническо обслужване и наличността на подвижен железопътен състав се въвежда бордова и стационарна диагностика, като се използва развитието на електрониката, сензорната технология и компютърни технологии. В превозно средство са инсталирани бордови системи, използвани за непрекъснато наблюдение на устройствага които се използват. Стационарните системи за диагностика се използват за ежедневна-периодична проверка на железопътните превозни средства и елементите на ситемите са монтирани директно на релсовия път, или много близо до пътя. Чрез крайпътната система за детектиране може да се постигне контрол на състоянието на превозните средства по време на редовна експлоатация, без да се налага спирането им. С помощта на събраната информация е възможно да се анализира състоянието на оборудването и да се предскажат потенциалните повреди и грешки, които могат да се появят в бъдеще. Тази публикация описва някои от крайпътните системи за детектиране и изтъква, че този подход може значително да подобри базовото техническо състояние на железопътните превозни средства.*