STATIONARY AND ON-BOARD DIAGNOSTICS FOR RAILWAY VEHICLES

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Abstract – Monitoring and inspection of railway vehicles is an essential part of vehicle maintenance. Maintenance of the railway vehicles is one of the most important tasks to guarantee the safety and efficiencies of railway transport. Because modern day maintenance is based on high quality diagnostics and in the analysis of the measured data, modern diagnostic systems are presented in this paper. Those systems can be on-board systems and stationary diagnostic systems. On-board diagnostic systems are positioned on the vehicles and they are used for their continuous monitoring. Stationary diagnostic systems can be positioned near the tracks (wayside diagnostic systems) and in the workshops (this type is used during the maintenance service of the vehicle). Both solutions are used for periodical vehicle inspection. Whether it is about of on-board or stationary diagnostic system, proper information about correctness and efficiency of railway vehicles or their components and parts are provided. These information could be later analyzed and used in order to predict failures of vehicle components and according that successful and effective maintenance of vehicles can be performed.

Keywords – Railway vehicle, maintenance, monitoring, on-board diagnostic, stationary diagnostic.

1. INTRODUCTION

Maintenance activities on the railway vehicles are necessary to maintain their functionality and availability [1].

Maintenance of the railway vehicles in Serbia is not on the required level as it is in the developed world countries. Vehicle maintenance has been covered by law order list of repairs given the vehicle status (years in service and mileage), or in the case of breakdowns.

Given the stage of reconstruction and modernization of the railway vehicles and procurement of the new modern vehicles, old and conventional maintenance methods must be overcome and replaced.

The following text of this paper will show flaws and imperfections of the conventional methods that are in use and present the possibilities and advantages of modern-day systems (on-board and wayside detection system) as well as their applications with their further development.

2. CONVENTIONAL MAINTENANCE METHODS

Periodical inspection of the railway vehicles is required in order to prevent any dangerous situation [2].

Maintenance of railway vehicles is divided into:
- Preventive (before break down) maintenance
- Corrective (after break down) maintenance.

Regular or preventive maintenance consists of actions, planned in order to prevent break down or other problem occurrence of equipment [3].

One of the actions is visual inspection of technical correctness of the equipment, which is done:
- During the preparation of the vehicle for its usage;
- During the vehicle is in use, and
- After it has finished working.

This control is under the jurisdiction of the trained technical personnel and they are responsible for correctness of all parts, assemblies, devices and aggregates of the vehicle. Most of these activities are

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The other type of vehicle maintenance is irregular maintenance. This type of maintenance is present when vehicle has suffered accidental failure [3]. This condition can be caused by crash or by some other extraordinary event (failure of some element of the vehicle or its worsening).

One of the main reasons of maintenance irregular maintenance performing is absence of automatic monitoring system, which could predict equipment and device failures of railway vehicles. This has direct impact on the transport planning integrity.

Parallel to modernization and procurement of new modern railway vehicles, new maintenance methods, as well as the diagnostic systems, should be developed and applied.

3. MODERN DIAGNOSTIC SYSTEMS

Diagnostic systems are mainly used to support the maintenance process [4].

Modern diagnostic systems (fig 1) can monitor the vehicles in operating conditions on different terrains, to check correctness of parts, to predict services and provide users with data bases, which could be used for further analysis. Newer railway vehicles already have embedded some standard diagnostic systems. Numerous sensors and information technics enables computer control of the vehicle. Also, vehicle management is possible even from outside of it.

![Fig.1. Modern diagnostic train systems [5]](image)

This way, monitoring of the whole system is constant, quick, reliable and safe.

Automatic diagnostic system can be:
- On-board diagnostic systems, which are mounted on the vehicles, or are its basic part.
- Wayside systems, which are stationary systems, positioned near the railway infrastructure.

The distinction between stationary and on-board diagnostic systems is made on the basis of diagnosis frequency and vehicle suitability; with stationary systems being used for periodic inspections and on-board equipment for continuous monitoring of operational status [4].

3.1. On-board systems

Diagnostic systems that are positioned on the vehicle (on-board diagnostics) can provide users with endless flow of information about targeted vehicle components while operating. Those systems can enable constant safety and comfort supervision.

This means that monitoring of chosen parts is constant; computer analysis of collected database is provided; early detection of possible irregularities on monitored components; adequate assessment of occurred damage, as well as the possibility of the fast response in rectifying current defect [3].

On-board diagnostic systems can be used for monitoring various parts and assemblies, such as: contact pantograph – contact line; wheel-rail contact; bogie; axle bearings correctness; diesel and electric motors; breaking system; side doors; air conditioner and ventilation systems, etc [6].

The most important characteristic of the on-board diagnostic system is that it provides status information on a train’s current running behavior [4].

Amini et al [7] has suggested an acoustic emission (AE) condition monitoring system for on-board detection of railway axle bearing defects.

Deterioration of the structural integrity of axle bearings can increase the risk of failure and hence the possibility of delays, costs and derailments, increased levels of vibration, noise and temperature. All of these negative effects can be a sign of a developing defect.

Following system has been developed in order to prevent such negative impacts to occur (fig 2).

![Fig.2. AE sensors on the axle bearing [7]](image)

This system can detect an axle bearing faults especially at an early stage of its problem evolution. Proper axle bearings are producing sounds of certain frequencies, given by the manufacturer. AE sensors, closely mounted to the source of sound (as close as possible to the bearing) can measure the produced sound, while being in use, and record those results for further analysis. Defected axle bearing will show deviations in sound frequencies (fig 3).
The results given by the acoustic analysis can show which axle bearings are safe and which are potentially dangerous.

Bosso et al. [8] measured acceleration on the axle-box of a vehicle and analyzed collected data in the time domain in order to detect wheel flats.

A wheel flat is one of the defects occurring to the wheels of railway vehicles during service life. This defect is related to the occurrence of anomalous braking events leading to the locking of axle rotation, with the consequence of a complete sliding at the contact and heavy wear of the wheel surface.

The used method for prevention of wheel locking during braking is given by the limitation of the brake force in relation with the weight acting on the bogie and measured with a device usually linked to one of the suspensions (fig 4).

Wheel corrugation and wheel flat play an important role, also in noise generation. The immediate detection of the flat formation can be also correlated to the braking occurrence if the braking system is also monitored, in order to develop strategies to reduce the occurrence of this event [8].

### 3.2. Wayside systems

Wayside diagnostic systems are stationary diagnostic systems, which are used for periodical inspection of correctness of the railway vehicles. These systems are installed near the tracks. Stationary diagnostic systems can also be installed in the workshops.

Stationary diagnostic systems that are installed inside the workshops can be used for the inspection of the certain assemblies of the vehicles, which are excluded from the traffic. On the contrary, wayside systems that are installed outside, on the railway infrastructure, can be used for the inspection of the certain components of the vehicles, which are used in railway traffic [9].

Basic principle in which these systems function is that railway vehicle is passing diagnostic part of the system at some slow speed in order to collect necessary data from inspection part of the system. After the data is collected, the further analysis can be made to predict the scale of intervention that needs to be done [3].

The main role of the wayside diagnostic systems is monitoring of the contact between the wheel and the rail. Failures that occur in this contact can lead to catastrophic consequences.

Lagneback [9] points out two types of wayside diagnostic systems:
- Reactive and
- Predictive systems.

Reactive systems detect annual faults on the vehicles; many of these faults are hard to predict or have very short failure to fault time. In most cases the information from these systems is not suited for trending, but is of importance to protect the equipment from further damage due to the fault. The systems also have reactive characteristics and they do not use the information in a trending way, even if the information could be used in a reactive way.

Some examples of reactive systems are: detectors for detecting the parts of the carrying wagons that exits from the load profile; overhear detectors of the axle bearings and heat detectors of the wheels; detectors of creep wheels, etc [3].

Predictive systems are capable of measuring, recording and trending the ride performance of the vehicle and its specific components. From the collected information, it is possible to analyze the condition of the equipment to predict possible failures and faults that may occur in a near or distant future. This makes it easier to plan the maintenance activates ahead and also to utilize the equipment in a more efficient way [9].

Some examples of these systems are acoustic detection of axle bearing failure; monitoring of vehicle performance; monitoring of wheel condition and video supervision of the vehicle [3].

Bannasch et al [4] describes a system that is currently in use for detecting the extent of wear on the brake pads of disk brakes. This system has recognition software that detects type of vehicle and prepares inspection unit (wheel sensors) for it. As the train is passing by a speed of 5-8km/h, diagnostic equipment starts individual cycles for every wheelset (around 400 brake pads). The relevant wheel geometry parameters, i. e. wheel flange height, wheel flange thickness, transverse dimension, flange gauge and
clearance dimension are measured. The concentricity module is responsible for measuring radial runout and any wheel flats defects (fig 5).

The results from the every inspection are stored and can be accessible and analyzed.

**Fig.5. The wheelset diagnostic facilities [4]**

The most important characteristic of this system is that it allows a complete wheelset inspection to be carried out as the train travels by it at its low speed.

Zhang et al [10] has proposed a wayside acoustic diagnosis system for detecting possible defects of bearings on the railway vehicles.

Conventional train has hundreds of wheelset bearings to support his entire weight. In addition, those bearings need to rotate at high speed.

Defective train-bearings may cause serious accidents. In order to prevent such accidents from happening, systems like the proposed one are developed and installed.

System that is presented by Zhang [10] is based on non-contact measurement technology. It consists of a set of microphones array near the track (fig 6).

This system acquires acoustic signals and detects bearing faults that the acoustic signal generated by the bearings contains relevant diagnostic information.

**Fig.6. Model view of the presented system [10]**

The main problem of a system as such is Doppler effect and multiple acoustic sources along with the sounds generated by defected bearings. Those two problems are overcome by the usage of enhanced computer software.

Problems such as this do not affect same on-board system (which are contact based devices), but in addition to wayside system, they can cover much wider field of observation.

### 4. CONCLUSION

A major step towards improving the quality of railway sector services, i.e. higher level of operational safety and availability, can be taken by employing intelligent stationary and on-board diagnostic techniques and integrating these with intelligent, applications-driven data analysis and management systems.

The governing statement that must be followed is that modern day maintenance is based on high quality diagnostics and in the analysis of the measured data.

### REFERENCES


