Smart vehicle railroad

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**Abstract.** Radio Frequency Identification (RFID) technology introduces the way of automated data collection, and processing to improve accuracy of processed data. In the present time possibilities in development and application of RFID technologies are almost limitless. Increasing expansion of RFID technology in almost any industry, where the RFID tag can be put on any product or material or component is an evidence of the previous assertion. Apart from technical aspects, i.e. security, the financial effect of the RFID technology implementation is also relevant in rail freight transport. Using this technology to keep records of technical condition of the wagons can be avoided a huge disaster caused by lack of knowledge about technical condition of the wagon. It can bring the return of initial investment and cost reduction.

**Introduction**

Nowadays, the rail freight transport and individual wagons are used widely and this level of workload can cause increased frequency of failures during operation, which can result in serious consequences. Application of appropriate modern transport telematics technologies for selected components of the wagon, we can avoid serious consequences such as derailment of the train unit due to poor technical condition of the wagon or even rails. The expectation from the modern technology is that it can warn us before such situation.

**Background**

Among the crucial problems on the railroad is the failure rate of the wagons. Poor technical condition is caused by inappropriate treatment of the wagons on the rails during the operation. Each individual part of the wagons is affected by each other and surroundings during the operation. These failures cause that the wagons are put out of operation. The most frequent failures of the wagons are the subject of our research. Railway Company carries out routine maintenance engineering, warranty technical services and part of revision services at their own expenses. The revision services can provide only in cooperation with authorized repair company of the wagons. [2]

The maintenance and repairs of the rail vehicles are planned periodically or preventively and unscheduled if failure occurs. During the operation of the wagons, the individual loading stations perform precise technical inspection activities and if a problem is detected with any part of the wagon, it has to be transported to the nearest repair center. Employees are responsible for the condition of the vehicle during operation.

If failure of the cargo wagon occurs it may cause malfunction or damage of the other functional parts of the wagon. This may cause tragically consequence like derailment of the railroad train unit. Due to the derailment, the section of the railroad is impassable. Shipper has to make all necessary action like replace fault wagons, reloading, and transport of fault wagons to nearest repair center.
All these and more actions have to be made so that transport could continue. Besides the technical consequences, there is also a threat of human security. [3]

Based on the data mining the most frequent failures of the wagons are dedicated to breaking system:

- **Shoe** made from grey cast iron. It can be defective or burst respectively.
- **Pressure break**
- **Trip cock** - arresting device is missing or malfunction.

![Fig. 1 One-shoe and two-show break block](image1)

![Fig. 2 Pressure brake](image2)

![Fig. 3 Train-mounted trip cock](image3)

In Table 1 we listed repair costs of the rail freight wagons for each individual year from 2009 to 2013. These costs are resulting from regular inspections and repairs of the wagons, replacement of the worn parts, emergencies. Analysis of ZSSK Cargo showed that they realized 45,091 orders for wagon repair in 2013. The average repair costs per one wagon are 131.76€.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total repair costs [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>4,592,872.56</td>
</tr>
<tr>
<td>2010</td>
<td>6,791,757.97</td>
</tr>
<tr>
<td>2011</td>
<td>5,966,131.33</td>
</tr>
<tr>
<td>2012</td>
<td>5,529,927.58</td>
</tr>
<tr>
<td>2013</td>
<td>5,941,341.62</td>
</tr>
</tbody>
</table>

The way of how to improve quality of the wagons and to extend their working life is to emphasize the real-time monitoring and signalization of the actual state of the wagon during the operation. From the production point of view it means that producers have to integrate specially adjusted sensor for measuring the temperature of the breaks, wear of the breaks, etc.

Preventive maintenance and measure is another way how to early enough identify and eliminate causes of undesirable side effects. If the problem occurs, the train must stop and train driver or
mechanist has to do visual inspection to find defective part of the wagon. The application of the preventive maintenance is RFID technology.

**Smart railway vehicle with RFID application**

RFID uses radio waves to automatically identify and track objects labeled by tag. The RFID tags contain stored information, which is transmitted to reader. Fig. 3 shows the principle of RFID.

![Fig. 3 Principle of RFID](image)

Tag with sensors allows the measurement of physical quantities including the temperature and thickness measurement of wear of material. RFID technology itself is not able to measure temperature, but it can be connected to another element such as temperature sensor.[5] Nowadays, these integrated sensors into RFID tags are produced. Measured data stored in memory can be further analysis. Using such tags, it could be monitor operating parameters. Real-time monitoring would create ideal conditions for ensuring safety in operation.

![Fig. 4 Wear of the shoe](image)  
![Fig. 5 Position of the sensors at the shoe](image)

In the Fig. 4, it is depicted the thickness of the wear of the shoe at a distance of x1 and x2. The parameter x1 represents the signalization that shoe is significantly worn out. The x1 value is set on $x_1 = 20$ mm. The x2 parameter presents maximal wear of the shoe. The x2 is 10mm. Fig. 5 depicts the placing of the sensor for monitoring of the shoe.

**Readers** : the each individual wagon should contain reader. The reader receives signal from every tag attached on wagon. The captured data are collected and transfer via middleware to central
computer unit for following processing. The computer unit evaluates collected data and signalizes failure visually or in terms of sound if any.

Sensor needs for its function power source. Sensor supply would be through photovoltaic cells mounted on wagon.

Software: Computer unit with the installed software should be placed in the train.

Features of the software:
1. Real-time monitoring – readers are capable to transmit signals to tags in required distance. Every change in state of sensors are detected and display to train driver.

Fig. 6 RFID technology application on wagon of EANOS type

2. Customizable warning - setting alert conditions, such as temperature threshold max/min. Alert condition for corresponding tag is highlighted on-screen by warning message with sound alarm.
3. Filter tags - through the software interface, users can choose the types of tags to be processed in the system in order to eliminate irrelevant records tags to improve performance of CU.

RFID technology can be used to collect all information about a particular freight wagon. it would be appropriate to apply tags resistant to external influences.

In the RFID tag it is encoded information of the ID number of the wagon. Together with information systems, wagon can be unequivocally identified.

Using the ID number of the vehicle we can search in database to get basic transport characteristics of the wagon (length over buffers, weight, braked weight, height and floor area, etc.). Using the electronic consignment note it can be identified sender, recipient and payer, type of goods, the total weight. In the information systems for operational management of train services wagon is characterized in terms of an event that takes place with the wagon (accepted for carriage, assigned to a particular train, removed from a particular train, determine the directional track, etc.).

We can distinguish between two readers configurations: stationary and mobile reader devices. Mobile devices should be used in practice especially at the local train service, where at the individual stations would be adjustments in the composition of the train and the train documentation. Stationary readers should be installed at border crossing stations and initial stations.

Summary and Conclusions

The objective of the presented paper is to show that it is necessary to accelerate and enhance the quality of the entire rail freight. The biggest advantage of RFID applications is to avoid accidents. Based on the analysis of the state it could be predicted how long or how many miles the wagon will be able to operate. On this basis it can be eliminated a situation that will be commissioned unleashed wagon with faulty part. The ultimate goal is to build a network of data collection, which will be used by train operators, logistics companies, transport companies and customers, managing everything from maintenance for freight.
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References

Reference to a book: