Marek Sokołowski
mgr inż.
Metro Warszawskie Sp. z o.o.

DOI: 10.35117/A_ENG_22_08_09_01

Modification of the metro rolling stock maintenance process, taking into account the condition of selected vehicle components

Abstract: The article covers the possibilities of using modern IT and electronic solutions to modify the maintenance process of railway vehicles operated in the Warsaw metro. The legal and technical aspects of rolling stock operation were discussed, and examples of three types of vehicles used in the Warsaw Metro were presented. The current technical solutions in the field of monitoring the condition of some vehicle components were indicated.

Keywords: Metro; Rolling stock; Maintenance system

Introduction

The technological development of recent years, both in the field of electronics and IT, gives rise to many optimization opportunities in virtually every field of the economy. It is also an opportunity to improve processes in the operation and maintenance of rolling stock. The article illustrates the possibilities offered by the use of modern technological solutions in the process of rolling stock maintenance by changing the way certain vehicle components are maintained. This allows for the extension of the adopted inspection periods while increasing the level of vehicle operation safety.

The described effect is achieved by monitoring the state of a selected element online by using sets of sensors, a data distribution unit, and an analytical module to collect, analyze and determine the current level and the safe level for the designated observation parameters of specific vehicle components.

Legal and technical requirements of the exploitation process

In terms of maintenance of railway vehicles, the key legal act in Poland is the Railway Transport Act of 2003 and the Ordinance of the Minister of Infrastructure of October 12, 2005, on general conditions for the operation of railway vehicles.

The regulation of October 12, 2005, indicates the reference documentation in this regard, i.e., the technical documentation of the maintenance system (DSU). All inspection and repair activities performed on railway vehicles must be defined in the DSU. This documentation is initially created by the manufacturer of the rolling stock and approved by the President of the Office of Rail Transport. Any changes to the procedure should be entered into the "change sheet", while significant changes require obtaining a new Maintenance System Documentation.

At the same time, the regulation defines in detail what elements should be included in the "Maintenance Plan," depending on the type and condition of the vehicle, and what the framework scope of maintenance work is, depending on the level of maintenance. This is described in the table, which constitutes Annex No. 3 to the above-mentioned Regulation. Therefore, the change will require changes to the DSU following the Regulation or even an appropriate request for a derogation.

The rolling stock used in the Warsaw Metro and its features

The proposal to modify the maintenance system must always be based on specific parameters of railway vehicles, so it is worth presenting here the rolling stock of the Warsaw Metro with its most important features.

Warsaw Metro currently operates 3 types of vehicles (Figs. **1**, **2**, and **3**), with Russian-made vehicles having numerous subtypes depending on the type of car and the year of production. These are the following vehicles: 81 series vehicle type 81572P and 81-573P, type Metropolis, type Inspiro.

1. 81 series 81572P and 81-573P vehicle. Vehicles with DC drive units (24 x 110 kW) on each axle. The car body is a welded steel structure. Vehicle weight 200 tons

2. Metropolis type vehicle. Vehicles with AC units (16 x 180 kW). The car body is an aluminum construction. Vehicle weight 186 tons

3. Inspiro type vehicle. Vehicles with AC units (16 x 160 kW). The car body is an aluminum construction. Vehicle weight 165 tons

Modern technical solutions for monitoring the condition of some vehicle components

The use of electronic equipment in modern vehicles, including current, voltage, position sensors, acceleration sensors (accelerometers), signal paths, and data aggregation computer units, allows for the collection of very extensive material that is the basis for further analysis as well as for almost immediate determination of the condition of vehicle components. Modern solutions in the fields of data analysis, analytical process prediction, and visualization of the achieved results allow you to use them to optimize vehicle service processes and thus achieve significant savings in terms of effort and resources. It also allows for increasing the level of safety of operated vehicles.

The tools described above can be used to monitor vehicle parameters online so that the process of assessing the condition of components does not require shutting down vehicles and dismantling many components. Such a modification will bring significant savings in operation related primarily to greater availability of the vehicle for use.

General description of the rolling stock maintenance system modification process

To implement the solution presented, first, select the components for observation. An indication of selected elements is based on technical analysis and risk analysis, which will result in the consequences of damage to a specific element.

Preliminary analysis shows that the elements related to the running system are optimal for this purpose, such as a wheelset (axle box bearings, axle, and wheels of the wheelset), bogie frame, friction brake, or suspension elements.

For selected elements, a parameter or a set of technical parameters for observations defining the state of the element should be determined, and the type of the appropriate sensor should be indicated. In addition, a transmission path, a local data aggregation unit, and a central data aggregation unit should be designed outside the vehicle.

The data recorded during operation should be sent online to the stationary unit, and then they should be analyzed and compared with the standard indicating the safe level with a defined margin, the service level with a time margin for servicing, and the red alarm level, i.e. a level not to be exceeded, at which the vehicle must be taken out of service immediately.

From this point of view, the key seems to be the correct calibration of the levels described above. This calibration must be based on an analysis using reliability theory and a set of data recorded during the operation of the vehicle. Such a task is relatively complex. The maintenance spare space must include a period when all (or most) of the components will be within the required maintenance range or coincide with the specified maintenance level. This is a key element of this transformation, as it requires a relatively long period of normal vehicle operation for data aggregation for further analysis. Such a period can be from 1 to 3 years because the key to this process is to observe the wear processes of the elements and correctly determine the prediction for each of them.

After carrying out the process of observed operation and determining the necessary service levels for selected vehicle components and testing the correct operation of the system to which it must react, you can close the system synthesis period and proceed to its industrial operation according to the new service cycle.

Summary - effects of applying modifications and conclusions

Warsaw Metro uses vehicles that have a number of both sensory and data aggregation elements to implement such a system, but they are not currently integrated into one system. Integration into a functional system would require further research and investment to complete and test the system proposed in this article. In addition, it would be necessary to launch formal activities related to the requirements of the Regulation of October 12, 2005. Nevertheless, from the preliminary analysis of the proposed approach, it can be concluded

that it will bring measurable and relatively large savings to the maintenance process. An equally important aspect of this change will be the increase in the level of operational safety. Certainly, such an approach will be increasingly used in rail transport around the world in the coming years, as indicated by the literature available in this area.

Source materials

[1] P. Dersin, A. Alessi, B. Lamoureux & M. Brahimi; „Prognostics and health management in railways"; Alstom, Saint-Ouen, FranceSafety and Reliability – Theory and Applications – epin & Briš (Eds)© 2017 Taylor & Francis Group, London, ISBN 978-1-138-62937-0

[2] Vepa Atamuradov, Kamal Medjaher, Pierre Dersin, Benjamin Lamoureux, Noureddine Zerhouni. „Prognostics and Health Management for Maintenance Practitioners - Review, Implementation and Tools Evaluation" Production Engineering Laboratory (LGP), INP-ENIT 47 Av. d'Azereix, 65000 Tarbes, France