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Ecology, energy efficiency and resource efficiency as the objectives of rail vehicles renewal

Adam Tułecki[a], Maciej Szkoda[a]*

[a] *Cracow University of Technology, Institute of Rail Vehicles*

Abstract

The paper concerns an evaluation of the justifiability of modernisation of rail vehicles as a method for improving the efficiency regarding a reduction of operation and maintenance costs. A decision-making model was developed in order to evaluate the effectiveness of the locomotive modernisation based on the Life Cycle Costs (LCC), taking account of RAMS characteristics and based on guidelines in the standard EN 60300-3-3 *Dependability management. Application guide. Life cycle costing*. An example of the methodology that has been applied is the modernisation of a 6D 588 kW diesel locomotive (6Dg type after modernisation) done following the criteria of the European transport development strategy concerning ecology, energy efficiency and resource efficiency. The LCC management for the modernised locomotive included an analysis of the costs at the stage of concept and design, through verification, to the optimisation of the costs dominating during its operation. Through joint work of the authors with leading suppliers of subassemblies, a modernisation contractor and Poland's largest rail carrier, 160 locomotives will have been modernised by the end of 2016, with savings of EUR 110 million thus confirming the correctness of the measures which have been taken.

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Keywords: energy efficiency, resource efficiency, modernisation of locomotives, RAMS, Life Cycle Cost

* Corresponding author. Tel.: +48-12-374-35-12; fax: +48-12-374-33-11.
E-mail address: maciej.szkoda@mech.pk.edu.pl

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1. Introduction

The pro-ecological nature of rail transport does not release rail operators from undertaking measures intended to strengthen their market position, especially in Europe. The documents developed and the measures taken by the European Parliament, the Council of Europe, the European Commission and the International Union of Railways (UIC) are intended to further reduce the impact on the natural environment (exhaust gas emissions, noise reduction, search for new energy sources). Major changes are now taking place in the structure of diesel rail fleet which comprises locomotives for shunting (line) operations, trainsets and light rail vehicles. A reduction in the number of locomotives with an increased proportion of trainsets and means of passenger transport is observed. It is also noteworthy that 1/3 of diesel rail vehicles in the European Union were manufactured before 1970. Nearly 10,300 diesel locomotives have been in active operation for more than 30 years now.

A major role amongst measures intended to improve the efficiency of rail transport vehicles is played by activities which aim at reducing the costs of rail vehicle operation and maintenance. A path towards the attainment of this objective is renewal of diesel locomotives meeting the requirements for exhaust gas emissions and energy efficiency. According to the European transport development strategy (White Paper 2011, *Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system*), the environmental impact and reduced consumption of energy are amongst the basic criteria for the evaluation of the construction, modernisation and operation of rail transport vehicles. Due to new restrictive exhaust gas emission standards and an increase in the price of rail fuel, recent years have seen great interest on the part of rail carriers in the modernisation of locomotives as a method for better utilisation of their transport potential A decision-making model was developed in order to evaluate the effectiveness of the locomotive modernisation based on the Life Cycle Costs (LCC), taking account of RAMS characteristics and based on guidelines in the standard EN 60300-3-3 *Dependability management. Application guide. Life cycle costing*. The LCC analysis required continuous monitoring and exchange of data between the manufacturer, the scientific research organisation and the locomotive's operator.

Based on the methodology that has been developed, in 2006 ÷ 2015, at the Institute of Rail Vehicles, Cracow University of Technology, modernisation concepts were devised for most diesel locomotives intended for shunting and line operations in Poland (CUT 2006; CUT 2007a; CUT 2008). Most of those solutions were completed with full implementation. The basic concepts for the modernisation concerned:

- reduction of the costs of fuel and consumables,
- better availability of new sub-assemblies and spare parts,
- improved technical availability,
- extended time between failures,
- improved ergonomic conditions for the engine driver, and
- reduction of the negative impact on the natural environment through reduced emissions of exhaust gases and noise.

This paper presents, as an example, the results of one of the most successful projects to modernise a 588 kW 6D diesel locomotive which, after modernisation, was renamed 6Dg. The project was implemented in collaboration with leading suppliers of sub-assemblies, a modernisation contractor and Poland's biggest rail carrier PKP Cargo S.A. As a result of the modernisation, the potential for the locomotive's applications improved considerably. It performs a significant role in the chain of deliveries of raw materials and semi-finished products to manufacturing plants, in so-called process trains which provide Just-in-Time system deliveries. In 2009 ÷ 2015, more than 150 locomotives were modernised for various rail transport carriers, and the modernisation has been continued until the present.

Such a success was possible with an accurately designed scope of the modernisation taking into account the criteria of ecology, energy efficiency and correct LCC management during the various stages of the locomotive's life cycle (Fig. 1). Modernisation of a locomotive to the 6Dg version is a typical example of utilisation of a carrier's resources in order to improve its transport potential. The LCC management comprised an analysis of costs at the stage of concept and design, through verification, to the optimisation of the costs (maintenance costs in this particular case) dominating at the stage of operation.