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Energy Saving Possibilities at the Hungarian State Railways

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Abstract

The reduction of energy consumption has gained significance in the past years as energy prices have been continuously increasing. Advances in railway telematics and the large amount of data obtained from train services enable the development of methods that are capable of further improving energy efficiency through the evaluation, control or prediction of energy utilization of the railways. The paper presents the results of a statistical analysis in which the rate of the possible energy savings is calculated using on-line telemonitoring system data. During the analysis one month real train data was processed from the MÁV Electronic Logbook System, narrowing the data to the electric locomotives.

First a general statistical analysis is introduced to show the deviation of the energy consumption of trains running under the same conditions using a sufficiently large sample. In order to compare the individual train runs properly the train load has been taken into consideration, i.e. to evaluate the real energy consumption of the runs the effect of mass parameter should be taken into account. Next important question is whether only the traffic situation or also the human factor plays role in the energy consumption. The same dataset was analysed as above, but with considering the differences between the engine-drivers. The research has ended with the analysis of some sections microscopically. For this purpose, sections with relatively busy schedule table and large amount of data were chosen. Several parameters on the consumption were examined such as total journey time and the number of stops.

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1. Introduction

The development of an energy-efficient operation strategy has been in the focus of research and development centers, suppliers and industrial/rail users. It is motivated by the competition between rail and road transportation, in which effectiveness, operation costs and reliability are important factors as mentioned formerly. The problem of minimizing the traction energy consumption can be split into three main tasks: choosing the proper vehicle type, development of energy-optimal timetable and optimal control of the train.

Many studies deal with the energy saving potential with different approaches, mainly by utilizing modeling and simulation tools to exploit these benefits, see. Rail Safety and Standards Board Ltd. (2009) and Emkamatik GmbH (2009).

Other approaches, such as the design of energy-efficient traction leads to various numerical optimization methods. In the first papers a large number of simplifications were assumed in order to develop methods which were fast enough even with the available computational power, see Ishikawa (1968) or Milroy (1981). Some examples of the simplifications are the linear expression of resistances, constant constraints, assumption that the external forces do not depend on the train position, and that the inclinations and the tracks are constant between two stations.

Golovitcher et al. developed an energy optimal control for rail vehicles moving along a known route. Using the maximum principle, they found a set of optimal controls, the control switching graphs and complementary conditions of optimality, see Liu & Golovitcher, (2003). The traction force was formalized as a continuous variable, which was suitable for modelling an electric locomotive, but not a diesel one.

The discrete traction force model for optimal control of diesel freight trains was taken into consideration in the research of Howlett et al. (1990, 1994, 1996) They developed various optimal driving strategies for on-board control. Using the local energy minimization principle they calculated the critical switching points for a global optimal strategy, see Howlett et al. (2009).

In another important approach only the coasting point was used for actuation and the coast control of train movement was proposed, see Wong et al. (2004). They used meta-heuristic (genetic) algorithms for computing the proper coasting point offset. Using these solutions the consideration of the changing speed restrictions was strongly limited.

The railway network with its interactions was considered in an energy saving train operation as a disturbance condition, see Fu et. al. (2009) and Yang et al. (2012). They assumed the predetermined routing and traversing order plan and used the coasting control method to seek optimal control strategies.

Several driver advisory systems exist on the market both for trains (such as Knorr-Bremse Leader) or for suburban railway or trams (such as in Dresden), though all of these systems requires an individual on-board unit and sensor system.

In the last decade more and more traction companies have introduced on-line telemonitoring systems, which can provide the necessary information and computation performance for implementing driver advisory systems or automatic train operation functions. On the one hand it is motivated by the deployment of new traffic safety and management systems such as the European Rail Traffic Management System/European Train Control System (ERTMS/ETCS), on the other hand the increasingly widespread operation control and information systems can also provide the necessary infrastructure for a driver advisory system.

Regardless of the many optimization based approaches it is also interesting to examine the energy saving possibilities in the train operation based on measurement data. With this approach, the individual differences of drivers and driving styles can be recognized, and the results show the way for further improvements in energy efficient train operation. In this paper the result of a statistical analysis is introduced in which the rate of the possible energy savings are calculated using the on-line telemonitoring system data. During the analysis one month real train data was processed from the MÁV Electronic Logbook System, narrowing the data to the electric locomotives. Having regard to the exact energy consumption comparing, nearly identical engine types were chosen, i.e. the 431, 432 and 432 locomotive series of MÁV.

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