Optimal design of metro automatic train operation speed profiles for reducing energy consumption

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Abstract-

Trains equipped with automatic train operation (ATO) systems are operated between stations according to the speed commands they receive from balises. These commands define a particular speed profile and running time, with associated energy usage (consumption). The design of speed profiles usually takes into account running times and comfort criteria, but not energy consumption criteria. In this article, a computer-aided procedure for the selection of optimal speed profiles, including energy consumption, which does not have an effect on running times, is presented. To this end, the equations and algorithms that define the train motion and ATO control have been modelled and implemented in a very detailed simulator. This simulator includes four independent modules (ATO, motor, train dynamics, and energy consumption), an automatic generator of every possible profile and a graphical assistant for the selection of speed commands in accordance with decision theory techniques. The results have been compared with measured data in order to adjust and validate the simulator. The implementation of this new procedure in the Madrid underground has led to a 13 per cent of energy saving. As a result, the decision has been taken to redesign all the ATO speed profiles on this underground.

Index Terms- energy consumption, speed commands design, train simulation, energy efficient driving, automatic train operation, metro, eco-driving

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