Energy Efficiency in traffic operation: Spanish experience in Metro de Madrid

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During the recent years there is an increasing interest in designing strategies to reduce the energy consumption in railways lines.
This criterion should be taken into account from the very beginning of the design of a railways line, and the design of new trains. However, with the existing infrastructure and the trains nowadays in service it is possible to reduce consumption optimising the traffic operation with insignificant investment.
This paper presents different strategies applied by Metro de Madrid: central traffic regulation system that regulates reducing consumption, improvement of regenerated energy transmission during regenerative brakes, and efficient design of the ATO speed commands.

Traffic Regulation System

Metro de Madrid centralised automatic traffic regulation system, developed by the IIT, supervises, calculates and sends train departure commands at stations as well as the ATO speed command to be executed by each train between stations. This system supervises and predicts when a train will have to be stopped due to a preceding delayed train. When that future situation is detected, the system sends slow and less consuming speed commands to the train, and then the extra stop time will be reduced or even avoided. The effect of this automatic traffic regulation strategy was tested and measured, providing reduction of the energy consumption of 15% compared to the previous manual regulation of traffic.

Efficient design of ATO speed commands

For each station 4 speed commands with different running times can be chosen by the centralised regulation system. Thus, speed commands faster than the nominal can be executed when the train is delayed, and slower commands when the train is too next to the preceding one. These 4 commands have to be designed according to the specific ATO equipment, the comfort and operational criteria, and in addition, energy consumption can be taken into account. A new design procedure and a decision support tool has been applied to redesign Line 3 ATO speed commands, considering also energy efficiency, and energy savings up to 10% have been measured (with no quality reduction). This redesign is going to be applied to the rest of the lines of Metro de Madrid.

Regenerative braking

Metro de Madrid trains are equipped with regenerative brakes. In the 1500V DC traction network of Metro, a speed-up process should coincide with a braking process of another train in the same electrical section to transfer the regenerated energy between trains. During peak hours the probability of random coincidences of speed-up and braking process is higher, however during the off peak hours, when delays are less frequent, the timetables could be designed to force these coincidences. A new optimisation model has been developed to design timetables that improve the regenerated energy transmission, and it has been applied to Line 3. The measures registered on board and on substations show energy savings of 3%. This value is expected to be higher for the rest of the lines with a traction network of 800v DC, and in lines with isolated electrical sections.