Optimizing Energy Consumption and Operating Cost of Trains by the Use of Flywheels

Alexander Rupp

Dept. of Mechanical Engineering, University of Alberta, Edmonton, AB, Canada
Dept. of Mechanical Engineering, Technical University of Munich, Garching, Germany

INTRODUCTION

Considerable energy is dissipated in conventional braking systems of trains (Rupp, Baier, Mertiny, & Secanell, 2015). Significant amounts of energy could be saved if the kinetic energy was stored and applied again to propel the train (Rupp et al., 2015). Flywheel Energy Storage Systems (FESS) are suitable for this purpose, as they can provide sufficiently large energy and power capacity (Castelvecchi, 2007). Furthermore, carefully designed FESS may also result in lower operating cost due to reduced energy consumption. The objective of this project is to determine FESS parameters that yield optimal energy or cost savings.

METHODS

In a previous study, we have built a simulation model to analyze the benefits of hybridizing a train with FESS units (Rupp et al., 2015). The model estimates the energy consumption and operating cost of arbitrary train and FESS configurations. Based on this model, optimizations are performed here in order to maximize energy and cost savings of an exemplary train.

RESULTS

The optimizations reveal feasible FESS parameters that are required for either maximum energy savings or cost savings. The results that correspond to these two objectives are different and suggest that there is a trade-off between optimum energy savings and optimum cost savings. However, the two objectives are not mutually exclusive. Hence, it is possible to obtain maximum cost savings along with substantial energy savings and vice versa.

CONCLUSIONS

This project optimizes the energy consumption and operating cost of trains by the use of FESS. The novelty of this approach is that costs of energy and FESS are simultaneously taken into account. The advantage is that not only the most energy efficient solution is found, but also the most cost effective one. The former might be interesting from an engineering point of view. However, the most cost effective solution may be even more important, as it is very attractive for a realization as it predicts not only considerable energy savings, but also maximum financial return.
Overall, this project can be seen as an example of how to reconcile economic incentives with ecological friendliness in order to achieve a solution that pays for itself and has a positive impact on the environment.

REFERENCES

Rupp, A., Baier, H., Mertiny, P., & Secanell, M. (2015). Analysis of a Flywheel Energy Storage System for Light Rail Transit. Manuscript submitted for publication.

Castelvecchi, D. (2007). Spinning into Control: High-tech reincarnations of an ancient way of storing energy. *Science News*, 171(20), 312-313.