ABSTRACT

The railway sector has emerged as a highly enhanced form of public transportation on a global scale. An essential aspect in enhancing the caliber of the railway sector involves the optimization of energy utilization. Optimization Plays a vital role in ensuring the uninterrupted functioning of activities and making a positive impact on the environment. The most significant source of energy consumption in railway operations is attributed to train traction. The process of train traction accounts for approximately 80% of the overall energy usage. Consequently, alongside the substantial expenses incurred, the utilization of the chosen power source for energy production also yields elevated environmental implications, thereby affecting sustainability. The exposure thereafter emerges as a prominent focal point in all studies pertaining to trains. The research is undertaken to understand and analyze the contribution of regenerative braking as a part of energy efficient train control operation

The experiment was performed utilizing the General Pseudo-spectral Optimal Control Software (GPOPS) method for the optimization of the used model. This work incorporates four case studies that employ different controlled inputs, including the independent variable of journey time, the number of collocation points utilized, and the inclusion of additional buffer time for each designated transit time. This research utilizes the GPOPS algorithm in conjunction with MATLAB software to optimize the model through coding. The case study is subsequently simulated utilizing the model implemented in the GPOPS algorithm. The simulations were performed by manipulating the operating speed, collocation locations, and the inclusion of travel time supplements to the stipulated trip time in the scenario for each individual case study.

The results suggest that the optimum amounts of energy consumption and regenerative braking energy generation were attained when the operational speed was increased to 100 km/h. The energy efficiency achieved accounts for 68% of total energy, whilst the energy generated by regenerative braking accounts for 18% of the optimal energy use. Furthermore, with the aggregation of energy consumption and the output of regenerative braking energy, it is possible to achieve an efficiency level of 74%. This study proposes the implementation of an on-board Energy Storage System (ESS) to effectively capture and utilize the energy produced during regenerative braking in order to assist in future train operations during the tracking phase. The suggested energy storage system (ESS) is an electrical double-layer capacitor (EDLC), which demonstrates exceptional efficiency and endurance properties.

Keywords: GPOPS, EETC, Regenerative Braking, Energy efficiency, Railway system, Train Control