A hybrid simulation and hardware approach for a regenerative braking system in an electric motorcycle

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Abstract

Conventional electric motorcycles mostly depend on mechanical braking systems that dissipate kinetic energy as heat, resulting in significant energy losses, frequent battery recharging, and reduced operational efficiency. To address these limitations, a regenerative braking system (RBS) is designed and developed to recover and store kinetic energy during braking phases. The proposed RBS integrates a brushless DC (BLDC) motor that serves as a propulsion and energy regenerative unit, a lithium-ion battery for energy storage, and an Arduino microcontroller for real-time control and seamless system integration. A hybrid methodology combining MATLAB/Simulink simulations and hardware prototyping was adopted to evaluate system performance under various operating conditions. The simulation results demonstrated effective braking torque generation and back

electromotive force (EMF) recovery to validate the system's ability to convert kinetic energy into storable electrical energy. The proposed RBS achieved a theoretical energy recovery efficiency of approximately 70, attributed to internal resistance and motor back EMF variations. These findings demonstrate the potential of regenerative braking in improving the energy efficiency of electric motorcycles, extending battery life, and reducing dependency on external charging. Furthermore, this study establishes a foundation for future RBS development incorporating lightweight materials, cost-effective components, and intelligent control strategies that can contribute to advancing sustainable and energy-efficient urban mobility solutions.

Author keywords

Electric motorcycle; Energy efficiency; Energy recovery; MATLAB simulation; Regenerative braking

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