A Regenerative Braking System for an Open Wheeled Single Seater Rear Wheel Drive Formula-Type Race Car

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Braking systems in high-performance race cars must deliver consistent stopping power, precise modulation, and high thermal resistance under extreme operating conditions. Modern motorsport increasingly emphasizes energy efficiency and sustainability, driving the adoption of regenerative braking technologies. Regenerative braking converts kinetic energy, generally lost as heat during deceleration, into electrical energy that can be stored and reused, improving vehicle efficiency. Consequently, regenerative braking has become vital in motorsport for improving efficiency and reducing energy losses. This project presents the design, development, integration, and validation of a combined conventional hydraulic and regenerative braking system for a single-seater rear-wheel-drive race car named Diablo XI, developed for Formula motor sports competitions in Sri Lanka. The project focused on advanced engineering integration, improved efficiency, and cost-effective safety enhancements. A novel belt-driven, generator-based regenerative braking mechanism is proposed, enabling energy recovery in a cost-effective manner suitable for internal combustion engine-powered race vehicles. SolidWorks, the computer-aided design and simulation tool, was used to model the system prior to physical implementation. The project used conventional braking system consists of ventilated disc brakes on all four wheels, a vacuum-assisted brake booster, a dual-line master cylinder, semi-metallic brake pads, production-based calipers, steel brake lines, and DOT 3 brake fluid. The regenerative braking system utilizes a modified alternator operating as a generator, driven via a belt connected to the engine crankshaft. Generator engagement is controlled through an overrunning clutch activated during braking events. The recovered electrical energy is stored in a 12V lithium-ion battery pack equipped with a battery management system (BMS). The hydraulic braking system was validated through static inspections and dynamic testing at speeds of up to 100 km/h. Braking performance under repeated racing conditions was evaluated, and the test results confirmed reliable braking performance, consistent generator engagement during braking events, and successful battery charging while maintaining vehicle safety, stability, and handling characteristics. Future work will focus on comprehensive track testing and further optimization of the regenerative braking strategy to maximize energy recovery and braking performance under competitive racing conditions. Overall, this study demonstrates the feasibility of implementing a low-cost regenerative braking system for student-level and grassroots motorsport applications.

Keywords: energy recovery, formula car, hydraulic braking system, motorsport, regenerative braking