Design and Optimization of a Waste Diesel Recycling-Based Generator System for Carbon Neutrality

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탄소중립 실현을 위한 폐디젤 재활용형 발전기 시스템 설계 및 최적화

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Abstract

With the rapid advancement of vehicle electrification, traditional internal combustion engines (ICEs) are increasingly being phased out, and stricter emission regulations are accelerating the replacement of gasoline, diesel, and LPG-powered vehicles with electric alternatives [1]. As a result, a large number of ICEs are being retired, which, if not properly recycled, may lead to significant resource waste and environmental pollution. Among them, diesel engines have been widely employed in construction, agriculture, and industrial applications due to their superior durability, high thermal efficiency, and high power output [2]. Recent studies have further highlighted that retrofitting old-generation diesel engines with after-treatment systems such as diesel oxidation catalyst (DOC), diesel particulate filter (DPF), and selective catalytic reduction (SCR) can substantially reduce harmful emissions, including nitrogen oxides (NO_x), carbon monoxide (CO), hydrocarbons (HC), and particulate matter (PM), while maintaining acceptable performance levels. Moreover, waste heat recovery technologies, particularly Organic Rankine Cycle (ORC) integration, have been shown to improve fuel economy and increase overall efficiency by up to 11%, offering additional opportunities for sustainable reuse [3]. Given these factors, the design and optimization of a carbon-neutral and high-efficiency generator system based on recycled diesel engines has become an urgent and necessary research direction.

In this study, a sustainable and high-efficiency diesel engine generator system was developed by recycling discarded diesel engines. The core approach of this research lies in applying artificial intelligence-based tools to optimize the engine control unit mapping, thereby ensuring that critical operating variables, including engine speed, load conditions, fuel injection timing, and fuel injection pressure are adjusted in accordance with the generator's real-time power demands. In addition, the system was designed with a direct coupling between the engine and the generator to minimize energy losses and improve overall efficiency. To further mitigate environmental impact, the original exhaust after-treatment devices that were initially designed for diesel vehicles, such as oxidation catalysts, particulate filters, and selective catalytic reduction systems, were integrated without modification into the generator setup. This strategy not only enabled the reduction of harmful exhaust emissions but also demonstrated the potential of reusing existing components in line with circular economy principles. Overall, the proposed system provides a practical pathway for transforming retired diesel engines into eco-friendly and carbon-conscious power generation units, contributing to resource efficiency and environmental sustainability.

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References

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