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Energy-Saving Performance Analysis of High-Efficiency Motor Drive Systems in Continuous Manufacturing Processes

With the rapid development of industrial automation and smart manufacturing, motor drive systems play a central role in power transmission and process control in continuous manufacturing processes. However, conventional motor drive systems often exhibit high energy consumption, fluctuating efficiency, and poor load adaptability, leading to significant energy waste. In the context of rising energy costs and increasing requirements for energy conservation and emission reduction, analyzing the energy-saving performance of high-efficiency motor drive systems and their application in continuous production processes is of great engineering significance.

High-efficiency motor drive systems achieve superior energy conversion from electrical to mechanical energy through optimized motor design, advanced control algorithms, and high-performance power electronic devices. In continuous manufacturing, load characteristics frequently vary, and power demands during startup, acceleration, and steady-state operation differ substantially, posing challenges to dynamic response and overall efficiency. Moreover, system efficiency depends not only on the motor itself but also on the integration of drive control strategies, mechanical transmission matching, and process operation modes. Therefore, system-level energy-saving analysis tailored to continuous production scenarios is essential to evaluate the practical benefits of high-efficiency motor drive systems.

This study proposes an energy-saving performance analysis methodology for high-efficiency motor drive systems in continuous manufacturing processes. A multi-physics coupled model encompassing the motor, drive electronics, and mechanical load is established to simulate energy consumption characteristics, efficiency variations, and dynamic response under varying load conditions. Furthermore, energy efficiency metrics and operational parameter optimization strategies are applied to quantify the energy-saving potential of the motor drive system. The results provide engineering guidance for equipment selection, process parameter configuration, and energy-efficient retrofitting in industrial facilities, supporting reductions in energy consumption and improvements in production sustainability.

The research not only provides a theoretical basis for the engineering application of high-efficiency motor drive systems in continuous manufacturing but also informs

energy management and optimization strategies in smart manufacturing environments, promoting efficient, low-carbon, and sustainable manufacturing systems.