Efficiency Measurements and Lubricant Optimization in Directly Cooled Electric Drives: Influence of Viscosity Index Improvers, Base Oil, and Viscosity Profile

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India's electric vehicle (EV) sector is rapidly growing due to government incentives, environmental concerns, and technological advancements. The country aims to achieve 30% EV sales in private cars and 80% in two-wheelers and three-wheelers by 2030, targeting 80 million EVs on the road. This growth presents significant opportunities for lubricant development, as the Indian EV market is expected to expand from \$3.21 billion in 2022 to \$113.99 billion by 2029. The surge in EV sales, which increased by 49.25% in 2023, highlights the need for specialized lubricants to enhance efficiency and performance. Additionally, the expansion of EV charging infrastructure, with over 12,000 public stations as of February 2024, supports the growing demand for EVs and related products.

In this study, we explore the impact of lubricant composition and physical properties on the overall efficiency of wet coil Electric Drive Units (EDUs) under both Worldwide Harmonized Light Vehicles Test Procedure (WLTP) and stationary conditions. Our investigation aims to enhance the utility and sustainability of EDUs, which allows for either reducing battery size or extending their range. We conduct experiments using a state-of-the-art EDU connected to two oppositely mounted load machines, monitoring input electrical power and output mechanical power to define overall efficiency. During driving cycles, we simulate EDU operation in a vehicle context with constant cooling conditions. Conversely, during stationary condition cycles, we carefully control internal temperatures to maintain comparable operation while varying the lubricant.

Our comprehensive study involves several lubricant options, varying in kinematic viscosity at 100°C (ranging from 4 to 6 cSt), viscosity index (ranging from 130 to 260), and base oil type (mineral and synthetic). Additionally, we explore the impact of viscosity index improvers with linear and comb structures. Our results demonstrate that reducing the operating viscosity of the lubricant significantly improves WLTP cycle efficiency by up to 0.15%, consistent with prior research. Moreover, we show that increasing the viscosity index of relatively viscous oils (6 cSt at 100°C) achieves similar efficiency gains without compromising durability—a crucial consideration when one wants to avoid extremely low viscosities (<4 cSt at 100°C). This study provides valuable guidelines for formulators seeking to optimize viscosity profiles, ensuring maximum efficiency without risking mechanical failure. By leveraging these insights, it is possible to drive advancements in EDU technology, thus promoting sustainable and efficient electric mobility. Improving energy efficiency in EVs by 0.15% through better lubrication can have significant economic and practical benefits. For instance, a 0.15% efficiency gain could extend the range, improving the probability of reaching the next charging station. This improvement can also translate to smaller battery sizes, potentially lowering the cost of EVs and making them more affordable for consumers. Additionally, over the lifespan of an EV, this efficiency gain could save hundreds of dollars in energy costs, enhancing the overall value proposition for buyers. For the lubricant industry, these benefits highlight the importance of developing advanced lubricants tailored for EVs, opening new market opportunities and driving innovation.

Gefördert durch:

Bundesministerium für Wirtschaft und Klimaschutz

aufgrund eines Beschlusses des Deutschen Bundestages

Results in this study have been partially funded by the German Federal Ministry for Economic Affairs and Climate Action in project CHEPHREN (Project Nr. 03EN4029D).

About the Author

As a Strategic Projects Manager Dr. Shakhvorostov is responsible for coordination and organization of projects with the target to establish existing and new lubricant additives in the context of new mobility, currently with focus on the electrical drive trains.

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