Institut für Antriebssysteme und Leistungselektronik

Bachelor /Seminararbeit

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Torque ripple minimization in multi-material additive manufacturing (MMAM) based SynRMs through structural asymmetry

Synchronous Reluctance Machines (SynRMs), while valued for their simple, magnet-free rotor structure and cost-effective material use, often fall short in performance metrics such as torque density, efficiency, and power factor when compared to permanent magnet machines. These limitations have restricted their broader adoption in high-performance electric drive system applications.

The emergence of Multi-Material Additive Manufacturing (MMAM) offers a new opportunity to rethink SynRM design. MMAM allows for the precise placement of magnetic (e.g., FeCo, FeSi) and non-magnetic (e.g., 316L stainless steel) materials within a rotor, enabling design freedom far beyond what traditional fabrication techniques can offer. This makes it possible to realize advanced rotor geometries that tailor flux paths, reduce losses, and improve mechanical integration.

However, these complex rotor structures come with new challenges—most notably**,** torque ripple. This refers to the unwanted oscillations in electromagnetic torque, often caused by non-uniform flux distributions or abrupt material transitions. In MMAM-based SynRMs, such ripple can be pronounced due to the inclusion of non-magnetic inserts and sharp geometric features. It negatively affects machine, increases vibration and noise emission, and complicates control.

This thesis shall investigate a purely structural approach to mitigate torque ripple without relying on control-side solutions like harmonic current injection**.** By introducing intentional asymmetries into the rotor design, such as offset barriers, skewed bridges, or shifted ribs, the machine can passively suppress oscillation, producing spatial harmonics of the airgap magnetic field. MMAM makes such detailed geometric tailoring not only possible but practical.

Student Task

- **Design & Modeling**: Create two rotor CAD models – one symmetric (baseline) and one with structural asymmetry (e.g., shifted barriers or skewed ribs) using MMAM principles.
- **Simulation**: Perform transient FEA simulations (e.g., in JMAG/FEMM) to evaluate average torque, torque ripple (%), harmonic content (FFT), and losses.
- **Analysis**: Compare both designs to assess torque ripple suppression, performance trade-offs, and mechanical feasibility.

Forschungsschwerpunkt:

Elektromobilität / Aviation ☐ Großmaschinen ☐ Industrieantriebe / Mechatronik ☒

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