



Transverse Flux Homopolar AC Machine

Transverse-flux homopolar AC machine delivers PM-class torque/efficiency with non-heavy-rare-earth stator magnets, wide constant-power speed range, and rugged, serviceable construction.

Conventional alternating current (AC) machines, and specifically permanent magnet AC motors, are widely used in electric and hybrid vehicles due to their high torque and power densities. However, these machines typically rely on rare earth materials like dysprosium, which are costly and have volatile supply chains. These machines also feature rotors assemblies wherein design for mechanical robustness compromises electromagnetic performance. While non-rare-earth alternatives and induction machines exist, these exhibit lower torque densities and efficiency than their permanent magnet counterparts.

Homopolar machines have very robust rotors, but, like induction machines, have historically struggled to deliver the required torque density and efficiency performance metrics for demanding applications.

Purdue researchers have developed a novel approach to homopolar AC machines, namely transverse flux homopolar AC machines (THAMs), that meet the torque density, efficiency, and robustness requirements of the market and substantially decrease the need for heavy-rare-earth elements. THAMs utilize permanent magnets that are constructed from non-heavy-rare-earth material and are placed in the stator, where they do not compromise mechanical robustness. Additionally, the THAM exhibits a wide constant power speed range without the need to reduce the magnet flux, allowing magnets with lower coercive force to be used. This property makes them particularly promising candidates for use in flywheel energy storage and electric vehicles. This technology provides a potential solution towards the production of high-performance electric machines that are cost-effective and sustainable.

Technology Validation:

-Detailed design code validated

Technology ID

2024-SUDH-70788

Category

Energy & Power Systems/Energy
Storage
GreenTech/Circular Economy &
Waste Reduction
Automotive & Mobility
Tech/Micromobility & Smart
Urban Infrastructure

Further information

Parag Vasekar

psvasekar@prf.org

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- Power density vs system efficiency calculations were performed
- Torque density vs system efficiency calculations were performed
- A physical prototype has been designed, built, and successfully tested

Advantages:

- Higher torque and power density than standard homopolar AC machines for the same efficiency
- Higher torque and power density than a standard permanent magnet AC machine when a wide constant power speed range is required (for the same efficiency)
- Wide constant power speed range
- Machine structure facilitates direct cooling of windings
- Inherently sectionalized to facilitate manufacturing and in-situ repair
- Magnets are readily removed for easy recycling

Applications:

- Electric and hybrid vehicles
- High-speed, highly robust, and highly efficient industrial motors
- Flywheel energy storage systems
- Applications requiring recyclability
- Applications requiring maintenance

TRL: 3

Intellectual Property:

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Utility-Gov. Funding, 2025-08-07, United States

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