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Electric-hydraulic conversion machine for off-road vehicle electrification

A new type of electric-hydraulic conversion machine that integrates the rotor of an electric machine with a hydraulic pump and is useful for electrification of off-road vehicles intended for use in construction.

IP Status: US Patent Issued; Patent No: 12,152,572

Applications

- Piston pump for Heavy machinery and equipment
- Off-road vehicle electrification

Key Benefits & Differentiators

- **Electrification of off-road vehicles**
  Energy efficient and compact designs are feasible Multiple design topologies offer design flexibility and integration into vehicle Allows for piston block and magnets to be designed with a diameter that minimizes their inertia
- **Integrates rotor of an electric machine and hydraulic pump:**
  Eliminates redundant bearings, seals, and point of energy conversion Hydraulic fluid is easily utilized to cool electric components Allows high electric loading Coaxial and coplanar design enables efficient space utilization
- **Combines hollow motor with piston pump:**
  Reduces inertia Allows for convenient use of hydraulic fluid
- **Permanent magnets mounted on either side of piston block**
  Cam ring causes pistons to move radially with rotors rotation Allows for piston block and magnets to be designed with a diameter that minimizes their inertia

Electric-hydraulic conversion machine - Overview

Off-highway vehicles represent a major portion of US energy consumption and greenhouse gas emissions. Electrifying or hybridizing these systems has the potential to yield substantial fuel savings through both efficiency improvements and energy recovery over the drive cycle. Legacy systems rely on hydraulic power transmission, which suffer from significant throttling and component losses. However, the extreme power density and transient requirements of these systems pose unique challenges to electrification that have so-far prevented broad commercial success. Moreover, extreme power requirements for these vehicles cannot be solved by using the electric drivetrain technology developed for passenger vehicles.

To overcome these challenges, researchers have designed a new type of electric-hydraulic conversion machine which integrates the rotor of an electric machine with a hydraulic pump. Benefits of both the hydraulic domain (high power density) and electric domain (elimination of throttle losses, high component efficiency, controllability) are offered in this new machine. Three novel topologies are developed which combine the rotor of radial and axial flux machines with an eccentric ball piston hydraulic pump. This approach eliminates redundant bearings, seals, and points of energy conversion. Furthermore, the hydraulic fluid is utilized to cool the

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electric machine and associated drive electronics, allowing high electric loading. All of this translates to highly desirable benefits of low inertia, high power density, and high electric-hydraulic energy efficiency.

Phase of Development

TRL: 2-3
Concept and simulation.

Desired Partnerships

This technology is now available for:

- License
- Sponsored research
- Co-development

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Researchers

- **James Van de Ven, PhD** Professor, Mechanical Engineering
- **Eric Severson, PhD** Assistant Professor, Electrical And Computer Engineering, University of Wisconsin-Madison

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References

1. Nishanth, F. N. U., Garrett Bohach, James Van de Ven, and Eric L. Severson(29 September 2019) , https://ieeexplore.ieee.org/abstract/document/8912685, 2019 IEEE Energy Conversion Congress and Exposition (ECCE)