EFFICIENT, COMPACT, AND SMOOTH VARIABLE PROPULSION MOTOR

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CCEFP Summit – Purdue 2019
June 5th, 2019
Project Team

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Project Overview

• Many off-highway vehicles use hydrostatic drives.
  – Variable displacement axial piston pump
  – Fixed displacement motor

• Pump displacement sets vehicle speed
  – Pump is inefficient at low displacements

• Variable displacement motor would decouple pump displacement and vehicle speed
Value Propositions

- **Motor Efficiency**: Saves fuel, increases power
- **Low Torque Ripple**: Improves control and productivity

- **Variable Displacement Motor**: Increases transport speed and higher system efficiency
- **High Displacement Motor**: Eliminates gearbox
- **Scalable Motor**: Applicable to wide variety of off-highway vehicles
Project Objectives

• Efficiency >90% above 50% displacement
• Torque ripple <5% of the mean torque
• Reduce vehicle fuel consumption by 30%
• Power density >5 kW/kg
• Cost <$4/kW
Low Speed High Torque (LSHT) direct drive hydraulic motor with track drive sprocket
Model Optimization

• 10 independent variables
  • Piston trajectory
  • Linkage geometry
  • Linkage location

• 3 objectives
• Multiple solutions that meet objectives
• Multi Objective Genetic Algorithm
**Objective Functions**

- Efficiency
  - Throttling losses
  - Frictional losses
- Torque Ripple
- Size
  - Diameter of outermost point of motor

**Penalty Functions**

- Efficiency
  - Cavitation
  - Excessive joint forces
- Size
  - Interference between
    - Bearings
    - Linkage modules
    - Adjustable ground pivots and the cam
  - Radius of roller follower too large
Pareto Front

Optimization Results

Efficiency [%]

Torque Ripple [%]

Selected Individual

Approximate Motor Diameter [mm]
Individual’s Results

**Efficiency**

[Graph showing efficiency vs. fractional displacement]

**Torque Ripple**

[Graph showing torque ripple vs. fraction of cycle]
Future Work

✓ Year One
  – Modeling
  – Early optimizations

☐ Year Two – Single Cylinder Prototype
  – More optimizations
  – Detailed mechanical design (CAD)
  – Experimental model validation

☐ Year Three – Full Prototype
  – Finalize scaled multi-cylinder design
  – Test multi-cylinder prototype
Acknowledgement

• This material is based upon work supported by the U.S. Department of Energy’s Office of Energy Efficiency and Renewable Energy (EERE) under the Vehicle Technologies Office Award Number DE-EE0008335

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THANK YOU

ANY QUESTIONS?

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