

Modeling and analysis of multi-phase permanent magnet synchronous machine for direct-direct application

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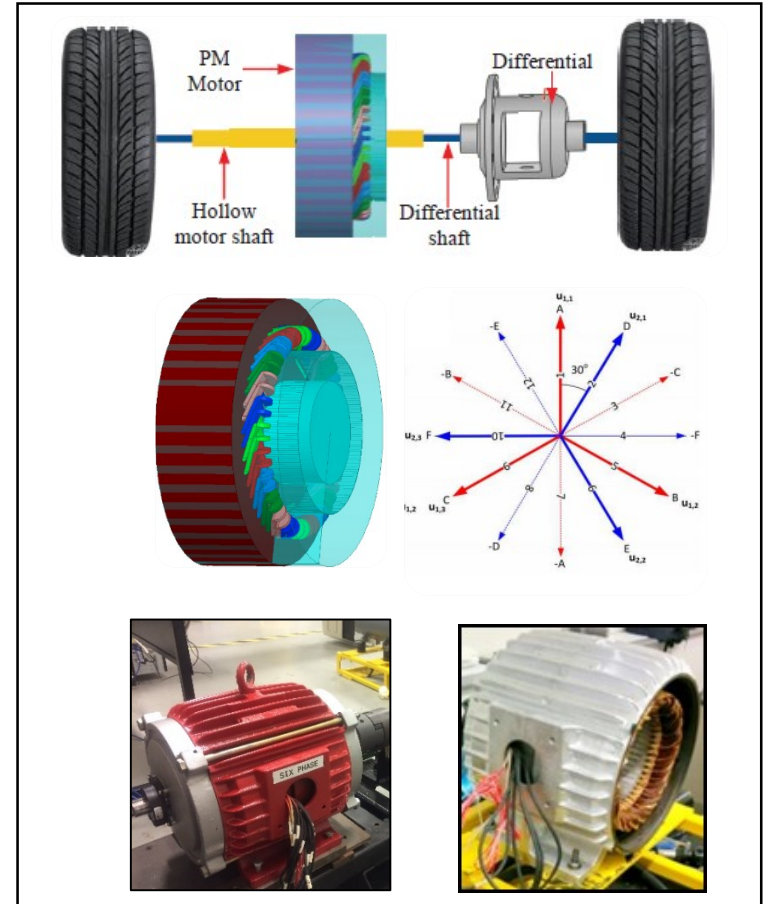
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Program: Electrical Engineering

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Project Description

- Study of multi-phase machine topologies for direct-drive application
- Modelling and analysis of multi-phase PMSM
- Prototype development of scaled-down multi-phase PMSM for direct-drive application
- Testing and performance analysis of the scaled-down prototype



Objective(s)

Study and develop concentrated windings (CW) multi-phase PMSM with reduced torque ripple and increased power density and efficiency

Expected Outcome & Deliverables

- An analytical model of CW multi-phase PMSM including machine non-linearities
- Scaled-down prototype of multi-phase PMSM for direct-drive application

Tasks/Plan

- Investigation of concentrated windings multi-phase PMSM for direct-drive application
- Analytical modelling of CW multi-phase PMSM
- Development of electromagnetic model for the scaled-down CW multi-phase PMSM using finite element analysis
- Prototype development of the scaled-down PMSM in collaboration with Ford and Canmet materials
- Testing and performance analysis of the scaled-down prototype using CHARGE Labs small test bench with other UoW researchers

Progress Report

- Testing of scaled-down PMSM
Tested until rated speed and torque condition of 400 rpm and 70 Nm respectively
- ✓ Maximum efficiency of 93.3% under rated torque and speed condition was obtained
- ✓ 37% improvement in torque per PM volume in the proposed PMSM was obtained compared to conventional surface PMSM
- Scaled-down prototype transferred to McMaster University for control development and testing

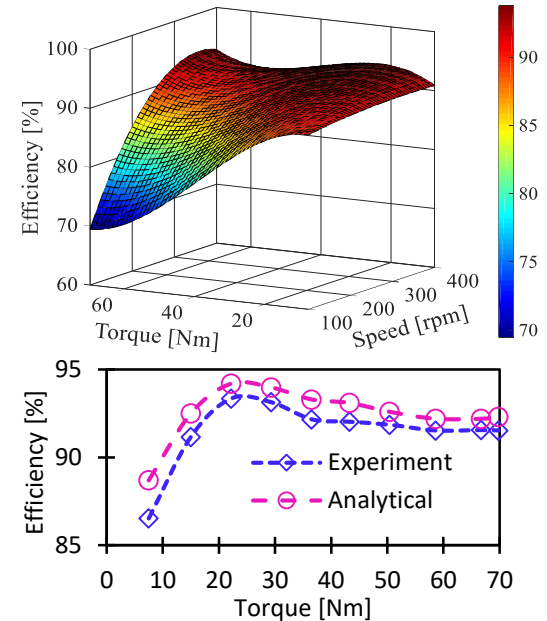


Fig. 1. Comparison of efficiency obtained from experiments and analytical model of the proposed PMSM.



Fig. 2. Scaled-down prototype of proposed PMSM.

Progress Report

- Full-scale PMSM

Scaled up the proposed PMSM to achieve full-scale targets of 1,050 Nm

- ✓ Maximum efficiency of 94% under rated torque and speed condition was obtained from simulations
- ✓ Maximum speed increased from 1,400 rpm to 2,000 rpm

- Future Work: Thermal and structural analysis of full-scale PMSM

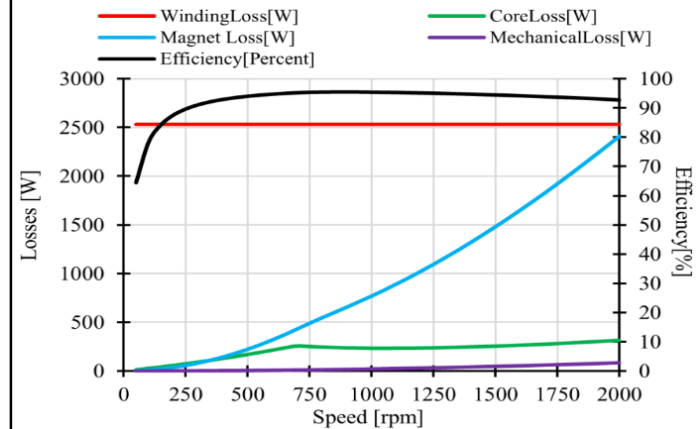
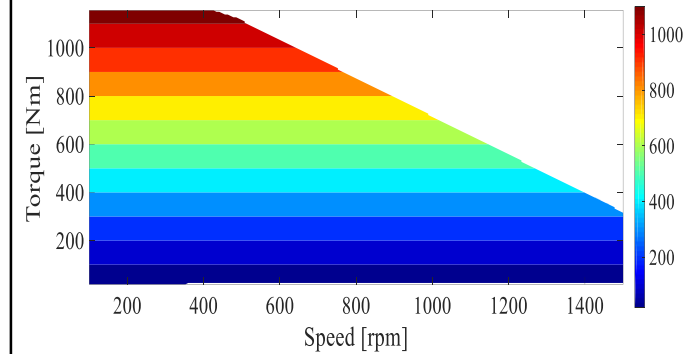


Fig. 3 Simulated torque-speed, loss and efficiency characteristics of the full-scale design.

Thank you!