The Beginnings of Developing an EM-CVT

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The development of transportation technology is ever growing. With stringent global emissions standards increasing and energy sources changing from traditional fossil fuel derived units to battery and electrically driven sources. There is an uptick in research supporting the development of sustainable technologies to continue to increase efficiency while decreasing emissions and improving our environment. Thus, The Pioneer Racing Club of Point Park University presents our concept, the Electromagnetic Continuously Variable Transmission (EM-CVT).

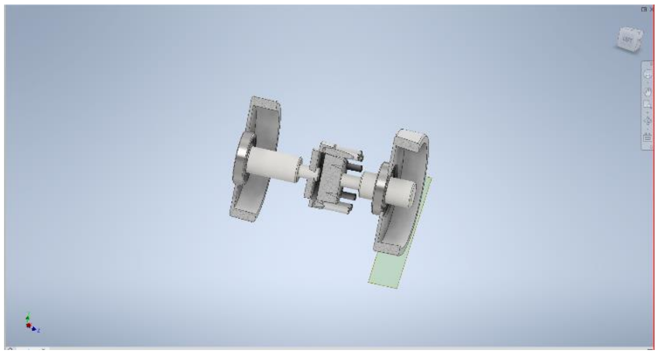

Figure 1: Half-section view of EM-CVT Model

Featuring a permanent magnet inner rotor, ferromagnetic pieces and a electromagnetic stator, we present a potential solution to the traditional belt-drive units. The motivation of this project is to find a competitive replacement to the belt driven CVTs popular in the BAJA SAE Design Competition. A rule compliant BAJA SAE entry features fully functional Four-Wheel Drive (4WD) system, a sealed Kohler CH440 single cylinder engine mated to a transfer case and transmission. Magnetic transmissions are relatively novel in the automotive space, especially as CVTs, thus there is little existing research with proven use in the automotive industry, Therefore, we would like to extend thanks to ElectroMagneticWorks for sponsoring us and allowing us the opportunity to begin this study using their EMS for Inventor Plugin. We were able to start the foundations of what will be an exciting project, tour magnetitic studies serve as the groundwork for understanding how to create a device that drives without the worry of friction.

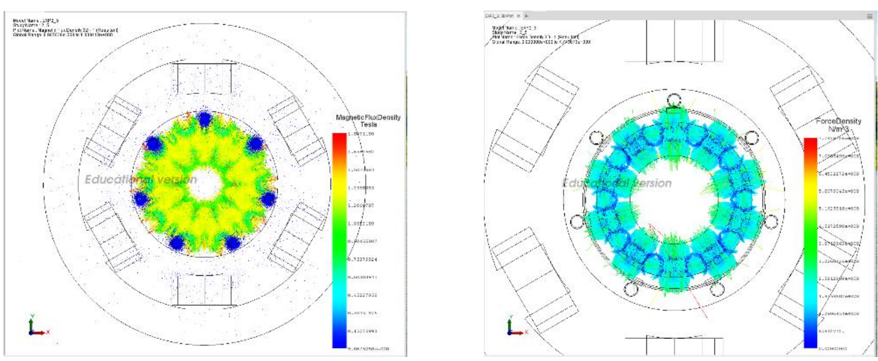

Figure 2: Magnetostatic study derived flux and force plots on a 2.5:1 ratio model of our EM-CVT

To key experiments were ran in the following ways:

Experiment 1:

Keep the 1 to 1 gear ratio of the control group, except swap out the stator's permanent magnets for electromagnetic ones. Have the electromagnet be 120-degree difference between each other and set the base frequency to 60Hz

Obtain the Magnetic Flux plots to observe that the flux varies between phases.

Experiment 2:

Take the Experiment 1 setup but change the permanent magnet pole pairs to the following values: Pole Pairs: 1,2,4,5 (adjust ferromagnetic ring as needed)

Set the frequency to 100Hz

Record the magnetic flux and magnetic torque.

Compare results to the control group

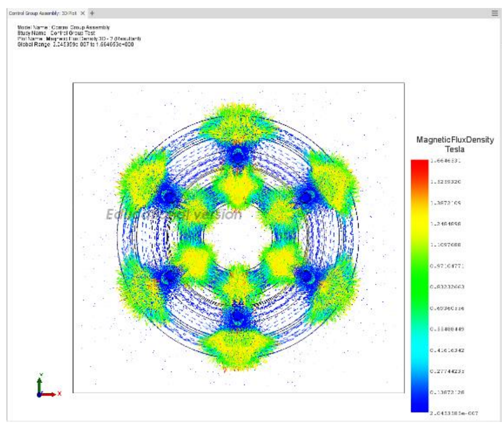

Figure 3: Control Group Flux Density

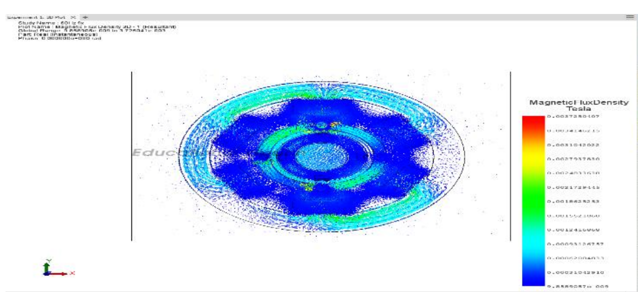

Figure 4: Experiment 1 with flux plot at @60hz and 0 degrees phase

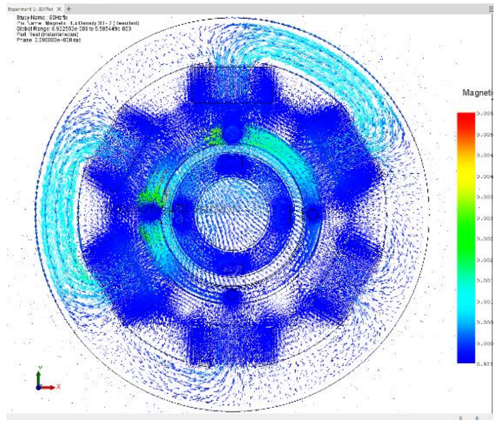

Figure 5: Experiment 1 with flux plot at @60hz and 120 degrees phase

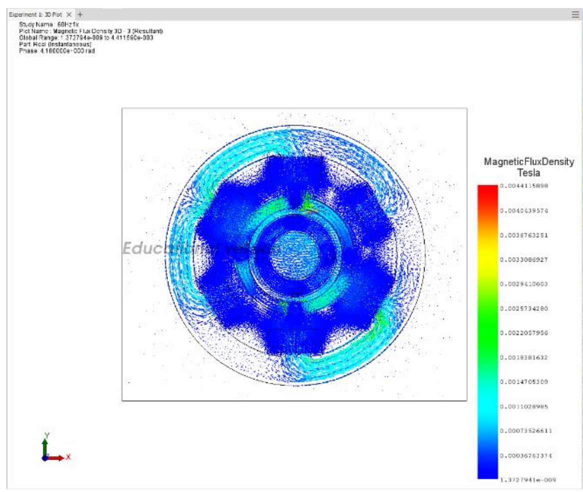

Figure 6: Experiment 1 flux plot at @60hz and 240 degrees phase

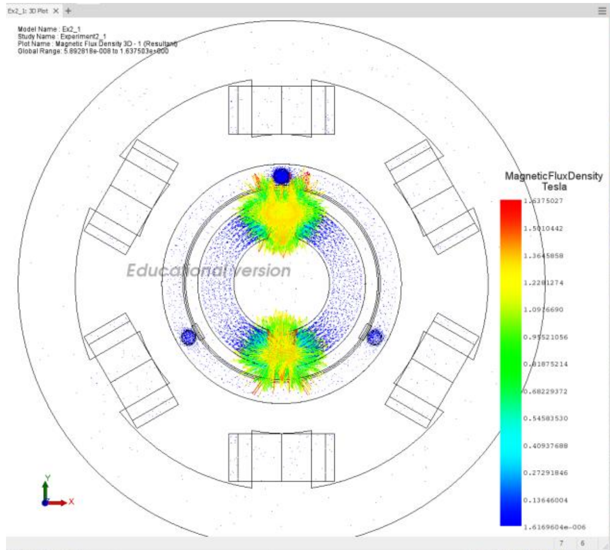

Figure 8: Experiment 2 flux density with 1:2 ratio

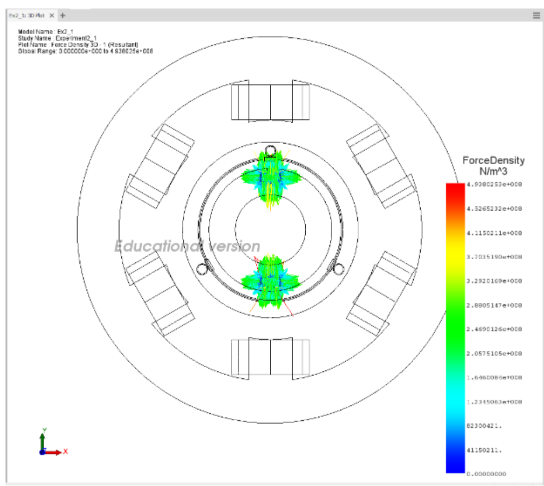

Figure 9: Experiment 2 force density with 1:2 ratio

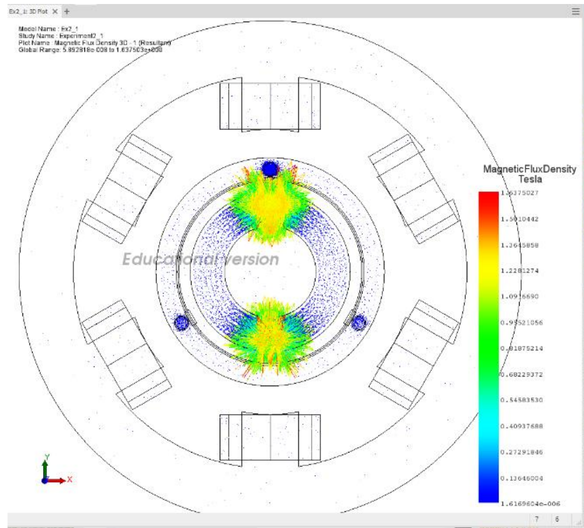

Figure 10: Experiment 2 flux density with 1:3 ratio

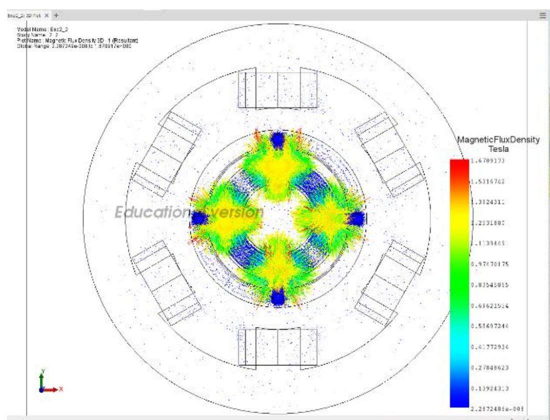

Figure 11: Experiment 2 flux density with 1:1 ratio

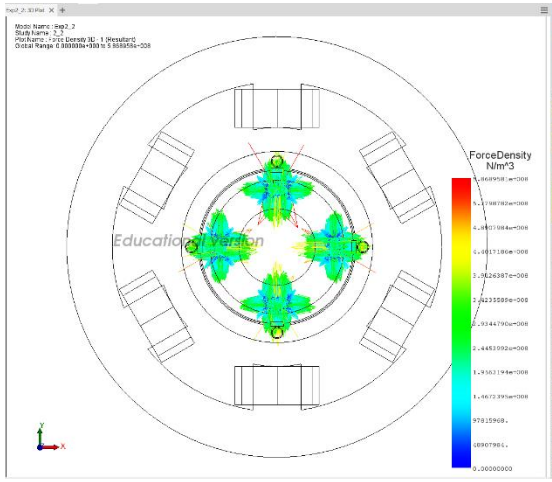

Figure 12: Experiment 2 force density with 1:1 ratio

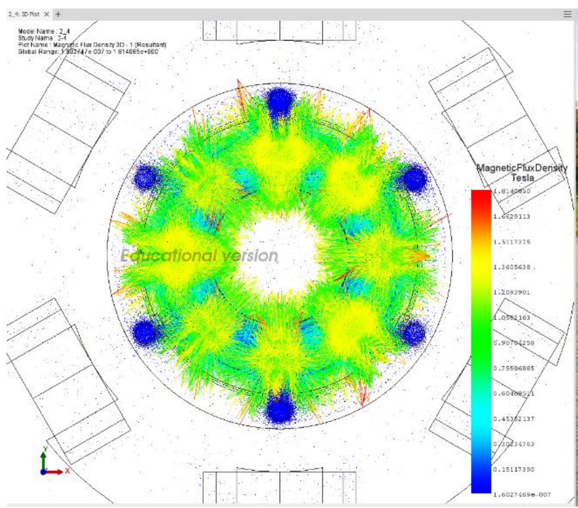

Figure 13: Experiment 2 flux density with 2:1 ratio

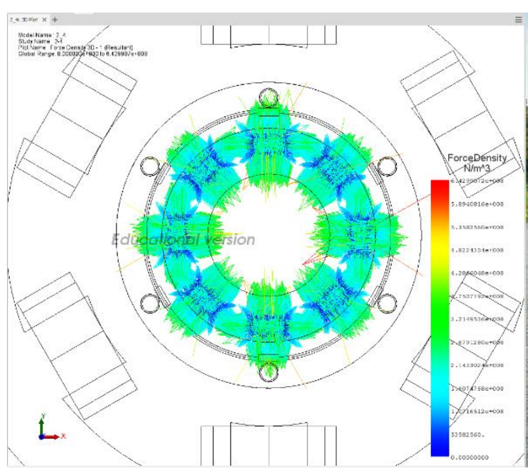

Figure 14: Experiment 2 force density with 2:1 ratio

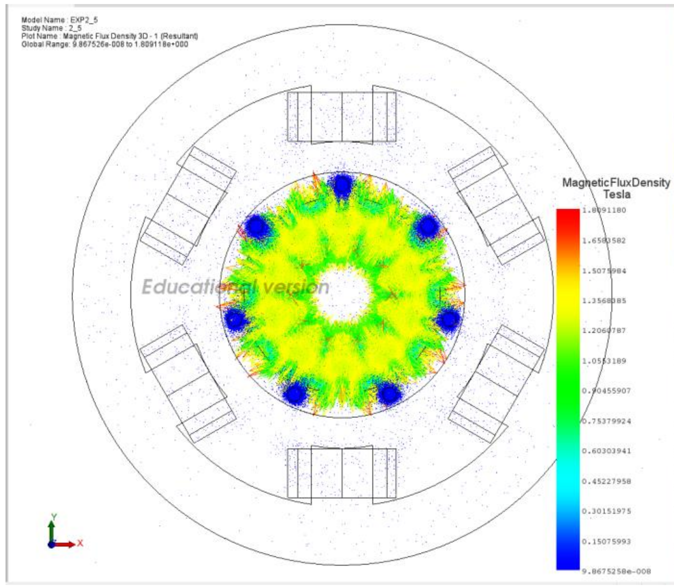

Figure 15: Experiment 2 flux density with 2.5:1 ratio

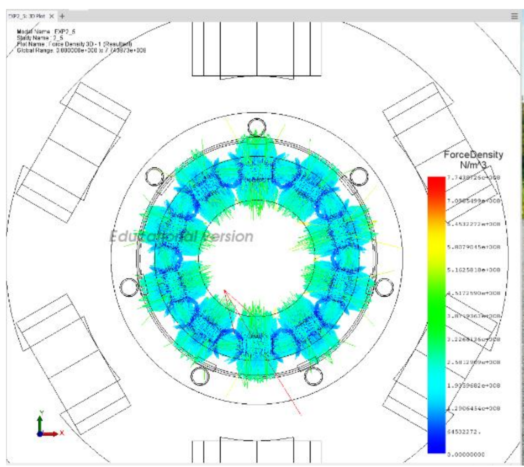

Figure 16: Experiment 2 force density with 2.5:1 ratio

Tables A-B: Pole pair/ratio and resultant force/torque relationships

Pole pair	Pole ratio	Force in X	Force in Y	Force in Z
1	1 to 3	7.92E-03	-2.02E-01	-1.52E+00
2	1 to 1	-1.02E-02	-1.12E-01	-6.94E+00
4	2 to 1	8.50E-02	-1.47E-01	-1.38E+01
5	3 to 2	2.50E-01	2.33E-01	-8.71E+00
Control	1 to 1	-1.12E-01	-4.14E-02	-6.41E+00

Pole pair	Pole ratio	Torque in X	Torque in Y	Torque in Z
1	1 to 3	4.60E-01	9.44E-02	-1.52E+00
2	1 to 1	-6.72E+00	-4.89E+00	2.67E-01
4	2 to 1	5.17E-01	-8.32E+00	4.11E-01
5	3 to 2	-2.28E+00	-3.28E+00	7.73E-01
Control	1 to 1	-4.54E-01	-7.77E-01	5.22E-01

In the end looking at the data, helped build the groundwork for this project, by showing how magnetic flux and torque on the inner rotor is affected by the change in frequency and pole pairs. We are in the hopes that another student team will use the data collected from this project to refine and complete the electromagnetic continuously variable transmission.

Thank you from,

Kesly Lubin, Noah Durso and Chris Mohr of Pioneer Racing Club