Spring 5-23-2018

Three Speed 3D Printed Magnetic Gear

Robert J. Rutherford
Portland State University

3D Printed Magnetic Gear

Maseeh College of Engineering and Computer Science
PORTLAND STATE UNIVERSITY

Robert J. Rutherford, Jonathan Z. Bird

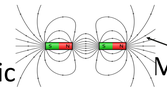
"The authors acknowledge the support of the Semiconductor Research Corporation (SRC) Education Alliance (award # 2009-UR-2032G) and of the Maseeh College of Engineering and Computer Science (MCECS) through the Undergraduate Research and Mentoring Program (URMP)"

Introduction

Gear reduction and power transmission is typically achieved through mechanical gears. These gears require maintenance, cause vibration, and have no overload protection. Magnetic gears (MGs) are innovative solution to these drawbacks. The 3D printed three speed axial magnetic gear prototype was assembled for demonstration of theory.

Concept and Design

All permanent magnets have invisible lines of force known as magnetic flux.

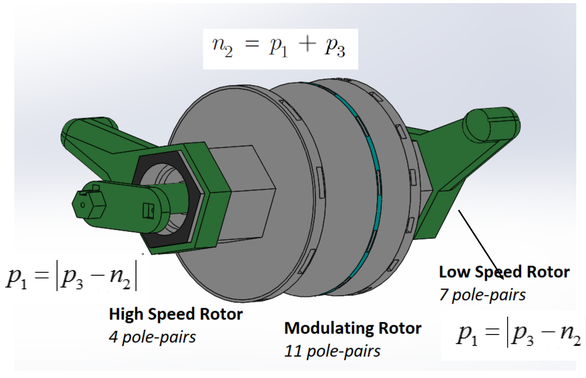


The amount of magnetic flux in a volume is know as flux density. A very powerful magnet has great flux density. This flux density is used in magnetic gears and results in a flux linkage, where the ratio of magnetic poles act like physical teeth in a traditional mechanical gear.

Gear Ratio

$$\omega_1 = \left(\frac{n_2}{n_2 - p_3}\right)\omega_2 = G\omega_2$$

Angular Velocity



Theory of the Magnetic Gear (MG)

Mechanical gears and magnetic gears can be used to transmit power, converting low speed, high torque motion into high speed, low torque motion, or vice versa, through a gear ratio. This 3d printed magnetic gear uses a ratio of magnetic poles to accomplish power transmission.

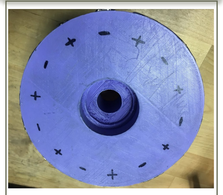
High Speed Rotor

$\mathbf{p_1}$ = 4 pole pairs

Modulating Rotor

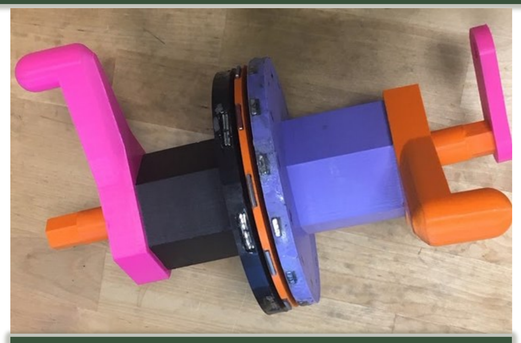
$\mathbf{n_2}$= 11 Steel Pairs

Low Speed Rotor



$\mathbf{p_3}$ = 7 pole pairs

Full 3D Printed Mechanical Assembly



Resulting Pole Ratios

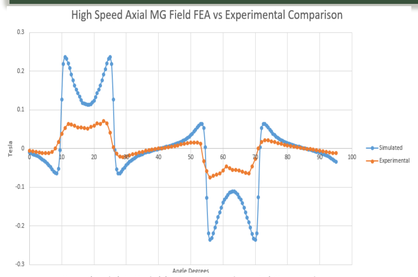
Gear Ratio 1: Stationary High Speed Rotor $\omega_0 = \left(\frac{11}{11-4}\right)\omega_1 = 1.57\omega_1$

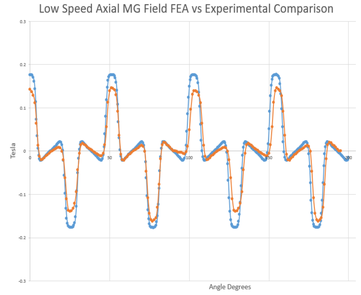
Gear Ratio 2: Stationary Modulating Rotor $\omega_0 = \left(\frac{7}{11-7}\right)\omega_2 = 1.75\omega_2$

Gear Ratio 3: Stationary Low Speed Rotor $\omega_0 = \left(\frac{11}{11-7}\right)\omega_3 = 2.75\omega_3$

Robert J. Rutherford: rjr6@pdx.edu, Jonathan Bird: bird@pdx.edu,
Adriane Burk, adriane.burk@gmail.com

Measured Data





Flux density was measured with a gauss meter as a function of degrees around the face of both the high speed and low speed rotor. This measurement was compared to the magnitude of the flux density which was simulated in the finite element analysis (FEA) software.

Conclusion

The 3D printed three speed magnetic gear was assembled successfully for demonstrational purposes. Magnetic flux density measurements were gathered and compared against simulations with results showing excellent correlation. The prototype is currently on display in the Laboratory of Electromechanical Energy Conversion in the Fourth Avenue Building Room 25.

Acknowledgements

The author of this poster would like to thank Adriane Burk, Jonathan Bird, Danielle Vournas, Mojtaba Bahrami, David Ho Yin Wong, Hossein Baninajar and PSU MCECS for all the support.