Coaxial Halbach Rotor Magnetic Gearbox

Introduction

The objective is to design, 3D print, and test an easy to assemble small scale halbach magnetic gearbox. Magnetic gearboxes offer many potential advantages over mechanical gearboxes. Magnetic gearboxes have the ability to operate at high torque densities because the losses are not a function of load. The frictionless nature of a magnetic gearbox reduces maintenance and increases life. Permanent magnetic gearboxes also have the ability to slip if overloaded therefore preventing them from failing under over torque conditions. The advantages of a magnetic gearbox would make it useful in ocean generation due to the high torque, low speed, and unpredictable nature of waves.

Electrical System Design

The project is emulating tidal power generator. This generator depends on the sea waves to generate the power. The sea waves rotate a turbine that is connected with a gearbox to increase kinetic energy. The energy is used by the generator to generate the electrical power. In this project, the motor is a dynamometer acting as sea waves. It would be controlled by DCS800 drive. The drive converts the AC to DC using full wave rectifier, and the kinetic energy that is applied to the machine would be conveyed to the DMP 132-4M DC motor. The motor is used for the project.

Mechanical Design

The objective is to design, 3D print, and test an easy to assemble small scale halbach magnetic gearbox. Magnetic gearboxes design included a unique 3D printed cage design with mating surfaces through the laminated steel cage. The advantages of a magnetic gearbox would make it useful in ocean generation due to the high torque, low speed, and unpredictable nature of waves.

Fabrication & Prototyping

The DMP 132-4M DC motor is used for the project. It would be controlled by DS800 drive. The drive converts the AC to DC using full wave rectifier, and by making square waves, it would be able to control the speed.

Generator

The Rexroth machine is used to be a generator for the project. It has 4 poles. According to Faraday law, the kinetic energy that is applied to the machine generates a magnetic field which establishes voltage and current.

Motor

The speed calculation and full wave rectifier is shown in Fig. 3. The arrangement of magnets in the gearbox which is without steel support is shown in Fig. 8. The forces of inner and outer magnets is gotten by simulating the gearbox without steel support is shown in Fig. 9. The radial force of inner and outer magnets is gotten by simulating the gearbox with steel support is shown in Fig. 10. The flux calculations and full wave recifier is shown in Fig. 4. The initial positions of magnets in the 2D model is shown in Fig. 5. The force of the magnets in the 2D model is shown in Fig. 6. The flux line in the c is shown in Fig. 7. The arrangement of magnets in the gearbox which is without steel support is shown in Fig. 11. The radial force of inner and outer magnets is gotten by simulating the gearbox with steel support is shown in Fig. 12. The group of magnets are simulated to calculate radial force in each magnet is shown in Fig. 13. The radial force indicates moving magnet with the moving magnet moves along the z-axis is shown in Fig. 14. The radial force indicates stationary magnets when the moving magnet moves along the z-axis is shown in Fig. 15. The radial force indicates moving magnet when the moving magnet moves along the y-axis is shown in Fig. 16. The radial force indicates stationary magnets when the moving magnet moves along the y-axis is shown in Fig. 17. The inner rotor R.8 using rectangular magnets is shown in Fig. 18. The inner rotor R.1 using rectangular magnets and magnetic PLA cage is shown in Fig. 19. Fig. 20. Magnetic gearbox assembly R.4 is shown in Fig. 21. Inner rotor redesign with surface R.6 is shown in Fig. 22. Cage rotor built around inner rotor R.6 is shown in Fig. 23. Magnetic gearbox assembly R.8 is shown in Fig. 24. Magnetic gearbox assembly R.8 is shown in Fig. 25. Magnetic gearbox assembly R.8 is shown in Fig. 26. R.5 of magnetic gearbox design included a unique 3D printed cage design with mating surfaces through the laminated steel cage. R.5 of magnetic gearbox design included a method for inserting magnets in the outer rotor is shown in Fig. 27. Outer rotor redesign for smaller print beds is shown in Fig. 28. R.8 of magnetic gearbox design includes grooves for all mating surfaces, a longer cage rotor input for increased surface area on high torque input shaft, and a outer rotor redesign for smaller print beds is shown in Fig. 29. Inner rotor R.6 for 60mm magnets 3D printed with mating surfaces is shown in Fig. 30. Outer rotor output housing R.6 during print is shown in Fig. 31. Inner rotors, outer rotor, cage sections, and bearings is shown in Fig. 32. Outer rotor R.8 required a redesign for fitting on certain 3D printer beds is shown in Fig. 33. Turning cage rotor rods on a Lathe in MME machine shop is shown in Fig. 34. Threading cage rotor rods using M3 die and lathe chuck is shown in Fig. 35. 3D printed outer rotor housings is shown in Fig. 36. Outer rotor housing assembled using surface mates is shown in Fig. 37.