Study on a New Type Magnetic Gear

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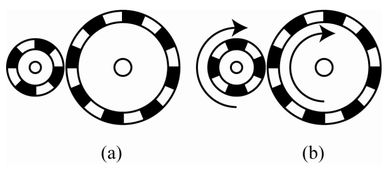
INTRODUCTION

Magnetic gears have some benefits such as low-noise, low vibration, maintenance-free as compared with mechanical gears. Some high performance magnetic gear topologies have been proposed, however, it is difficult to simplify the structure because of a number of magnets.

Magnetic gear

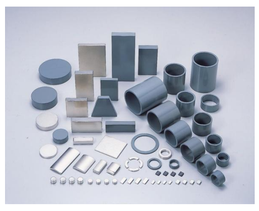


Potential advantages
- Low-noise
- Low vibration
- Maintenance-free
- Overload protection

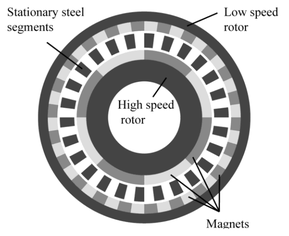
Problems
- **Poor torque density →large size**
- **A number of magnets →high-cost**

Recent technology and study

Improve torque density



Utilization of the permanent magnets



Harmonic magnetic gear

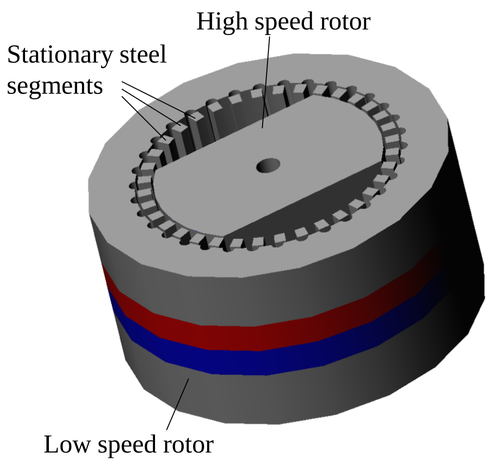
Disadvantages
- cost
- productivity
- reliability

We propose a new magnetic gear with high gear ratio which consists of only two magnets which solves costly, productive and reliable problems.

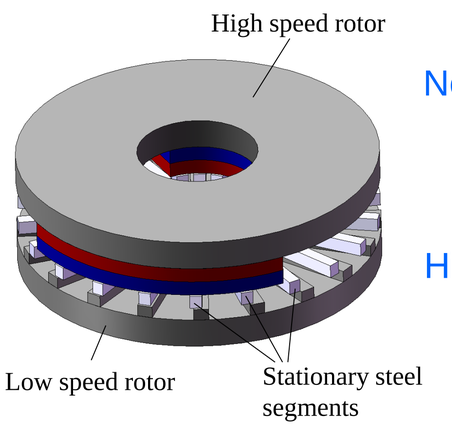
NEW TYPE MAGNETIC GEAR

Design of New Type Magnetic Gear

Radial-type magnetic gear



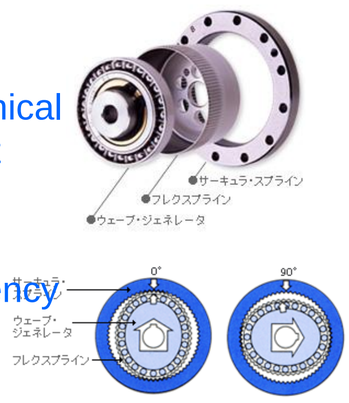
Axial-type magnetic gear



※except

No mechanical contact

High efficiency



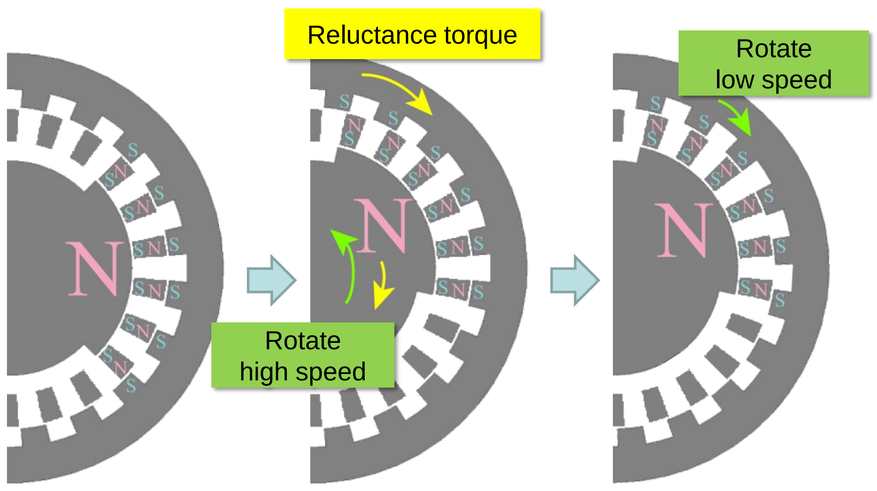
Harmonic drive gearing

Characteristic

- Needs no more two permanent magnets
  ⇒low cost
- The resulting gear ratio depends on the number of pole-pairs on high speed and low speed rotors and the number of pole pieces
  ⇒productive, high gear ratio

- High speed rotor: NdFeB permanent magnet
- Stator: Soft magnetic pole-piecies
- Air gap length: 0.5mm

Principle of Operation



※$n_1=20, n_h=2, n_s=22$

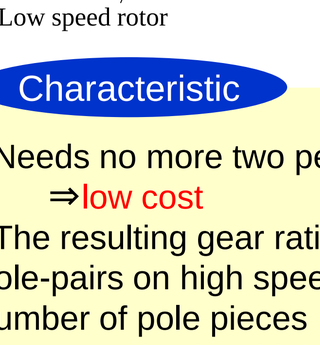
- Gear ratio $G_r = \dfrac{n_l}{n_h}$
- Number of pole-pairs $n_s = n_l \pm n_h \quad (n_s > n_h)$

3D-FEM and EXPERIMENTAL RESULT

3D-FEM Result

purpose

Require transmitted torque of the proposed gear

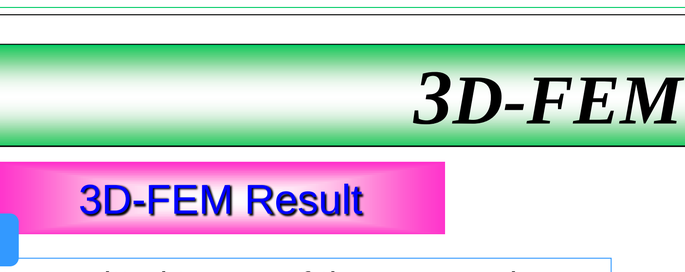


Maximum value＝Limited torque

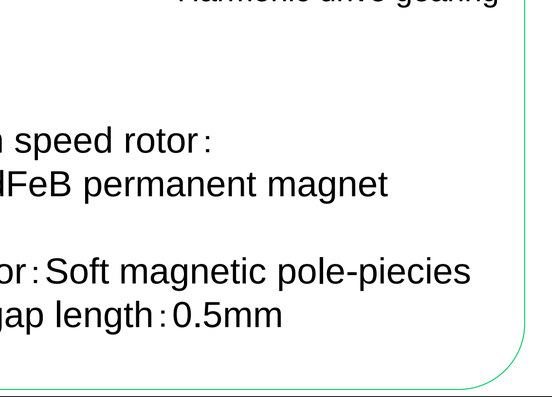
Number of element	2,171,067
Number of edges	2,564,759
Number of nodes	389,153

※3-D finite element mesh except air

Variation of flux density



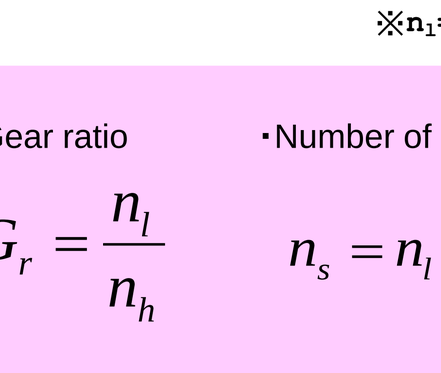
Demonstrator magnetic gear



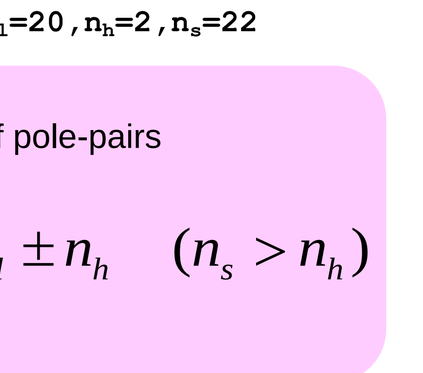
Prototype magnetic gear (radial-type)

Torque Transmission

Predicted



Measured



The predicted result agree with measured one
predicted 5.8Nm measured 5.0Nm
Torque density 10 kNm/m^3 can be achieved

Conclusions

- The new radial and axial type magnetic gear with high reduction ratio which consists of only two magnets which solves costly, productive and reliable problems has been designed.
- The 3-D finite element mesh method for magnetic gear was taken into consideration, and it was found that our model realized large transmitted torque.