

Evaluation of the effect of using magnetic gear in improving the performance of process systems based on mechanical gear

Valeh Educational And Cultural Institute
Iranian Youth Science and Technology Center (IYSTC)

Team members: Artin Radmatin_Niki Abtahi _Baran Bahman _Mohammadhossein Ezzati_Baran Derakhshandeh Daryasari _ Sarina Nosrati

Supervisor : Mohammad Arjmand

IYSTC

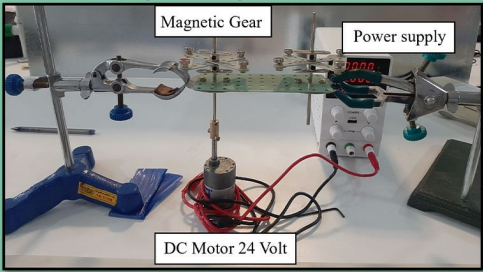


Background : Mechanical gears, foundational since antiquity, evolved through Euler and Willis' 17th–18th-century theories. Despite centuries of use, friction-induced wear, backlash, and lubrication needs limit efficiency. Magnetic gears emerged in the late 20th century but faced low torque density until rare-earth magnets (NdFeB/SmCo) and FEM simulations enabled breakthroughs: coaxial (95%+ efficiency), harmonic (precision robotics), and hybrid designs (torque-to-weight optimization). Current challenges involve accurate force modeling for industrial scalability.



Setup :

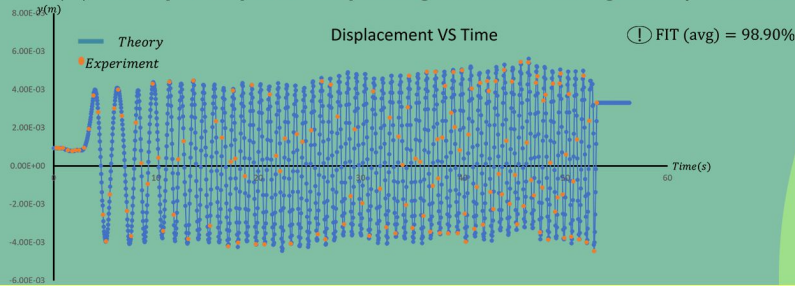
Magnetic gear setup



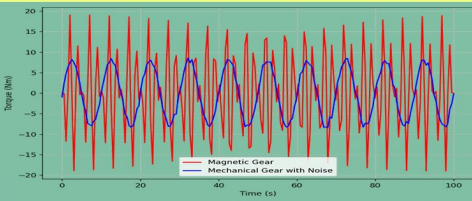
Test method : Tracker measured motion parameters, and MATLAB performed data analysis. A 24V DC motor powered the magnetic gear with NdFeB magnets for non-contact torque transfer. The system operated in a controlled environment with precise data collection and repeated trials.

Experimental verification : The system demonstrated proper functionality in terms of backlash presence, overload tolerance, heat generation, durability, angular speed, and power and work output.

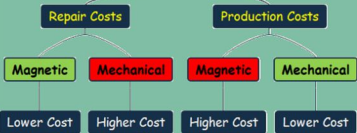
The differential equation was numerically solved using MATLAB, and the displacement as a function of time was plotted. Experimental data were subsequently fitted to the theoretical curve, the coefficient of determination (R^2) was computed, expressed as a percentage, and the mean fitting accuracy was evaluated.



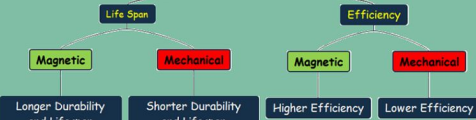
Comparison : The magnetic gear system exhibited superior performance in terms of overload capacity, heat generation, durability, angular speed, and power and work output due to reduced friction and enhanced torque transmission.



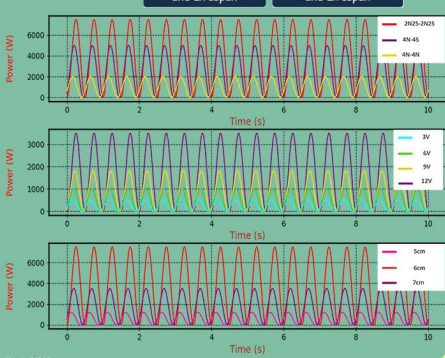
Comparison of Magnetic and Mechanical Gear



Comparison of Magnetic and Mechanical Gear



Analysis : In the analysis of the magnetic gear system, the magnet pole configuration, gear spacing, and rotational speed of the primary gear were identified as critical parameters. It was found that increasing the primary gear's speed generally increased the secondary spinner's rotation, except when phase opposition occurred. Gear spacing that was too large or too small caused system instability, indicating that an intermediate distance provides optimal stability. Experimentally, the 2N-2S magnet pole configuration on each gear produced the most effective rotational performance.



$$P = \tau \dot{\theta}$$

Conclusion : Magnetic gears advance sustainability (SDG 7, 9, 12) through non-contact efficiency, reducing wear and energy loss. Future focus of this idea will be on enhancing magnetic torque density and mitigating mechanical friction via material innovation. The magnetic gear system outperformed the mechanical gear in stability, efficiency, and torque transfer under constant conditions.

Sustainable Development Goals



12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Durable magnetic systems minimize resource depletion and industrial waste

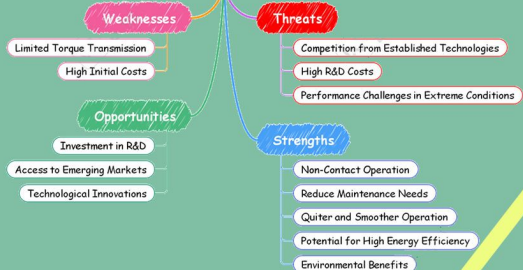
Magnetic gears enhance energy efficiency via wear-free, low-loss power transmission

7 AFFORDABLE AND CLEAN ENERGY

Advanced material innovation reduces friction, enabling sustainable industrial infrastructure

9 INDUSTRY INNOVATION AND INFRASTRUCTURE

SWOT For Magnetic Gear



Acknowledgment :

- 1-Thanks from Ali Valeh, Head of Valeh Educational and Cultural Institute.
- 2-Thanks from Mohammad Arjmand, Head of the Research Department of Valeh Educational and Cultural Institute.
- 3-Thanks from Mehdi Rashidi Jahan, Head of Iranian Young Science and Technology Center (IYSTC).
- 4-Thanks from YISF Event organizing committee.

REFERENCES



Patent rights for developed technologies belong to the Valeh Educational & Cultural Institute, positioning it as a pioneer in eco-industrial power transmission solutions.