Magnetic Transmission Vehicle (CPTDS)

Mr. Mahesh A. Navale[1], Mr. Karan R. Ranmode[2], Mr. Ajit M. Shete[3], Prof. Ravi N Deshmukh[4]
[1,2,3]*B-Tech Students, Mechanical Engineering, SMSMPITR AKLUJ (MS)*
[4]*Assistant Professor, Mechanical Engineering, SMSMPITR AKLUJ (MS)*

***Abstract*—The Magnetic Transmission Vehicle is a prototype designed to demonstrate contactless power transmission using neodymium magnets. The system is powered by a 12V DC motor (30 RPM) and transmits torque through magnetic coupling between two flanges without direct mechanical contact. The setup includes a 12 mm shaft, bevel gears, pedestal bearings, and 5-inch wheels mounted on a steel frame.**

The main objective of the project is to reduce noise, vibration, wear, and maintenance compared to conventional transmission systems. The magnetic transmission mechanism provides smooth operation across a small air gap while maintaining effective torque transfer.

Design calculations for torque, magnetic force, gear ratio, and vehicle speed were performed and verified successfully. The project demonstrates the potential use of magnetic transmission systems in applications such as medical devices, food-processing equipment, underwater systems, and precision machinery, where clean and low-maintenance operation is important.

***Index Terms*—Bevel Gear, Contactless Transmission, Magnetic Coupling, Neodymium Magnets, Pedestal Bearing, Torque Transmission, 12V DC Motor.**

I. INTRODUCTION

Power transmission is an important part of mechanical systems. Conventional systems such as gear, belt, and chain drives involve physical contact, which causes friction, wear, noise, and maintenance. Magnetic transmission provides a contactless method of power transfer using magnetic forces between permanent magnets.

The Magnetic Transmission Vehicle is a prototype that demonstrates this concept using a 12V DC motor (30 RPM) and neodymium magnets mounted on opposing flanges. Torque is transferred magnetically across a small air gap and transmitted to the 5-inch wheels through a bevel gear arrangement. The system is supported by pedestal bearings and a steel frame powered by a 12V battery.

This project demonstrates smooth, low-noise, and low-maintenance power transmission suitable for precision and contamination-free applications

II. WORKING PRINCIPLE

When the 12V battery is switched ON, the 30 RPM DC motor rotates the driving flange fitted with neodymium magnets. The rotating magnetic field produced by these magnets creates magnetic attraction and repulsion across a small air gap, causing the driven flange to rotate without direct mechanical contact.

The driven flange is connected to a 12 mm shaft, which transmits power to a bevel gear arrangement. The bevel gears change the direction of motion by 90° and transfer power to the wheel axle. As a result, the 5-inch wheels rotate and move the vehicle forward smoothly.

If the load exceeds the magnetic coupling capacity, slipping occurs between the flanges, protecting the motor and transmission system from overload and reducing mechanical damage.

III. LITERATURE REVIEW

3.1. Review of Magnetic Coupling Technology

Yonnet (1981): Developed analytical models for permanent magnet couplings and explained the relation between torque and air gap distance.

Furlani (1993): Proposed a 3D analytical model showing that alternating pole magnet arrangements improve torque transmission.

Dolisy, Davat & Rezzoug (1995): Developed a simplified model for estimating torque in permanent magnet couplings and validated the use of NdFeB magnets.

Charpentier & Lemarquand (2001): Studied optimization of magnetic couplings and found that alternating pole arrangements provide higher torque efficiency.

Faiz, Ebrahimi & Akin (2010): Demonstrated the use of magnetic drives in vehicle systems for improved reliability and reduced maintenance.

- Neodymium Magnets in Engineering Applications

Neodymium Iron Boron (NdFeB) magnets are the strongest commercially available permanent magnets. Due to their high magnetic strength and resistance to demagnetization, they are widely used in motors, generators, medical devices, and magnetic coupling systems.

- Bevel Gear Drives in Vehicle Systems

Bevel gears are used to change the direction of power transmission by 90°. In this project, bevel gears transfer motion from the transmission shaft to the wheel axle efficiently at low speed.

- Research Gap

Magnetic couplings are commonly used in industrial equipment, but their application in vehicle transmission systems is limited. This project demonstrates a low-speed magnetic transmission vehicle model for educational and experimental purposes.

IV. COMPONENTS OF MAGNETIC TRANSMISSION VEHICLE (CPTDS)

Mechanical Components

- Round Flanges
- Pedestal Bearings
- Shaft (12 mm Diameter)
- Bevel Gear Set
- Wheels (5-inch Diameter)
- Frame Structure

Electrical Components

- DC Motor (12V, 30 RPM)
- Neodymium Magnets (NdFeB)
- 12V DC Battery

V. METHODOLOGY

- Project Methodology

The project was carried out using a systematic engineering methodology for the design, fabrication, and testing of a contactless magnetic transmission vehicle.

Initially, the problem was identified and the project objectives were defined based on the need for contactless torque transmission with reduced mechanical wear and maintenance. A detailed literature survey was conducted on magnetic couplings, neodymium magnets, bevel gears, and DC motor drive systems to understand existing technologies and design methods.

Based on the study, a conceptual design of the vehicle was prepared using an axial magnetic coupling and bevel gear arrangement. Engineering calculations such as torque requirement, magnetic force estimation, gear ratio selection, shaft design, and bearing selection were performed to finalize the system dimensions and specifications.

After completion of the design stage, components including neodymium magnets, DC motor, bevel gears, shaft, bearings, wheels, and frame materials were procured. Fabrication work was then carried out, which included frame welding, flange machining, shaft preparation, and assembly of mechanical components.

The complete prototype was assembled and integrated with the electrical system. Experimental testing was conducted under no-load and loaded conditions to evaluate speed, current consumption, and torque transmission performance. The obtained experimental results were compared with theoretical calculations to analyse system performance and identify deviations.

- Design Approach

A bottom-up design approach was adopted in this work. The required wheel speed and torque were determined first, followed by the selection of motor specifications. Based on these requirements, the magnetic coupling and bevel gear system were designed.

Proper consideration was given to compactness, smooth torque transmission, and ease of fabrication. A safety factor of 1.5 was used in the design calculations to account for starting load and operating variations.

Finally, all observations, calculations, testing results, and conclusions were documented systematically for report preparation and paper publication.

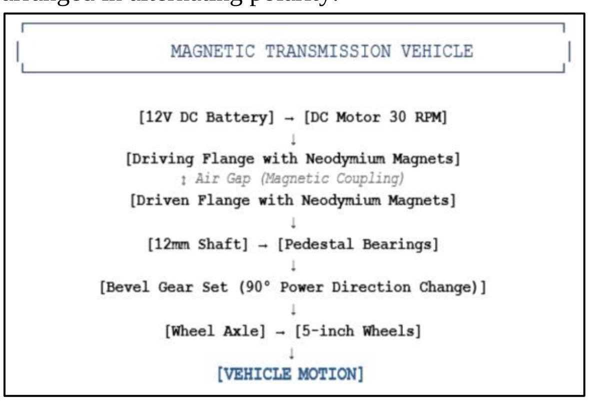
- APQP Planning

An Advanced Product Quality Planning (APQP) approach was used for systematic project execution.

APQP Stage	Purpose in Project
Planning	Define project objectives and schedule
Product Design	Design a magnetic transmission system
Process Development	Fabrication and assembly planning
Validation	Testing and performance checking
Feedback & Documentation	Result analysis and report preparation

CONSTRUCTION & WORKING

When the 12V battery is switched ON, current flows through the DC motor, causing the motor shaft to rotate at approximately 30 RPM. The motor shaft carries the driving flange with neodymium magnets arranged in alternating polarity.



As the driving flange rotates, its rotating magnetic field pattern exerts a tangential magnetic force on the opposing neodymium magnets of the driven flange on the other side of the air gap. The attractive force between opposite poles (N-S pairs across the gap) creates a torque that pulls the driven flange into synchronous rotation with the driving flange. Since both flanges rotate at the same speed under normal load conditions (below pull-out torque), the drive is synchronous.

The driven flange is coupled to the 12 mm shaft, which transmits rotation to the bevel gear (driver). The bevel gear meshes with the driven bevel gear on the transverse axle, changing the drive direction by 90° and rotating the wheel axle. The four 5-inch wheels then roll on the ground surface, propelling the vehicle forward.

If the load on the wheels exceeds the magnetic pull-out torque, the magnetic coupling slips (the driven flange falls out of synchronism with the driving flange), protecting the motor and transmission from overload—a key advantage of magnetic couplings over rigid mechanical connections.

VI. ADVANTAGES

- Contactless Transmission
- Overload Protection
- Low Maintenance
- Low Noise & Vibration
- Long Service Life
- Clean Operation
- Shock Absorption
- Simple Construction

VII. LIMITATIONS

- Lower torque capacity than gear drives.
- Slips under heavy load.
- Performance depends on the air gap between magnets.
- Neodymium magnets are costly.
- Magnets can weaken at high temperatures.
- Extra load acts on bearings due to magnetic attraction.

VIII. APPLICATIONS

Current Applications
- Industrial pumps for chemical and fluid handling
- Food and pharmaceutical machinery
- Underwater and marine equipment
- Medical devices and sterile equipment
- Precision instruments with overload protection
- Aerospace and spacecraft mechanisms

Emerging Applications
- Electric vehicle auxiliary systems

- Wind turbine and renewable energy systems
- Robotics and automated machines
- Consumer electronics and silent drive systems

IX. FUTURE SCOPE

- Improve magnetic coupling using stronger magnet arrangements for higher torque.
- Increase speed and power by using higher voltage motors.
- Add steering and remote-control operation for better vehicle control.
- Develop sealed designs for underwater or harsh-environment use.
- Apply the concept in magnetic gear systems for advanced transmission.
- Integrate sensors and IoT for real-time monitoring of speed, motor performance, and battery condition.

X. CONCLUSION

The Magnetic Transmission Vehicle was successfully designed, fabricated, and tested. The project proved that neodymium magnet coupling can transmit torque without physical contact and effectively drive the vehicle. The system showed smooth operation, low noise, and reliable performance with good agreement between theoretical and experimental results.

The magnetic coupling also provided overload protection by slipping under excessive load, preventing damage to the motor and transmission parts. This project demonstrates that magnetic transmission is a practical alternative to conventional mechanical drives for low-speed applications.

Overall, the project successfully achieved its objectives and highlights the potential of magnetic transmission technology for future use in automotive, industrial, and precision engineering applications.

REFERENCES

[1] J. P. Yonnet, "Permanent magnet bearings and couplings," *IEEE Transactions on Magnetics*, vol. 17, no. 1, pp. 1169–1173, 1981.

[2] E. P. Furlani, "A two-dimensional analysis for the coupling of magnetic gears," IEEE Transactions on Magnetics, vol. 29, no. 5, pp. 2406–2413, 1993.

[3] B. Dolisy, B. Davat, and A. Rezzoug, "A new formulation for coaxial permanent magnet couplings," IEEE Transactions on Magnetics, vol. 31, no. 6, pp. 4106–4109, 1995.

[4] J. F. Charpentier and G. Lemarquand, "Optimisation of unconventional p-q tooth ratio permanent magnet couplings," IEEE Transactions on Magnetics, vol. 37, no. 2, pp. 1006–1014, 2001.

[5] J. Faiz, B. M. Ebrahimi, and B. Akin, "Dynamic analysis of mixed eccentricity signatures at various operating points and scrutiny of related indices for induction motors," IET Electric Power Applications, vol. 4, no. 1, pp. 1–16, 2010.

[6] J. E. Shigley and C. R. Mischke, Mechanical Engineering Design, 9th ed. New York, NY, USA: McGraw-Hill, 2011.

[7] R. L. Norton, Machine Design: An Integrated Approach, 5th ed. New Jersey, NJ, USA: Pearson Education, 2014.

[8] R. S. Khurmi and J. K. Gupta, Theory of Machines, 14th ed. New Delhi, India: S. Chand & Company, 2015.

[9] V. B. Bhandari, Design of Machine Elements, 4th ed. New Delhi, India: McGraw-Hill Education India, 2014.

[10] S. M. Arnold and S. Miri, "Application of permanent magnet couplings in industrial drive systems," in Proc. ASME International Mechanical Engineering Congress, Seattle, WA, USA, 2007.

[11] Bureau of Indian Standards, IS: 2062 – Steel for General Structural Purposes. New Delhi, India: BIS.

[12] Supermagnete, "NdFeB Permanent Magnet Grades N35–N52," Technical Data Sheets, 2024.

[13] SKF Group, Bearing Selection and Application Handbook. Gothenburg, Sweden, 2024.

[14] D. C. Meeker, FEMM (Finite Element Method Magnetics) User Manual, Version 4.2. Waltham, MA, USA, 2020.

[15] Pololu Robotics, "DC Gearmotor Specifications and Selection Guide," Las Vegas, NV, USA, 2023.