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Contactless Power Transmission Using Magnetic Gears

Mr. Shubham Singh, Mr. Pratik Ghuge, Mr. Aditya Lohar, Mr. Rushikesh Khandgavare, Mr. Gunwant Shelke
JSPM's Rajarshi Shahu Collage of Engineering, Tathwade, Pune, Maharashtra

Abstract: *Neodymium magnets are powerful magnets, which are about 12 times stronger than normal magnets used in speakers. With the advent of magnetic gears, researchers have developed a new breed of permanent-magnet machines. These magnetic geared permanent-magnet machines artfully incorporate the concept of magnetic gearing into the permanent-magnet machines, leading to achieve low-speed high-torque direct-drive operation.*

Keywords: Power transmission

I. INTRODUCTION

Gears and gearboxes are extensively used for speed change and torque transmission in various industrial applications. It is well known that the mechanical gear has a high torque density, but suffers from some inherent problems such as contact friction, noise, and heat, while vibration and reliability are of great concern. In contrast, the magnetic gear (MG) offers significant advantages of reduced acoustic noise, minimum vibration, free from maintenance, improved reliability, inherent overload protection, and physical isolation between the input and output shafts. The objective of these study is to replace mechanical gears which are noisy, require frequent maintenance and lubrication, and suffer from friction losses.

II. PROBLEM STATEMENT AND OBJECTIVES

It is well known that the mechanical gear has a high torque density, but suffers from some inherent problems such as contact friction, noise, and heat, while vibration and reliability are of great concern. This decreases the efficiency of transmission system. To overcome these problems researches has developed use of permanent magnets in transmission system to avoiding mechanical contact between gears.

1. To replace mechanical gears which are noisy, require frequent maintenance and lubrication, and suffer from friction losses.
2. To achieve higher transmission efficiency.
3. To avoid friction and to reduce wear & tear.

The magnetic gear is contactless and quiet in operation, and it requires no lubrication. In addition, it slips when overloaded whereas the mechanical gear may break down when overloaded. The magnetic gear transmission is used for mechanical gear transmission with help of the magnet and electrical motor. A magnetic coupler transmits a force without any actual physical contact. Since magnetic forces attract and repel, and this force performs work, the action can be linear or rotary.

3.1 Components

1. 2 Wheels
2. Magnetic disc: Neodymium Magnets
3. Magnetic rod
4. Motor
5. Shafts: mild steel, Bearings
6. Frame as shown in image

3.2 Working

In our project motion and power transmission takes place by magnetic field generated by permanent magnets. Firstly, motor is connected to driver gear via belt drive. Permanent magnets of driver create magnetic field due to which driven gear having permanent magnets also starts rotating. So that power is transmitted from one shaft to another by magnetic gears.

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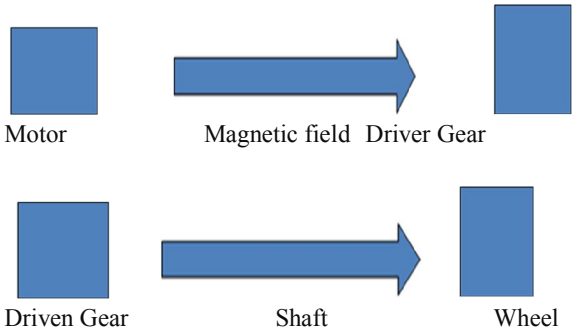


III. EXPERIMENTAL CALCULATIONS

SHAFT:

COMBINED BENDING AND TORSION:

In practice the shaft in general is subjected to combine bending as well as torsional stresses.

Shafts design Input Power by AC motor = 15 watt.

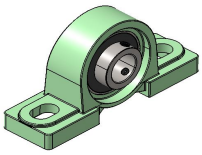
$d3 = Mt \times 16 / \pi 10\text{^}3\ \tau$

PRIME MOVER:

We have selected high speed sewing machine motor with specifications are as follows:

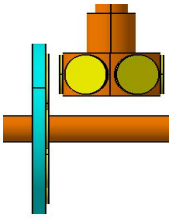
1. AMPS :0.5
2. VOLTS :220/230
3. HP :1/16
4. RPM :6500
5. WATTS :50

SHAFT & BEARINGS:



MS shaft of diameter 20mm is selected which is supporting member of driver and driven gear. The shaft diameter is 20 mm so requires bearing has to be 20 mm inside diameter. According to bearing designation, 204 will be appropriate for this assembly. As it has 20 mm inside diameter to mount the pulley shaft. Here we have two pulleys giving us two shafts which has four ends, so quantity of bearings required is 4.

MAGNETIC DISC AND MAGNETIC ROD:



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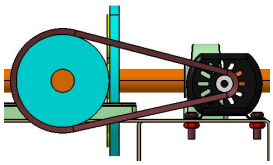
We have taken magnetic disc of 130 mm diameter of material Ms. It having 8 Neodymium magnets attached on its outer periphery. Material of magnetic rod is also Ms. It having 6 numbers of neodymium magnets attached on it. So that we can get appropriate gear ratio.

Taking allowable shear stress for shafts under small loads in coupling as
τ= 8 MPa = 8×10^6 Pa
d3 = Mt×16 /π τ 10^6
d3 = 1.47×16 /π×8×10^6
d3= 0.935 ×10^6 m
d= 0.0097 m = 9.7 mm
Considering factor of safety as 1.5, the shaft size will be
D= 1.5×d
D= 1.5×9.7
D= 13.5 mm.
So selected shaft diameter closest to D= 13.5 mm is = D=20 mm. Which is taken as 20 mm to add better safety and availability in market? So, we take diameter of second shaft will also be 20 mm.

MAGNETIC DRIVING DISC:
Force exerted by magnets in magnetic discs, Force is calculated by
F = 0.577 ×B^2 ×A×N
For Neodymium Iron Boron magnet B= 175 kJ/m3
N= Number of magnets = 10
Round magnet= π/4 D^2 = 7.06×10^-4m2
F=0.577×1752×7.06×10^-4×4
F=49.9 N
Torque transmitted: Torque exerted by this magnetic force onto disc coupling is calculated by, Torque = force× radius of disc
Disc diameter= 130 mm; R= 65 m= 0.065 m
Torque T = F×R; T= 49.9×0.065
T= 3.24 Nm.
So, the torque transmitted by the magnetic coupling is 3.24 Nm.

Power transmitted:
P= 2πNT/60 watt.
P= 2×3.142×30×3.24/60
P= 10.18 watt.
Transmission efficiency of system Transmission efficiency of mechanical contact system i.e., belt drive Transmission efficiency of the system is calculated by

BELT AND PULLEY:



Motor is connected to the driver shaft with the help of pulley and leather belt over it. Diameter of pulley is taken as 70mm.

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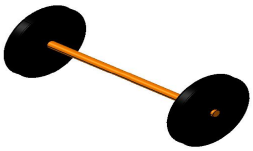
WHEELS:

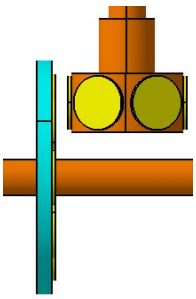


We have taken two plastic wheels of diameter 200mm as an output element to which motion is transmitted

Fabrication Process:

MS sheet of thickness 2.5mm is used for base frame. Shape of this frame is made by bending operation according to the size of the other component which has to place on this frame. Sewing machine motor is used as a prime mover which is connected to the pulley by belt drive. This pulley is used for connecting the driver shaft to the prime mover. Two pedestal bearings are used for smooth movement of driver shaft. On this driver shaft there is driver gear on which 6 neodymium magnets are attached. This arrangement is done on first half of the frame.

On the second half there is the arrangement for driven mechanism, where Driver gear is mounted on a shaft which is also placed on frame with the help of two pedestal bearings. On the driver shaft there is circular MS disc is attached which act as driven gear on which 8 numbers of permanent magnets are attached on its periphery. Axis of both driver and driven gears are perpendicular to each other. The gap between both the gears is kept as 3mm.Two plastic wheels which act as a output element are attached to the driven shaft ad the end.



ηt = power transmitted by belt drive / input power from electric AC motor

ηt = 11.13 / 15; t = 0.76 = 74.20 %

Transmission efficiency of magnetic drive system is calculated by,

ηt = power transmitted by magnetic coupling / input power from belt drive

ηt = 10.18 /11.13 =0.9604; t= 91.46 %

So, the transmission efficiency of this magnetic coupling is 91.46 % which is way better than contact mechanical coupling of joints and gears which is considered normally as 70-80 %.

IV. RESULT

The calculated numerical values during testing of the project are as follows,

1. Power transmitted by belt mechanism = 11.13 watt
2. Power transmitted by magnetic coupling = 10.18 watt
3. Torque transmitted by magnetic coupling = 3.24 Nm.
4. Transmission efficiency of mechanical contact system = 74.20 %
5. Transmission efficiency of magnetic non-contact system = 91.46 %

ADVANTAGES

- Reduced maintenance and improved reliability.
- Lubrication free.
- Higher efficiency than conventional gears.

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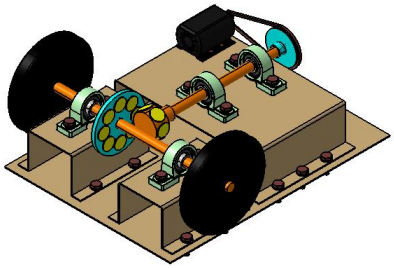
- Precise peak torque transmission and inherent overload protection.
- Physical isolation between input and output shafts.
- Inherent anti-jamming transmission
- Very low acoustic noise and vibration.

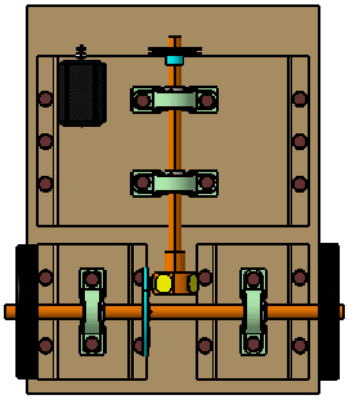
V. CONCLUSION

1. Our system successfully demonstrates the benefits of contactless power transmission like, higher transmission efficiency, reduced power loss, no friction as it is contactless and hence no wear of components and system so greater life of system.
2. They are particularly useful where it is necessary to ensure a strict, physical separation between the drive and driven side.
3. For higher power ratings a magnetic gear will be smaller, lighter and lower cost than a mechanical gear.

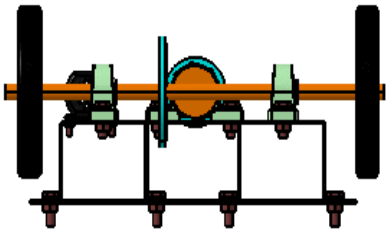
CAD MODEL:



Isometric



Top view



Front view

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