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Magnetic Gear Drive used in Gear Pump

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***Abstract*— New magnetic gears show promise as replacements for mechanical gears, not only because of high reliability and low maintenance, but also because of superior torque-to-weight ratios. A superior torque-to-weight ratio is most unexpected but is surfacing as a real possibility when the full perimeter of the gear is used to generate torque. Mechanical gears are to be distinguished in this one aspect since only two to three teeth are engaged in a single stage. For this same reason, high gear ratio magnetic gears can be constructed without the use of multiple stages. In this project work, we were planning for design and fabricate a Magnetic Gear drive which will utilize Electric energy as input source and further with the help of magnetic gear drive we will be transmitting the speed variation at output shaft. Using Magnetic Gear drive we will be able to increase or decrease the output speed at the output shaft. So by using the no of gears we will be able to transmit different gear ratios.**

***Keywords*— mechanical gear, torque-weight ratio, high gear ratio, fabricate a Magnetic Gear drive.**

I. Introduction

What is a Magnet?

• Any material that attracts iron or steel
• Can be permanent or temporary

Magnetism Basics

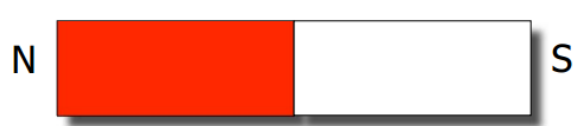

Figure 1: Polar Magnet

This shows the magnetic fields of a bar magnet – it's 3-dimensional around the magnet.

• Like poles repel (notes: demonstrate to the students attract and repel using 2 magnets)
• Man-made materials from:
o Ceramic
o Alnico (aluminum, nickel, & cobalt)
o Flexible rubber-like material
• Created using current (electricity)

Magnetization of the test piece can be accomplished using a variety of direct and indirect methods tailored to specific component geometry and required magnetization direction. The relevant Australian Standard categories these methods as follows:

1. Current flow methods: A large applied current is passed through the test piece to produce the magnetic field. Electrical contact is provided using either contact heads or current prods. The test piece is part of the electrical circuit.

2. Magnetic flow methods: Permanent magnets or AC/DC electromagnetic yokes (such as a Parker Contour probe) are used and the component is part of the magnetic circuit.

3. Coil methods: The applied magnetic field is provided directly by an insulated coil carrying a current. The test piece is either held in the vicinity of the coil or located inside the coil.

4. Induced current methods: In this case, current is generated in the test piece by electromagnetic induction. The test piece acts in effect as the secondary winding of a transformer. The magnetic fields or currents in these cases can be DC, AC, rectified AC, or pulsed, depending on the requirement.

To be detected, the discontinuity must also be favorably oriented to the direction of the magnetization. For optimum detestability, the direction of magnetization should be 90° to the line of the defect. However, it is possible to detect discontinuities which are up to ±45° to the direction of the magnetic field. If the orientation of expected discontinuities is not known then a part is normally tested at least twice by magnetizing in at least two directions which are perpendicular to each other.

II. Literature Review

1) Kais Atallah et al. He states that A magnetic gear uses permanent magnets to transmit torque between an input and output shaft without mechanical contact. Torque densities comparable with mechanical gears can be achieved with an efficiency >99% at full load and with much higher part load efficiencies than a mechanical gear.

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For higher power ratings a magnetic gear will be smaller, lighter and lower cost than a mechanical gear. Since there is no mechanical contact between the moving parts there is no wear and lubrication is not required. Magnetic gears inherently protect against overloads by harmlessly slipping if an overload torque is applied, and automatically and safely reengaging when the fault torque is removed.

2) M. Cheng1, and W. Hua et al. he states that With the advent of magnetic gears, researchers have 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. Initially, the development of the magnetic gears, including the converted topologies and field-modulated topologies, is reviewed.

3) A. Matthee, S. Gerber et al. he states that Magnetic gears are receiving more attention in recent years. Among different types of magnetic gears, the concentric magnetic gear (MG) has been the focus of research and development. With a torque density comparable to mechanical gears, concentric MGs also demonstrate other distinct benefits such as high efficiency, low noise, and low maintenance and overload protection. The potential applications for this novel gear technology include industrial drives, material handling, electric vehicles and wind turbine applications. This paper reports the design improvements of a previously designed concentric MG, which shows inferior torque and efficiency performance when compared with the design values. Design recommendations mentioned in as well as other possible solutions will be investigated.

4) Yiduan Chen et al. he state that hybrid-flux magnetic gear, which integrates a transverse-flux magnetic gear and an axial-flux magnetic gear into a single unit. When compared to the transverse-flux magnetic gear, this new structure employs an extra iron segment between the low-speed rotor and high-speed rotor to modulate the magnetic field and contribute to the transmission of additional torque. A three-dimensional (3-D) finite element method (FEM) is used for the analysis of the magnetic field.

5) Vishnu M Nair et al. he states that 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. 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, heat, vibration and reliability are of great concern.

In order to avoid these types of problems we are using magnetic meshing gears. That is the gears are meshed together with the help of magnetic force of attraction without making into contact. By using such kind of gearing systems we can reduce the wear and tear that are commonly seen in mechanical spur gear systems and the magnetic gears works smoothly without any sound and the main advantage of magnetic gearing is it will not get heated as long as it works.

III. Experimental Setup

Magnetic Gear drive circuit diagram:

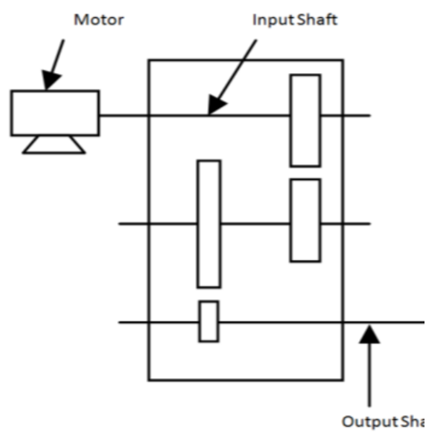

Figure 2: Magnetic Gear Drive Circuit Diagram

The electric motor are connected to input shaft of the gear box. On which input gear is mounted by using the hub. In our model input and output shaft with intermediate shaft, two intermediate gear and one is output gear all the gears are mounted on the shaft with helping hub. Before that we mount the permanent magnet in the gear and this gears and shaft assembly are fired with frame by using the bearing total 6 bearing are used. The input shaft are connected to motor shaft by using the coupling. And power is given by the battery of the 12V.

IV. Working

Basic principle of the magnetic gear drive is based on the magnetic effect. In this proceed we are used permanent magnet for producing the magnetic field. The aim is to transmit the speed and torque from input shaft to output shaft rim changing. The speed and gear ratio for this purpose repulsive force are used. Magnet have a two pole N and S.

The attractive force are between two different pole and repulsive force between the same poles. The repulsive force between two some pole are used transmitting the speed and torque.

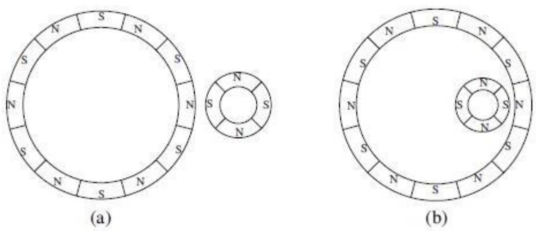

Figure 3 External & Internal Meshing of gears

First of all we use the 12V battery for power supply to the motor. The motor produce the speed of 45 rpm. And it is connected to the input shaft of the gear box. By using coupling the 1st shaft rotate with 45 rpm with gear and the magnet mounted on the gear. Which is used to produce repulsive force and this force are used to rotate the intermediate gear. The assembly of gear are made close to each other. The distance between two gear are close enough and high magnetic power of magnet are produce large repulsive force avoid the slip, Since the intermediate gear are rotate by using repulsive force. Between the magnet of first and second gear same as that intermediate gear on the intermediate shaft are rotate the gear on output shaft same as previous operation of the repulsive force. Hence we obtain required speed and torque.

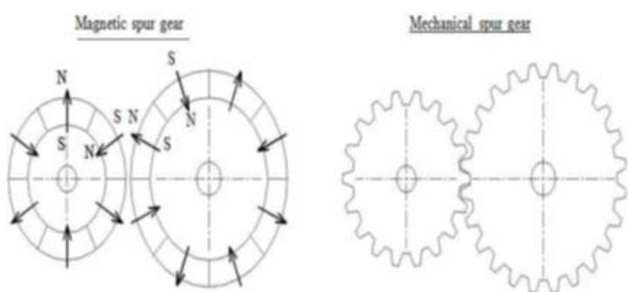

Figure 4: Magnetic spur gear with magnets and mechanical spur gea

V. EXPERIMENTAL PROCEDURE

The torque transmission capability is evaluated with another simulation that runs the inner rotor at constant speed, while gradually increasing the load on the outer rotor. When the load exceeds the torque limit of the magnetic gears, the outer rotor starts to slip.

Before this point, the outer rotor will lag the inner rotor and, in fact, the relation between torque and lag is approximately sinusoidal, with a period equal to twice the rotor magnet spacing (360/22 degrees). This graph shows that this set of gears is capable of transmitting up to 665 Nm of torque per meter of length of the gears.

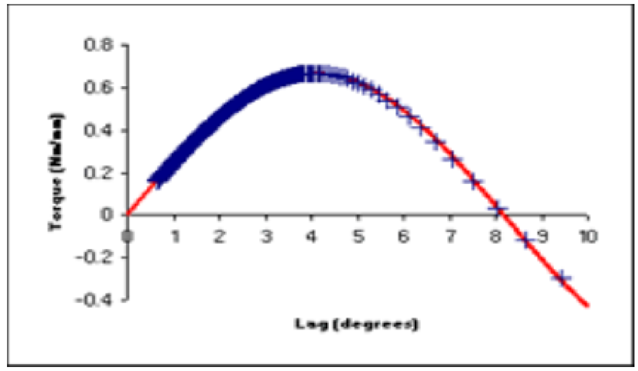

Figure 5: Graph between torque and lag

1) No-load test: This test determines the no load loss (including wind friction and core losses) in the magnetic gear. As shown in Fig. 2, the no-load loss of the previous magnetic gear is 157W at 1700 rpm while this loss reduces to only 49W at the same speed for the new gear design. This works out to be 68.7% reduction in losses at the mentioned speed. It is evident that the new magnetic gear prototype has much reduced no-load loss when compared with the previously designed one.

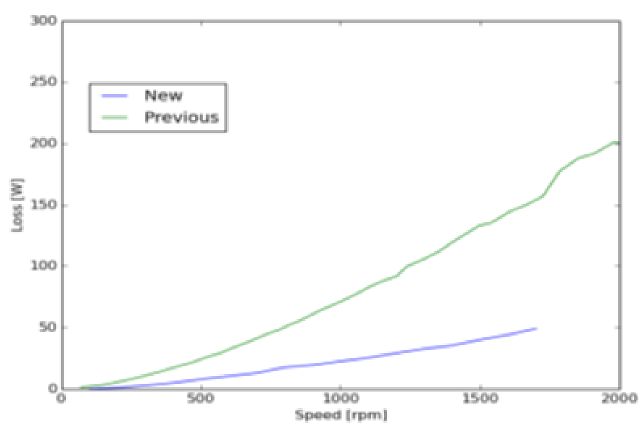

Figure6: Comparison of no-load loss between the previous and the improved magnetic gears.

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2) Load Tests: The loss in a magnetic gear is mainly affected by its operation frequency and thus its rotational speed. The load placed on the gear has little effect on the losses of the gear. The load tests are performed at different speeds ranging from 100 rpm to 1700 rpm (on high speed side). At every speed interval the load is adjusted to vary the torque on the low speed shaft at intervals of 10Nm starting at 10Nm to a maximum value of 40 Nm

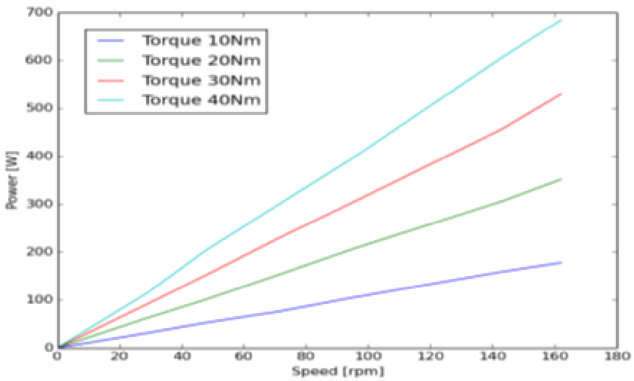

Figure 7: The output power of the magnetic gear as a function of speed for different loads (on low speed side)

VI. Applications

1. Comparison of magnetic-geared permanent- magnet machines.
2. Magnetic drive gear pump.
3. Turbine Generators.
4. Energy Storage Flywheels.
5. Gearing for Drilling Motors
6. Robotics
7. Aerospace

VII. Future Scope

- To increase the torque the magnetic are required to generate the maximum repulsive force.
- To increase the repulsive force external energizer is required.
- So we can say that to torque is directly proportional to the repulsive force generated by magnet.

VIII. Conclusion

Thus we conclude that by Using Magnetic Gear Drive we can achieve following objectives

- Increased efficiency (>99% at full load and high part load efficiency).
- High reliability.
- Low maintenance.
- No Lubrication oil Requirement

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