International Journal of Electronics, Electrical and Computational System
IJEECS
ISSN 2348-117X
Volume 6, Issue 8
August 2017

Study of Contactless Gearing System

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ABSTRACT

The aim of this paper is to study about the contactless power transmission of gears with the use of some magnetic and electromagnetic forces. A gear or more correctly a "gear wheel" is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part in order to transmit torque. Geared devices can change the speed, magnitude, and direction of a power source. A mechanical gear transfer torque and power by meshing with another toothed part or gear. But a contactless gear transfer torque without the use of frictional power of mashing. Due to rubbing of teeth of two gear wheels very high amount of noise, Vibration, Friction, heat generated removal of gear material occurs which limits the life of gears. So in this work the whole research is concerned with that how force of magnet can be utilized to transfer the torque from one gear to another gear. For this reason different construction of magnetic gears are analyzed and studied with different requirement and mechanism of contactless gearing. Permanent magnet of soft iron and electromagnets are used in different ways for analyzing that how much torque is transferring due to each construction. These types of construction will be helpful for those places where lubrication and changing of gear is difficult.

Keywords:-Permanent Magnet, ferrites , Gear, Poles, Torque

INTRODUCTION

A magnetic (contactless) 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 efficiency more than 90% at full load and with much higher part load efficiencies than a mechanical gear. 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. Here we studied a self constructed ferrite magnetic gear and force transferred by it. A magnetic gear is also a transmission device that can transform low torque and high rotational speed to a high torque low rotational speed. Magnetic gears can also achieve high efficiency, but a high torque capability can be hard to achieve unless carefully considerations are made regarding magnetic gear technology and design.

OBJECTIVE

A magnetic gear uses permanent magnets to transmit torque between an input and output shaft without mechanical contact.The concept of torque transmission using ferrite magnetic gears was patented as early as 1940 , it is only the relatively recent introduction of high energy permanent magnets (PMs) in the 1980's that has re-ignited interest in the use of magnets for gearing purposes. On the other hand, it is quite clear that high energy rare-earth permanent magnets have had a significant impact on the construction of modern motors, giving rise to permanent magnet a.c. machines (PMSMs).

MECHANISM OF CONTACTLESS GEARING SYSTEM

The whole concept of contactless gearing system revolves around magnetism and properties of magnets. Magnetism is the phenomenon by which iron attracts another iron or the property of iron to attract another iron piece is called magnetism. Magnetic moments and electric currents of elementary particles give rise to the

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property of magnetic field , which acts on another current and magnetic moments. like ferromagnetic materials are strongly attracted by magnetic fields and can be magnetized to become permanent magnets, producing magnetic fields themselves. Some of the main ferromagnetic materials are iron, cobalt and nickel.

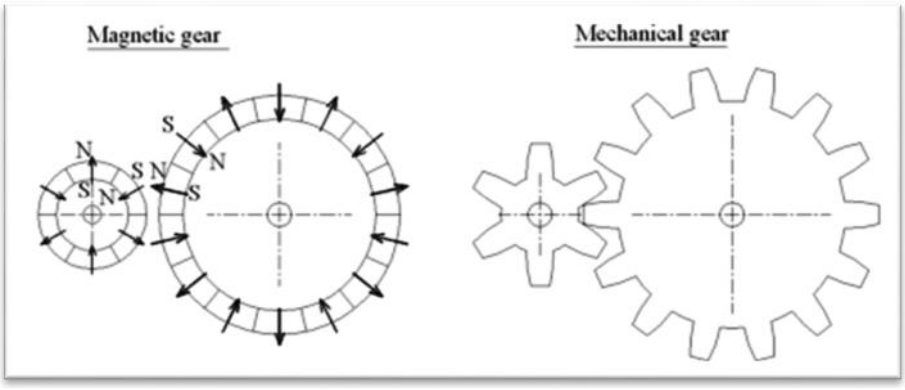

Fig 1 : Contactless gear (Magnetic Gear) and Mechanical gear [1]

BASIC PRINCIPLE

First two gear blanks are taken. Material of gear blank is plastic since it is a light weight non ferromagnetic polymer. Using an adhesive (Araldite and Bond) we are placing the magnets in alternate poles along the circumference of gear blank. One of the blank is driven by a motor which is the driving gear. Other driven gears are placed near the driven gear. Driving gears are not in contact but lie inside the magnetic field of driving gear. By this way we can transmit torque from driving gear to driven gear without any frictional loss. Gear ratio can be changed by changing the number of magnets and diameter of the gear blanks. Normally even number of magnets are fixed at the outer surface.

Earlier we have seen so many types of contact less gears but for experiment we have use a permanent magnet type gear which are transferring torque at two different gear ratios. For this materials used are:-

a) Permanent Magnet

Permanent magnet of ferrite are used for this purpose and size of these magnets is 40mm(length)x25mm(width)x10mm(thick) as shown in figure 2.These magnets are of N35 grade and are fixed at the outer surface of gear blank with proper space and in even number. Magnets are in even number for alternate poles at the periphery of the gear.

Fig 2 : Permanant Magnet

Why ferrite magnet is used in this project on the place of neodymium magnets?

Basically ferrite magnets are used in following circumstances:-

- Tight Budget
- High Temperatures (80-250 °C)
- Outside use
- Low aesthetics required

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b) Gear blank

Gear blank is used for supporting the magnet for making permanent magnet gear.For making gear blank we have tried so many things but at the end we use plastic wheels used in robotic vechicles as shown in figure 3.For making proper gear blank the outer tyre type layer of elastic component is removed and cleaned.Here we are using four gear blanks of diameters ,two of 120mm,one of 105mm and lastone of 85mm.These are made up of plastic but in place of this some other sheets can also be used but weight of the material should be less and it should be n on metallic also.

Fig 3 : Wheel For Gear Blank

c) Shaft

M.S. shaft of 6mm is used for supporting these gear as shown in figure 4.These shaft have proper key hole for the fixing og shaft with coupler and gear. Here we are using one input shaft of length 200mm and two outputr shaft of length 200mm and 100mm.

Fig. 4 Shaft

d) Bearing and coupling

Six roller bearing of no KG 6265 are used for supporting the M.S.Shaft on the wooden frame. Coupler of internal diameter 6mm are used for coupling shaft of motor and shaft of gears.roller bearing are shown by figure 3.6(a) and mild steel coupler is shown by figure 5.

Fig. 5 Bearing

e) Motor

A DC motor of 12V ,1100 RPM is used as a input motor for transferring torque to the driver gear. This motor provides input rpm for gear which is transferred to the output gear.

f) Adhesive Components

Mseal, Bond etc are used for fixing of magnets at the gear blank. These types of components are used for fixing of magnet in the outer surface of blank.

g) Wooden Base

A wooden base is used for supporting the gear assembly and motor. This wooden frame acts as a base for the whole system for making this wooden base drilled plyboard sheets are used with proper specification.

EXPERIMENTAL SETUP

Initially the gear blank outer surface is cleaned and magnets are attached at the gear blank with the help of adhesive bond and m seal. Magnets are placed alternatively with the north pole and south pole. North pole of the magnets are marked with plus sign as shown in figure 6.

Fig. 6 Designed Magnetic Gear

Secondary these magnetic gears are fixed in the shaft and then fitted in the bearing. Input and output Shaft are fixed in such a way that distance between two gears is 7mm.Now motor shaft is coupled with the input shaft with coupling and connections of motor are made.

RESULT

Standard graph For Force between Contact less Gearing

When the setup is checked with the help of software then different observations regarding ferrite contactless gears are obtained. Force of repulsion and pull between two ferrite magnets is observed to be less in comparison to neodymium magnets but they are used at very high temperature and also in cheap structures.

When the distance between the ferrite contactless gears is fixed i.e. 7mm and with proper dimension the gear is calculated with the help of K & J magnetic software and magnetic-sales design software the attraction force between two gears at one place is found to be **1.4 pound(6.2275 Newton)** and repulsion force is found to be **0.8 pound(3.558577 Newton)**.

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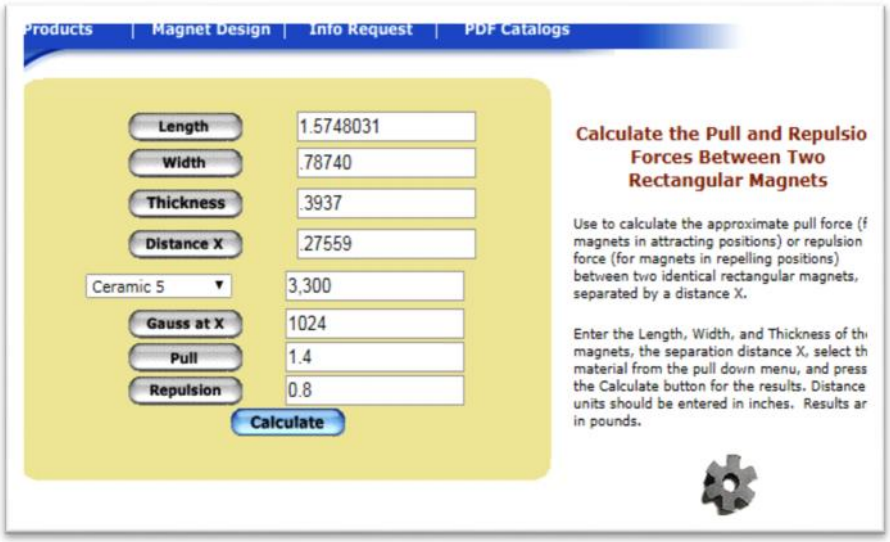

Fig. 7 Force transferred by one magnet to another magnet when distance between one gear to another is 7mm

For ferrite grade C5 contactless gears the force transferred between the gears can be changed by changing the distance between them. The two gear blanks on the same shaft should be placed minimum 50 mm to avoid magnetic interaction between the two gears.
When the magnets are observed with the software the graph showing the flux density and applied field is as under.

4.2 Gear Ratio

The prime mover motor is kept at 1100 rpm so the input shaft rotates at same speed. In order to decease and increase the output speed at our desired level we have to design the diameter and the number of magnets of meshing gears.

$$\frac{N}{N} = \frac{D}{D}$$

1st gear Analysis
Input gear Speed =1100 rpm
Diameter of first gear on input Shaft = 120 mm
Diameter of gear on output shaft = 105 mm
Now gear ratio and speed obtained on the output gear

$$\frac{N}{N} = \frac{D}{D}$$

$$\frac{1}{N} = \frac{1}{1}$$ No = 1142 rpm

So Output speed for first gear assembly = 1142 rpm

2 nd gear Analysis
Input gear Speed =1100 rpm
Diameter of Second gear on input Shaft = 120 mm
Diameter of gear on second output shaft = 85 mm
Now gear ratio and speed obtained on the output gear

$$\frac{N}{N} = \frac{D}{D}$$

$$\frac{1}{N} = \frac{8}{1}$$ No = 1411 rpm

So Output speed for second gear assembly = 1411 rpm

CONCLUSION

The above results of ferrite C5 contactless gears shows that they have approximate 8 times less force transfer than neodymium magnets but on seeing other factors related to neodymium magnets they can be used for various applications. These factors are:

- Ferrite magnets are corrosion free and can be used about 300^0C temperature in comparison to neodymium magnets which are used only at 70^0C temperature.
- Ferrite magnets are cheap and require less adhesive strength in comparison to neodymium magnets.
- These gears can be used in all condition without any generation of heat.

Overall contactless gears of ferrite can be used if cheap construction is required.

APPLICATION

- In planetary gear boxes
- In space shuttle
- In wind turbine
- In noise free systems
- Pumps and compressors
- Transmission system
- Energy Storage Flywheels
- Smart Aero Engines
- Robotics
- Reduced sizes valves

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