Simple Experimental Analysis for the Axial Force and Pull-out Torque of Disc type Permanent Magnetic Coupling

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Abstract

This paper presents the pull-out torque and axial force analysis of a disc type permanent magnetic coupling under steady state. This magnetic coupling employ rear-earth permanent magnets. The pull-out torque and axial force of magnetic calculated by changing the air-gap between two disc as a function of geometrical parameters. And its shows that if length of air-gap is increases pull-out torque and axial force is decreases. The experimental analysis results are verified by carrying out measurement on a prototype.

***Keywords**:* Pull-out torque, Disc type magnetic coupling, axial force, Analytical Model, Permanent magnets.

1. INTRODUCTION

Magnetic couplings are used to transmit torque from a primary driver to a load without any mechanical contact. As the torque could be transmitted across a separation wall, magnetic couplings are well suited for use in isolated systems. Among the advantages of this type of coupling compared to mechanical couplings is the self-protection against the overload (pull-out torque). Moreover, magnetic couplings tolerate shaft misalignment. As shown in Fig. 1, the studied axial magnetic coupling consists of two discs equipped with sector-shaped permanent magnets (rare-earth magnets) and separated by a small air-gap. The magnets are axially magnetized and are arranged to obtain alternately north and south poles. Soft-iron yokes are used to close the flux. Through magnetic interaction, the torque applied to one disc is transferred through an air-gap to the other disc.

Ordinary couplings need mechanical contact and lubrication, resulting in dust, noise, and maintenance of the systems. In order to solve these problems, magnetic couplings are of considerable interest in many industrial applications because they can transmit torque from a primary driver to a follower, without mechanical contact. In particular, as the torque could be transmitted across a separation wall, axial permanent magnetic couplings (APMCs) are well suited for isolated systems such as vacuums or high-pressure vessel. An event such as a frequently operating overload or damage in the mechanical couplings may occur, causing parts to break and scatter. In such a situation, the APMCs would not create any broken parts, and the magnetic slip offers the torque limit function via prediction of the accurate torque characteristics.

1.1 Geometry of the axial magnetic coupling

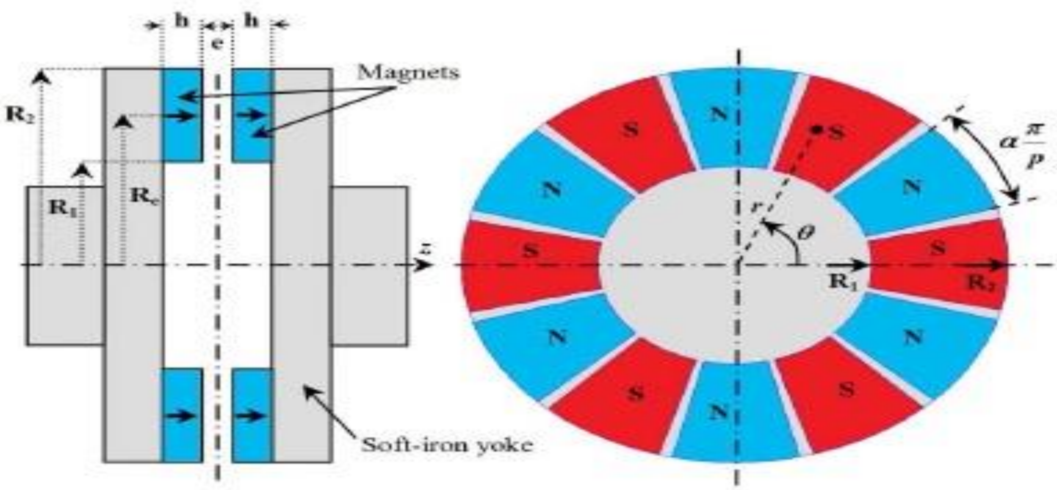


Figure. 1.1 Geometry of the studied axial magnetic coupling

This two piece rare-earth permanent magnet coupling is for contact-free torque transmission through any non-ferrous wall, with the benefit of slipping when the maximum torque is exceeded, protecting mechanical components in the drive line from damage. Magnetic couplings are of great interest in many industrial applications. They can transmit a torque from a primary driver to a follower without mechanical contact. As the torque could be transmitted across a separation wall, axial field magnetic couplings are well suited for use in isolated systems such as vacuum or high pressure vessels. Moreover, they present a maximum transmissible torque (pull-out torque) giving an intrinsic overload protection. Axial magnetic couplings consist of two opposing discs equipped with rare earth permanent magnets. The magnets are magnetized in the axial direction. They are arranged to obtain alternately north and south poles. The flux is closed by soft-iron yokes. The torque applied to one disc is transferred through an air-gap to the other disc. The angular shift between the two discs depends on the transmitted torque value. The main drawback of axial-type magnetic couplings is the significant value of the axial attractive force between the two discs. Permanent magnet couplings (SPMCs) are used to transmit torques between two rotating parts without mechanical contact. They are widely used in industrial applications e.g. ammonia pumps and centrifugal pumps for pharmaceutical and chemical industries. In particular, the coaxial type device is suitable for high torque demands. Knowledge regarding the SPMC pull-out torque is very important because this torque acts as an overload protection.

2. FABRICATION OF MAGNETIC COUPLING

2.1 How disc coupling works

Disc couplings consist of opposing discs with powerful rare earth magnets. The torque applied to one disc is transferred through an air gap to the other disc. Because of the simple flat design, you can have angular misalignment of up to 3 or a parallel misalignment of up to 6mm and still transmit nearly full rotational torque. Easily isolate drive side components from clean or contained processes. This is our simplest and most versatile coupling.

2.2 Parameters of axial magnetic coupling

Symbol	Specification	Value
R_1	Inner radius of the magnet	25 mm
R_2	Outer radius of the magnet	75 mm
R_e	Mean radius of the magnet	50 mm
ϕ	Axial angle of magnet arranged	90^0
g	Air-gap length	Variable
h	Magnet thickness	10 mm
p	Number of pole	4
B_r	Remanence of permanent magnet	12.8 T
--	Surface gauss value	4.6 kilogauss
Magnet material - Neodymium magnet (NdFeB)		

Table 1:- Parameters of axial magnetic coupling

Take iron discs of diameter 75 mm, mark angle on same disc as it divides to four angular positions i.e 90^0. The neodymium magnets of cylindrical shape fixed by (lock-tite) industrial glue. Same arrangement is done to second disc. One disc of magnetic coupling is assembled to shaft of motor and second disc of coupling is arrange on adjustable screw by bearing. Due to that changes of air-gap is possible.

3. EXPERIMENTAL SET-UP AND MEASUREMENT

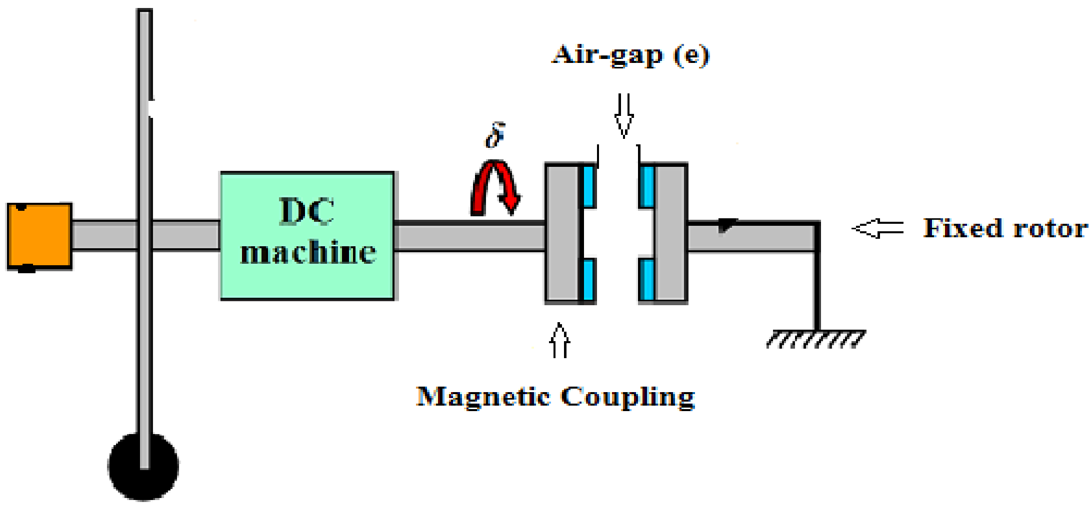


Figure. 3.1 Block diagram of experimental set-up

Experimental set-up

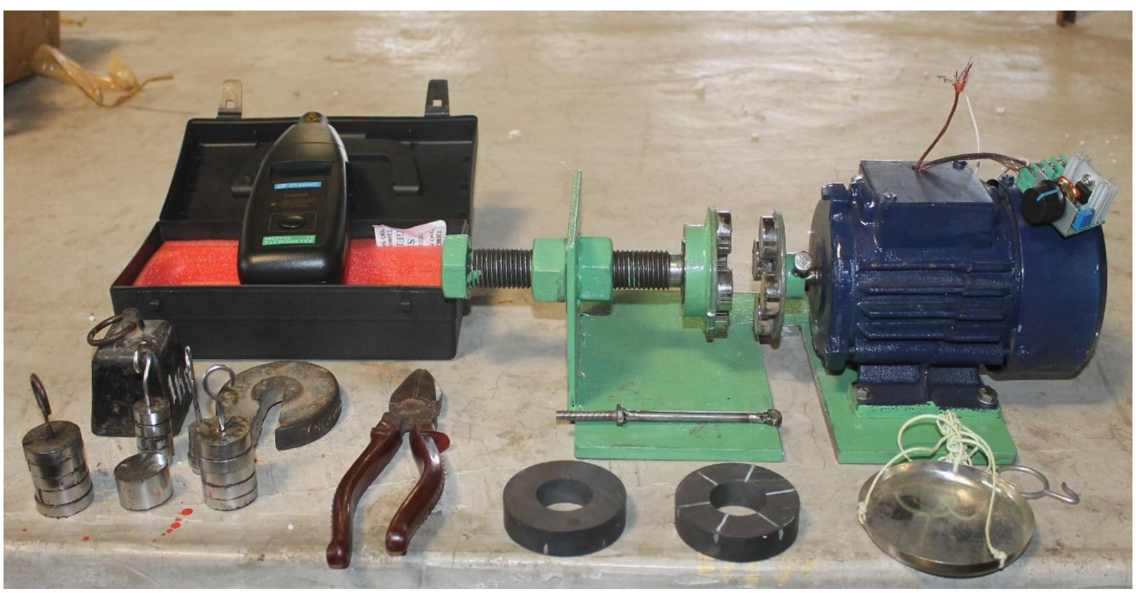


Figure. 3.2 Actual experimental set-up

Fig. 3.2 shows the axial magnetic coupling placed on the test bench. The axial coupling is inserted between fixed rotor and electrical machine. In fig. 3.2 the air-gap value is *e* = 20 mm. The air-gap length has been set by moving fixed rotor. Figs. 3.1 and 3.2 shows a photograph and a block-scheme representation of the test bench arrangement for the static torque measurement respectively. The static torque was measured thanks to weights (10g, 20g, 50g, 100g, 500g, 1kg) suspended to a rod (l = 0.137 m) locked to one rotor, the other being fixed. And following readings are taken.

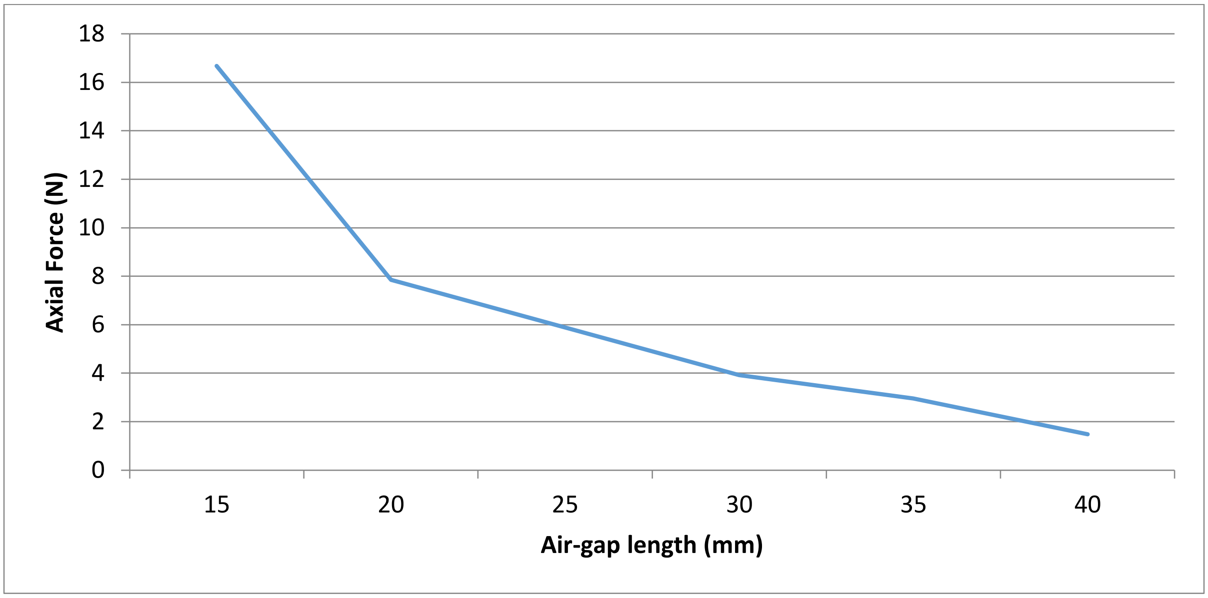
3.1 Torque calculated as the air gap of magnetic coupling is changes.

Sr. No.	Air Gap (mm)	Force applied F (N)	Distance to load applied r (m)	Torque F*r(Nm)
1	15	16.68	0.137	2.29
2	20	7.85	0.137	1.08
3	25	5.89	0.137	0.81
4	30	3.92	0.137	0.54
5	35	2.95	0.137	0.40
6	40	1.48	0.137	0.21

Table 2:- Experimental readings for torque and axial force

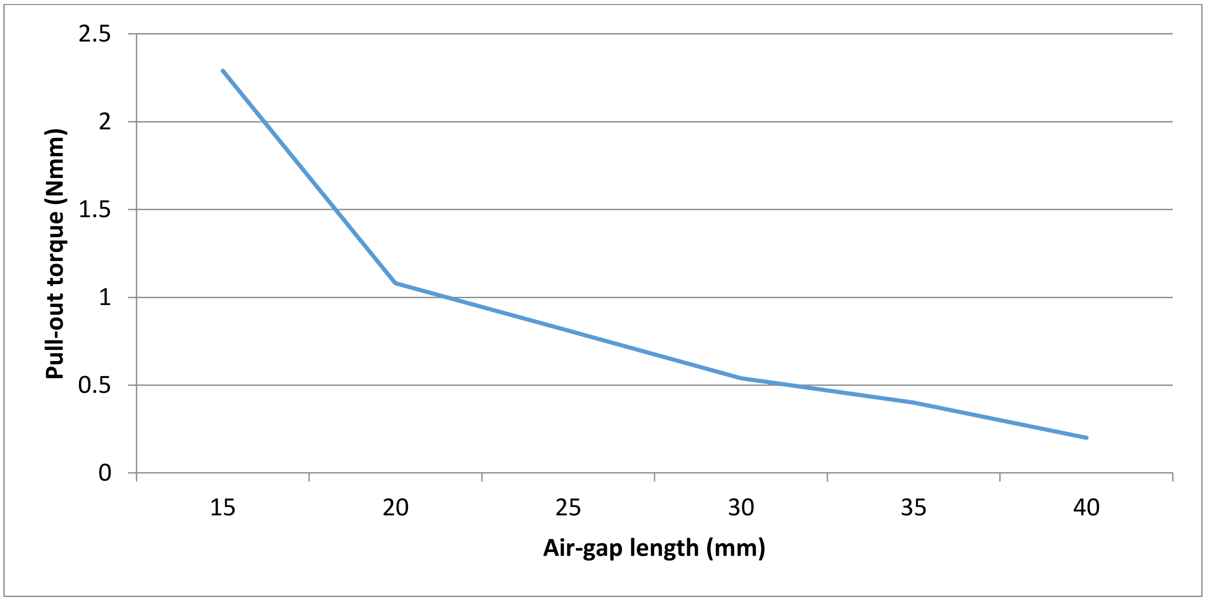
4. GRAPH

4.1 Comparison between air-gap and axial force



Graph 1 – Air-gap vs Axial force applied

4.2 Comparison between Air-gap and pull-out torque



Graph 2 – Air-gap vs Torque

5. RESULT AND DISCUSSION

From the experimental analysis it observed that there is a torque variation obtained as the changes of air-gap. As the air-gap is changed from minimum to maximum value there is a decrease in torque as well as force applied. The pull-out torque of the magnetic coupling decreases quickly as the distance between the magnets increases. The maximum torque is almost divided by two when the air-gap is increased from 2mm to 7mm. In the same way, the maximal axial force is reduced when the air-gap length increases. The optimal number of pole pairs is p = 4 if we consider an air-gap length e = 15mm. We can observe that the maximum axial force decreases when the number of pole pairs increases.Also it observed that if the magnetic poles are increased the results obtained are different.

The results and observation shows that the drive is positively maintained as any change of air gap length is changed.

6. REFERENCES

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A Brief Author Biography

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