Possible Theory for Free-Running Magnetic Motors

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1. Introduction

There have been a number of demonstrations of motors that free run consisting entirely of permanent magnets, these apparently breaking the law of Conservation of Energy (CoE). While some of those seen on YouTube are certainly fakes, others are almost certainly not. Of note is the motor demonstrated by Muammer Yildiz at both Cologne and Delft Universities which on both occasions was partially taken apart to reveal most of its inner construction. Because there is now strong evidence that such motors can break CoE attention has been paid to how these motors might work.

The author has spent many years investigating PM motors using the 2D finite element program FEMM. The most significant of these have used saturation of magnetic materials to introduce variable magnetization during the rotation in an attempt to overcome the classical force and energy reciprocity that applies to magnets moving relative to each other, and so far all such simulations have failed to indicate any breaking of CoE. More recently the simulations have been extended to include changes in the coercivity of the magnetic materials, and these do produce the wanted anomalous effects if the changes are appropriately synchronised with the magnet's relative positions. This is not surprising since changing H_C is equivalent to having a coil carrying current, and the motor is then driven by that supplied current. The challenge then is to see whether such drive can be derived, not from current through a coil, but by genuine changes in the atomic dipoles that are responsible for H_C. This paper presents a possible solution to that challenge.

2. FEMM Simulation with Changing H_C

Figure 1 shows the magnet layout used for the simulation.

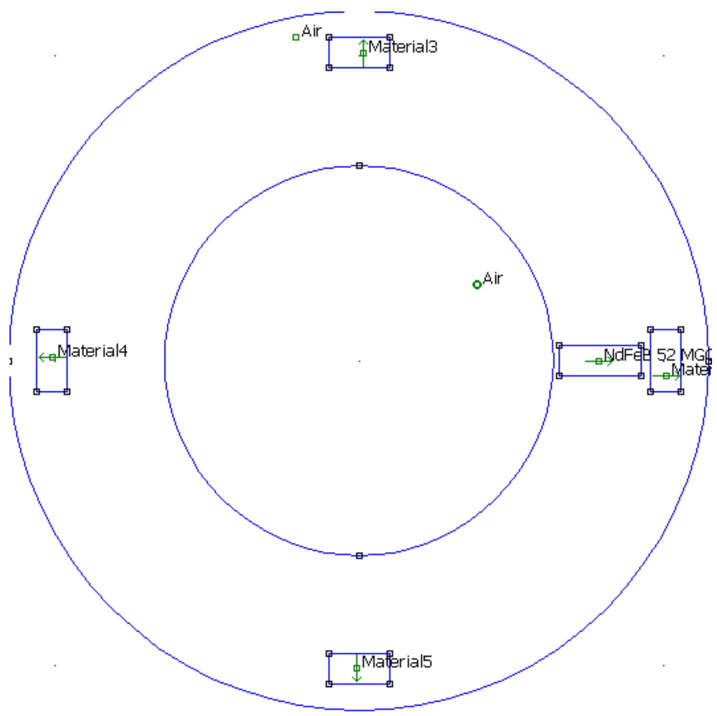

Figure 1. FEMM Layout

The stator consists of four equispaced magnets each with S pole facing inwards towards the rotor. The stator magnets are shown to be of four different materials, this is to enable each one to have its H_C varied independently. The rotor has one magnet with N pole facing outwards. By symmetry it is only necessary to perform a 90 degree movement of the rotor to see whether there is any average torque present.

Figure 2 shows the torque obtained where clearly there is asymmetry of the torque waveform yielding an average positive torque in the rotation direction (CCW in FEMM).

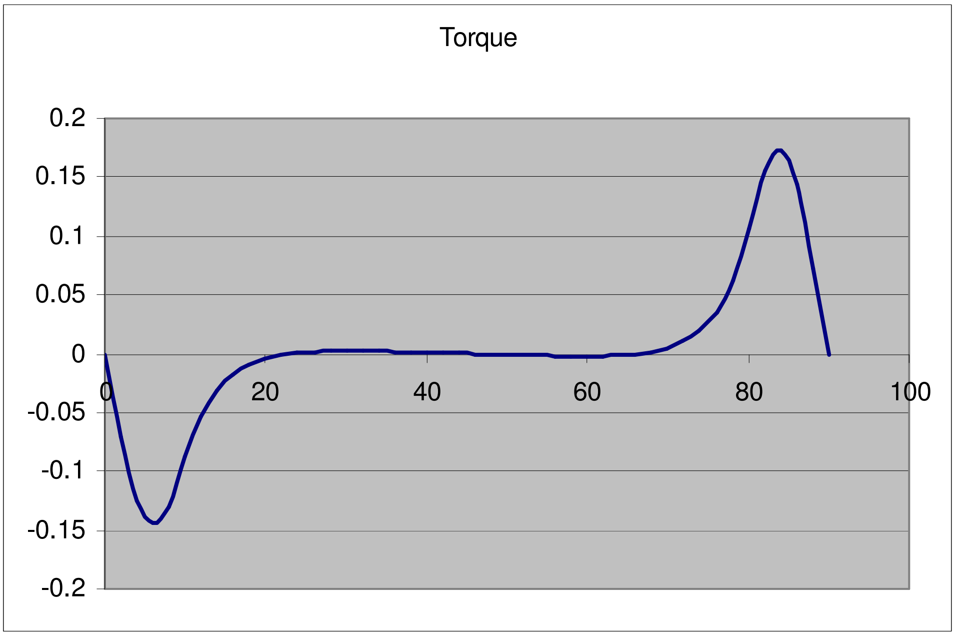

Figure 2. Torque Waveform

This desirable waveform was achieved by controlling the H_C of the stator magnets according to the component of field (within the stator magnet) coming from the nearby rotor magnet. The logic to decide this is shown in Figure 3.

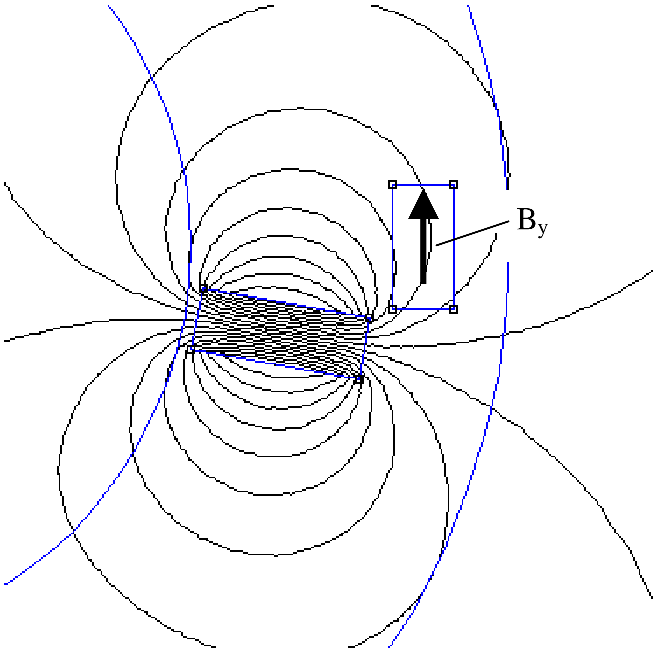

Figure 3. Rotor Magnet approaching Stator Magnet

Here it can be seen that as the rotor magnet approaches the stator magnet the field from the rotor has a significant B_y (vertical) component within the stator (in this image the field of the stator magnet is suppressed). Use was made of the FEMM facility of providing the volume integral of B_y (or B_x for the top and bottom stator magnets) so that the change in the H_C of the stator magnet could be made proportional to the average value of B_y. For the approach shown in Figure 3 H_C is proportionally increased. When the rotor magnet is receding the B_y field is reversed in direction (Figure 4), hence H_C is proportionally decreased.

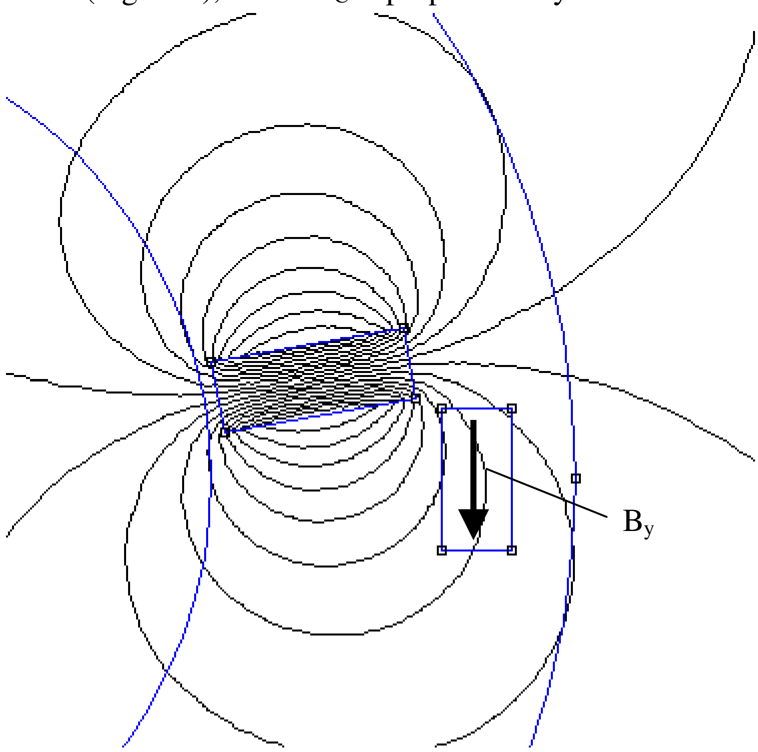

Figure 4. Rotor magnet receding

This change in H_C between approach and recede accounts for the asymmetry of the torque waveform. Each stator magnet is initially set to be of NdFeB-like characteristic having a relative μ of unity and H_C of 795774A/m, yielding a B_{sat} of 1T. The torque values in Figure 2 were obtained using the algorithm $H_C = 795774\left(1 - \frac{B_{average}}{B_{sat}}\right)$ where $B_{average}$ is the B_y (or B_x for the top and bottom magnets) value averaged over the volume of the magnet. Of course such values are arbitrary but they do indicate what changes in H_C are required for a given average torque, and that helps in the search for physical phenomena that might supply those changes.

3. Constrained Magnetostriction

One area where magnetization *can* be changed is via magneto-striction and the Villari effect. The suggestion is made here that the Villari effect (change of magnetization with applied stress) would also apply to H_C in permanent magnets. In particular that stress in an axis *at right angles* to the magnetization direction would alter H_C hence alter the magnetization. For this to work here the B_y field in Figures 3 and 4 would have to induce stress in the y direction. With NdFeB known to be magneto-strictive, that field would try to stretch the magnet in the y direction but if it were constrained by a strong housing to prevent such stretch, then internal stress would automatically occur. So here we have a known effect creating compressive stress in the y axis, and all we need now is for that stress to alter the x axis magnetization. It is certainly possible to derive a composite material that would meet that requirement, and this could be a route for producing more effective PM motors, but for now it is posited that NdFeB materials tend to exhibit such a characteristic and that explains how they work.

To follow through this idea there are some conditions that must apply to the stator magnets so that the changes in H_C can follow the polarity of the applied field.

- The magnets must have some pre-stress applied
- The magnets must have a bias field along the stress axis

Pre-stress implies that the magnets are force-fitted into a tight surround, and of course the surround must have the appropriate Young's modulus. The bias field could be supplied by additional magnets, such as those shown in Figure 5.

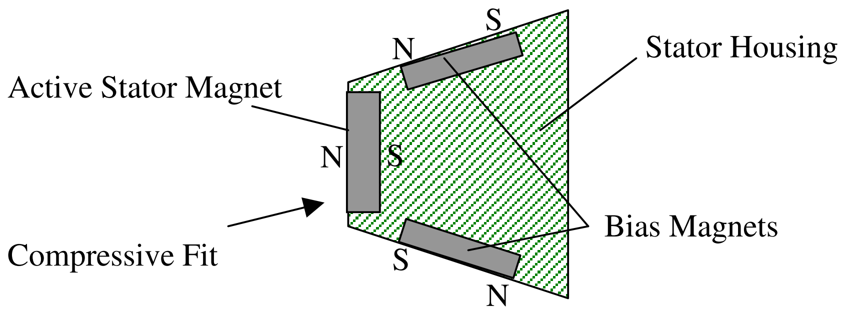

Figure 5. Stator Magnet Complex

It may be noted that the Yildiz motor has some stator assemblies that resemble this layout, see the following image of Dr. Duarte holding a segment from the motor at Delft University.

It may also be noted that the same dynamic considerations could be applied to the magnetization of the rotor magnets, which would require additional magnets within the rotor.

Examination of the Yildiz patent reveals the existence of an inner rotor so there are extra magnets there.

4. Suggested Experiments

The torque variations in this scheme are not time or speed dependent and would apply to static rotor positions. It is therefore suggested that a simple rig be manufactured suitable for testing this theory by a series of static torque measurements. If this shows signs of the expected asymmetry the same rig could be used to select magnets that exhibit maximised effects. It is also noted that there have been recent advances in magneto-strictive materials, in particular with composite materials such as short-fibre Terfenol-D within epoxy bonding. Magnets using bonded NdFeB powders also exist, so there is the possibility of combining the two techniques to manufacture Terfenol/NdFeB composites with the desired characteristics. If this transpires the rig could be used to qualify the materials.

5. Conclusion

An effect has been identified that might explain how free-running PM motors work. It uses known magneto-striction to induce and change internal stress in the stator magnets, and that in turn alters the magnetization. This dynamic pumping breaks the cyclic torque symmetry and results in an average driving torque. Such a scheme requires a complex array of stator magnets, and if also applied to the rotor a similar complex arrangement there. It is noted that the Yildiz motor has complex stator and rotor magnet patterns, so this theory may apply to that machine. It is suggested that some experiments be performed on a rig measuring static torque to see whether this asymmetry is present.