More on my PM Motor Discovery.
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1. Introduction

This is a continuation from my paper [1] on a possible explanation for why permanent magnet motors work, disclosing where the energy comes from and suggesting a means for designing such motors from first principles. Since writing that paper I have looked further at certain aspects in order to resolve doubts that this really is a breakthrough in the search for an environmentally clean source of energy.

2. Equivalent Currents

In my paper [1] I reproduced an image from Nussbaum's book [2] that shows the field from a cylindrical magnet to be identical to that from a solenoidal coil close wound onto a cylindrical surface that is the same size as the magnet, the solenoid being air cored. As that image could have been an artist's impression I wanted to convince myself that replacing a magnet with its equivalent surface current really did reproduce the magnet's field, and particularly for the case of disc magnet where the surface has little length. As the main focus was on rectangular discs (figure 1) I used the FEMM 2D finite element model to look at this problem.

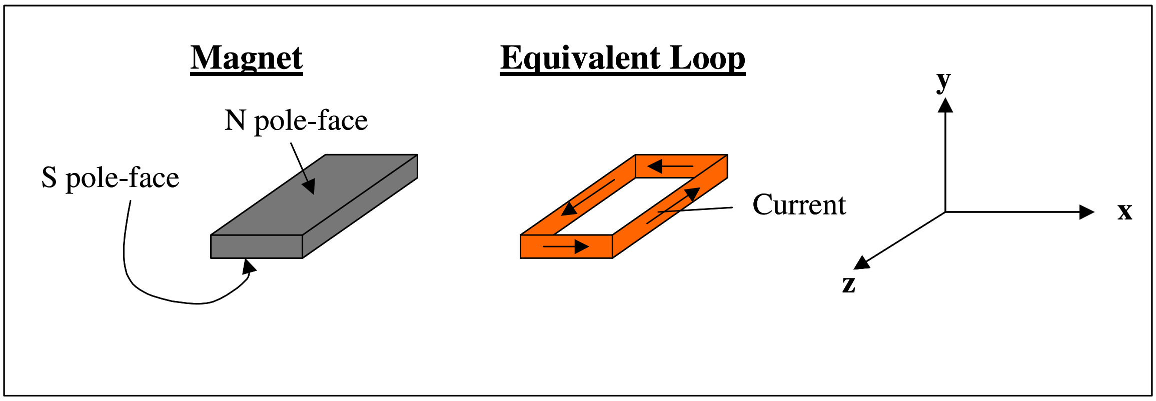

Figure 1. Permanent magnet and its equivalent current loop

FEMM models systems that are infinitely long in the **z** dimension hence on its output image of the **xy** plane the magnet appears as a single rectangle and the current sheet appears as two rectangles depicting the conductors, figure 2.

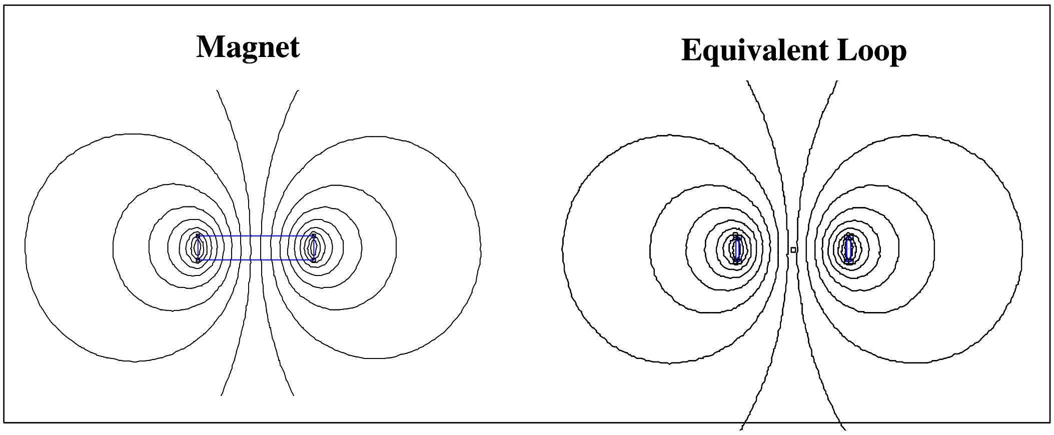

Figure 2. Field from a magnet and its equivalent current loop

It can be seen that the current loop produces an identical field to that from the magnet.

The next thing I looked at was whether the forces between magnets could be accurately determined from the forces between the equivalent currents. FEMM calculates the force on a magnet by using the Maxwell stress tensor, it creates a stress tensor mask surrounding the magnet (in the air space) and integrates around that mask, thus it is obtaining the force directly from the magnetic field. The same method can be used for obtaining the force on a current loop, and since both the magnet and its equivalent loop create the same field, it would be expected that the same results would be obtained. But FEMM also calculates the Lorentz force on a conductor, so it has two methods for determining the force on a current loop. I wanted to convince myself that force on a magnet can be accurately determined from the fictitious surface current, and FEMM gave me the opportunity to do so.

Figure 3 shows two identical magnets in repulsion, and their equivalent current loops. Also shown are the forces as determined by FEMM. As this is a finite element model where accuracy is seriously affected by the mesh size, which here was 1mm for the air space (and note the conductors are 1mm thick), the results are not expected to be identical, but they do show that the force on magnets ***can*** be determined from the forces on the fictitious surface currents.

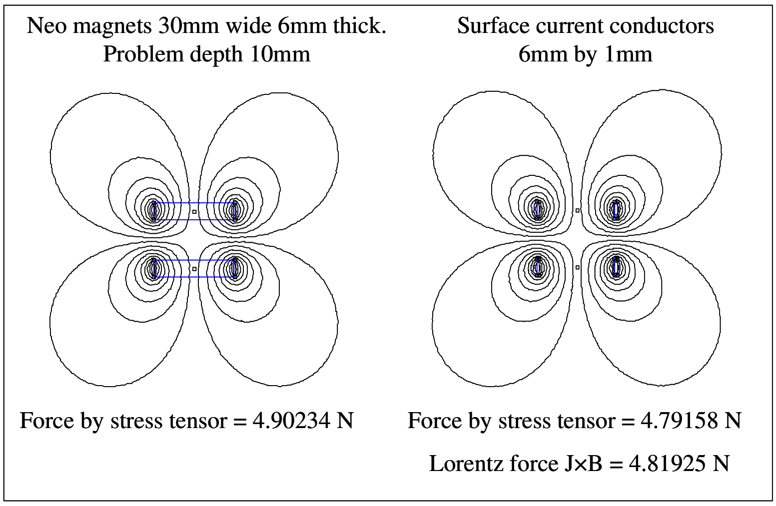

Figure 3. Magnets and loops in repulsion

I find this result quite significant, since it offers an alternative means for calculating the forces between magnets using Ampere's Law for the force between current elements. Now for completeness the following figures show magnets and loops in attraction mode and in torque mode.

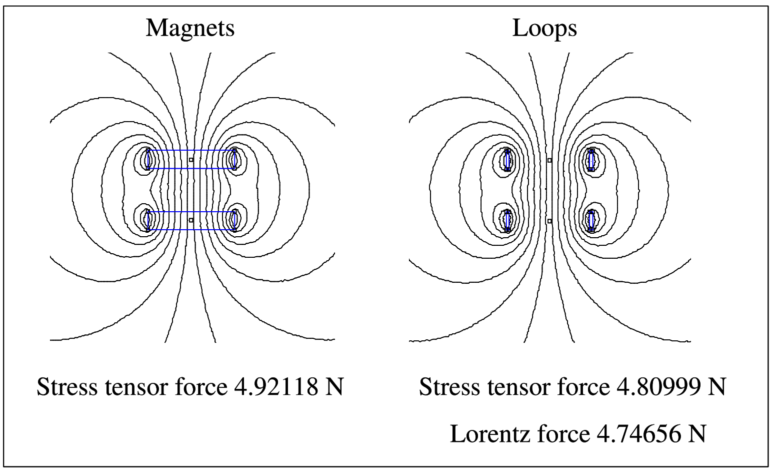

Figure 3. Magnets and loops in attraction

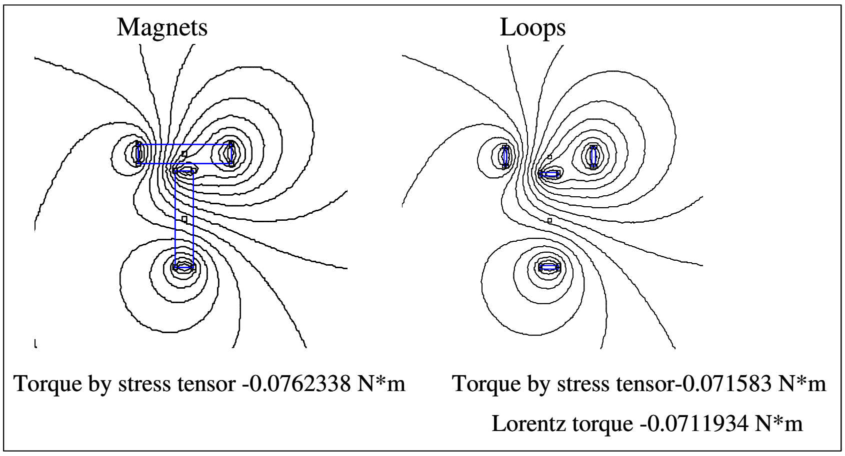

Figure 4. Magnets and loops in torque mode

Having rectangular magnets the surface currents are represented by straight conductors, and it is a simple process to calculate the force on each segment, on each edge of the rectangular magnet.

3. Correction to my previous paper

For the forces on the long edges of the rectangular rotor magnet I stated in [1] "the force there from one end stator element is exactly cancelled by the force from the other end of the stator". That is incorrect, and I have found it necessary to perform more calculations in order to show that these forces do not cancel the non-zero average torque forces over a complete cycle. This involves integrating the force along each edge for which a math expression was derived. In the past I have used Wolfram's online integrator, but for some reason their latest version doesn't work and I had to do it the hard way by summing each increment value. I am pleased that my results do still show that non-zero torque, so the conclusions in [1] are still valid.

4. Conclusions

For performance calculations permanent magnets can be replaced by loops carrying the magnet's equivalent surface currents. The magnetic fields from those loops exactly replicate the fields from the actual magnets. Forces on the loops can be calculated by Ampere's force Law between current elements, and this exactly replicates the forces on the actual magnets. This method has been shown to produce non-zero torque on a rotor magnet when averaged over a full cycle of rotation. Voltage induced into the current loop can be deduced by the $\mathbf{E} = \mathbf{v} \times \mathbf{B}$ motional induction for conductors moving through a magnetic field, and it is reasonable to assume that the mechanical power from that non-zero torque is accounted for by the product of the average induced voltage and the loop current. Since that current is a representation of all the atomic current loops within the magnet, the power thus obtained represents the power derived from those atomic currents, the electron orbits and spins responsible for the permanent magnetism.

However, as the saying goes "a swallow does not a summer make". This offering from an 86-year-old pensioner needs confirmation from others. The door is open for some younger whiz kid to produce better math models or some actual working motors before the scientific establishment is prepared to abandon some of its cherished laws.

References.

[1] Permanent Magnet Motor Discovery, Cyril Smith December 2020.

[2] Electromagnetic Theory for Engineers and Scientists by Allen Nussbaum, Prentice Hall Inc., page 291.