Another Wild Idea
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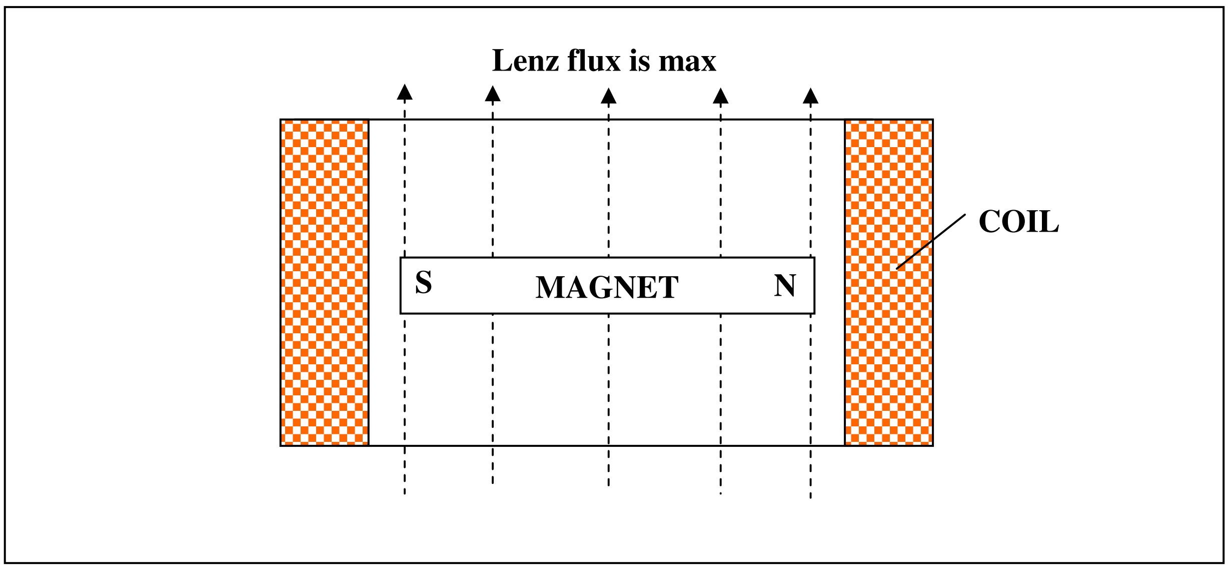
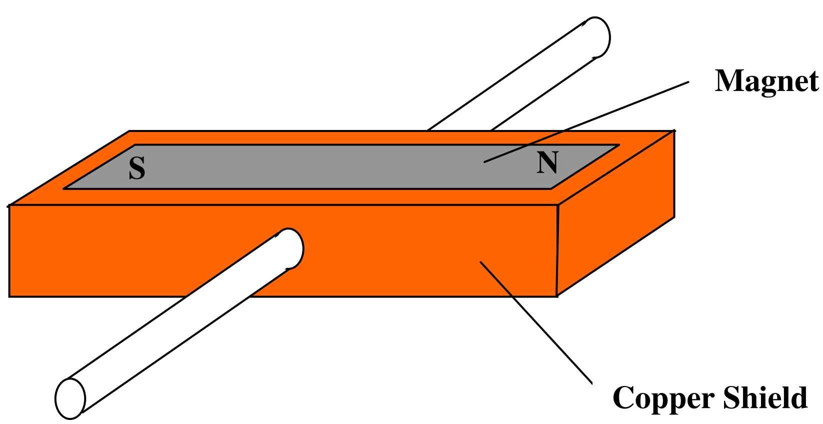
I had a mixed-up dream last night where I was using a sort of Faraday shield in an experiment involving a moving rectangular "thing" which may have been a magnet (I had yesterday been running FEMM with a rotating PM). A Faraday shield consisting of a planar grid of uniformly spaced thin parallel wires held in an insulating frame (so the wires are not connected) will shield an electric field which is parallel to the wires (hence also parallel to the plane), but will not affect a field which is parallel to the plane but at 90° to the wires. In my dream the shield worked when the "thing" was in one orientation, but not when the "thing" was in another orientation. Anywise when I woke up I tried to make sense of the dream, and this led my brain towards the following idea.

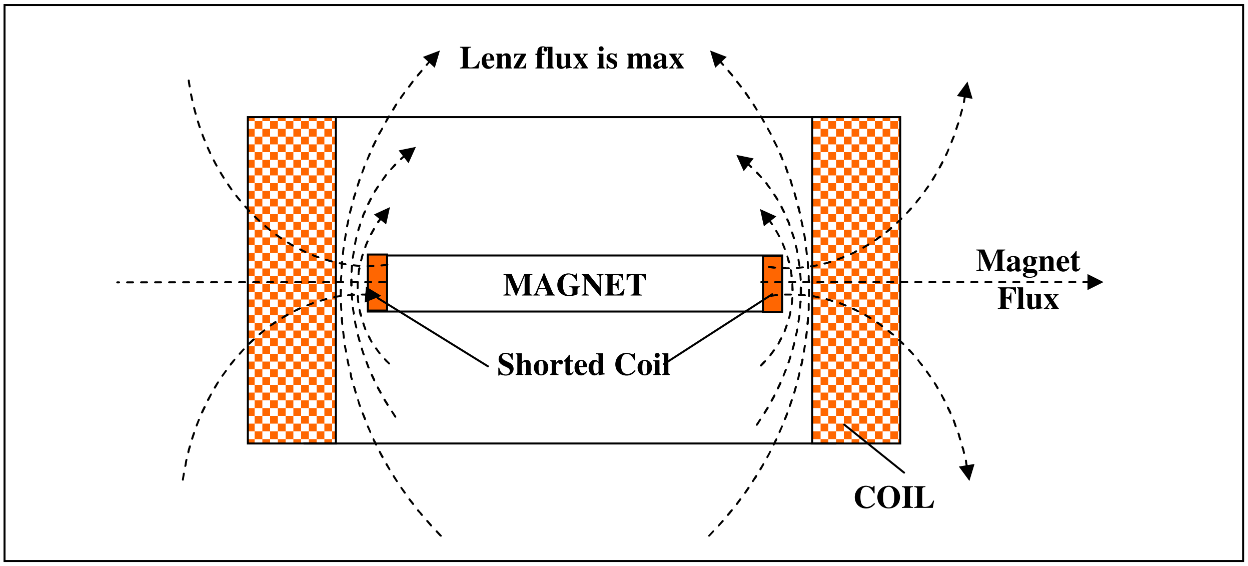
Take a generator where a PM rotates within a coil. We know that the Lenz flux occurs when the load current and load voltage is a maximum, which occurs when the driving flux has maximum rate of change. So the Lenz flux is at maximum when the magnet is across the coil.



The torque on the magnet is also at maximum in this orientation. Now imagine the magnet to be surrounded by a shorted conductor, fixed to the magnet and therefore rotating with it.



This coil bucks the Lenz flux, so if we had a super-conducting coil then the Lenz flux is all expelled and passes around the ends of the magnet. *The magnet doesn't get any drag torque*.



Let's imagine the rotor moving so fast that a practical copper coil around it excludes the Lenz Flux. The magnet flux is ever present to induce current into the coil, but the Lenz flux doesn't reach the magnet. Now OU sceptics will argue that the shorting coil carries the induced current necessary to buck the Lenz flux, and this therefore introduces torque on the shorting coil itself which will take the place of the magnet torque. But this S/C coil torque can't exactly follow the missing magnet torque. For instance, at the magnet position shown, the S/C coil torque is zero whereas the magnet torque would have been at maximum. Note the S/C coil axis is normal to the magnet axis.

Let's examine the equations for this scheme. Assume the generator is lightly loaded, there is no armature reaction phase shift, which implies $R_{LOAD} >> \omega L_{COIL}$. Take the flux in the output coil to be a sine wave of peak value Φ_{PK}. First let's take the case *without* the S/C coil around the magnet. Using the magnet position shown as the start point at t=0, we can put this flux waveform as

$$\Phi = \Phi_{PK} \sin(\omega t) \qquad (1).$$

The output voltage is

$$V = \omega N \Phi_{PK} \cos(\omega t) \qquad (2)$$

Load current is

$$I = \frac{\omega N \Phi_{PK} \cos(\omega t)}{R_{LOAD}} \qquad (3)$$

and power is

$$P_{LOAD} = \frac{\omega^2 N^2 \Phi_{PK}^{\ 2} \cos^2(\omega t)}{R_{LOAD}} \qquad (4)$$

The current I creates a Lenz flux

$$\Phi_{LENZ} = \frac{\omega L_{COIL} \Phi_{PK} \cos(\omega t)}{R_{LOAD}} \qquad (5)$$

which produces a B field

$$B_{LENZ} = \frac{\Phi_{LENZ}}{A_{COIL}} \quad (6)$$

where A_{COIL} is the coil area. The magnet of dipole moment m has an imposed torque

$$T = mB_{LENZ}\cos(\omega t) \quad (7)$$

giving a shaft power of

$$P_{SHAFT} = \omega m B_{LENZ}\cos(\omega t) \quad (8)$$

which from (5)and (6) becomes

$$P_{SHAFT} = \frac{\omega^2 m L_{COIL}\Phi_{PK}\cos^2(\omega t)}{R_{LOAD}A_{COIL}} \quad (9)$$

For (4) and (9) to be identical then

$$\Phi_{PK} = \frac{mL_{COIL}}{N^2 A_{COIL}} \quad (10)$$

which gives us a 100% efficient generator with no OU.

Now have the S/C coil in place. The magnet sees no Lenz flux, so the only torque is that on the S/C coil. If the area of this coil is A_{SHORT} then the Lenz flux through that area would be

$$\Phi_{SHORT} = B_{LENZ}A_{SHORT}\cos(\omega t) \quad (11)$$

and the current needed to buck this flux is

$$I_{SHORT} = \frac{\Phi_{SHORT}}{L_{SHORT}} \quad (12)$$

From Ampere's Law we get the torque on the S/C coil as

$$T_{SHORT} = I_{SHORT}A_{SHORT}B_{LENZ}\sin(\omega t) \quad (13)$$

Which using (5), (6) (11) and (13), then multiplying by ω to get power, gives

$$P_{SHAFT} = \frac{\omega^3 {L_{COIL}}^2 {\Phi_{PK}}^2 {A_{SHORT}}^2 \sin(\omega t)\cos(\omega t)\cos^2(\omega t)}{{A_{COIL}}^2 L_{SHORT} {R_{LOAD}}^2} \quad (14)$$

Clearly this is a different power waveform to that of the load (4). It also has a different average value of

$$P_{SHAFT} = \frac{\omega^3 {L_{COIL}}^2 {\Phi_{PK}}^2 {A_{SHORT}}^2}{8{A_{COIL}}^2 L_{SHORT} {R_{LOAD}}^2} \quad (15)$$

compared to the average of load power (4)

$$P_{LOAD} = \frac{\omega^2 N^2 {\Phi_{PK}}^2}{2R_{LOAD}} \quad (16).$$

Taking the ratio of (16) to (15) we get

$$COP = \frac{4N^2 {A_{COIL}}^2 L_{SHORT} R_{LOAD}}{\omega {L_{COIL}}^2 {A_{SHORT}}^2} \quad (17)$$

If we take Nagaoka's expression for inductance L

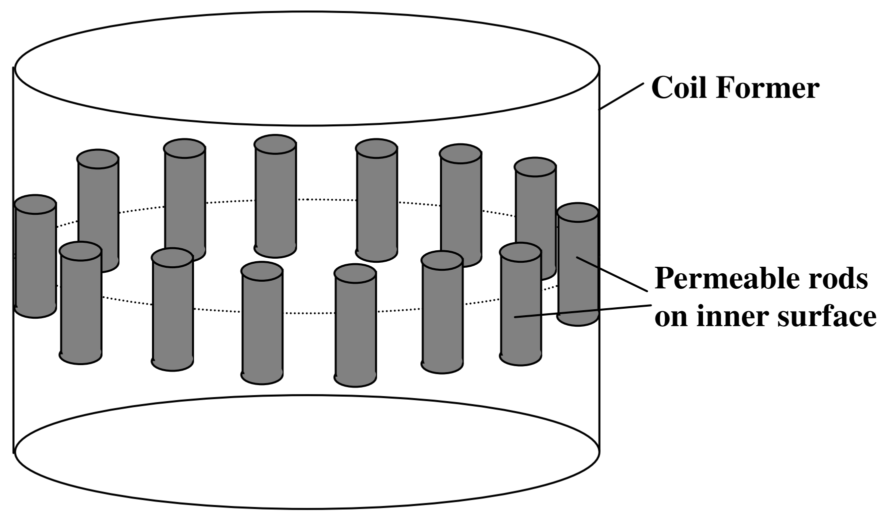
$$L = \frac{K\mu_0 N^2 A}{l} \quad (18)$$

where K is a dimensionless number between 0 and 1 determined from the length/diameter ratio, we can eliminate some L's and A's from (17) to get

$$COP = \left(\frac{4}{N^2}\right)\left(\frac{R_{LOAD}}{\omega L_{SHORT}}\right)\left(\frac{l_{COIL}}{l_{SHORT}}\right)^2\left(\frac{K_{SHORT}}{K_{COIL}}\right)^2 \tag{19}$$

where l_{COIL} is the axial length of the output coil and l_{SHORT} is the axial length of the shorted coil. Since we don't have a tiny magnet inside a large coil, l_{COIL} is of similar magnitude to l_{SHORT} and K_{COIL} is of similar magnitude to K_{SHORT}. Hence the COP is primarily determined by the ratio of R_{LOAD} to $N^2\omega L_{SHORT}$, and since $N^2 L_{SHORT}$ is almost equal to L_{COIL} this ratio becomes $R_{LOAD}/\omega L_{COIL}$. But in the opening sentence of this paragraph we assumed $R_{LOAD} >> \omega L_{COIL}$, hence the COP>>1.

It will be desirable for the Lenz flux which is diverted around the outside of the shield to remain inside the output coil (the above analysis assumes this), so the machine could benefit from the addition of permeable material to aid this. It is suggested that the output coil has a "magnetic Faraday screen" attached to its inner surface. This consists of thin rods of highly permeable material arranged parallel to the coil axis as shown.



This arrangement provides an attractive path for the Lenz flux, but does not create a magnetic "shorting" path for the magnet's flux when the magnet is lying across the coil diameter (which a solid annulus would do).

From the above analysis it appears that shielding the magnet from the Lenz flux, and hence the Lenz reaction drag torque, can be achieved without imposing another significant drag force. However to do this the S/C coil must have a long L/R time constant compared to the cycle time. Using copper for this shield, it is known that L/R scales with the mass of copper, so this principle may only apply to very large machines. For small machines the rotor must rotate at impossibly high RPM, but when room temperature superconductors become a reality this situation will change. *Alternatively it should be possible to deliberately supply the shorted coil current, i.e. to drive a shielding coil (now this can me a multiple turn coil) with the right current waveform to achieve the torque cancellation*. The shielding principle may also apply to other types of PM machine involving ferrous parts.