Considerations on the Steorn magnetic motor and the Naudin replication

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1. Introduction

Steorn have produced a novel form of magnetic motor that uses rotor magnets attracted to stator permeable material in the form of ring cores carrying toroidal windings. By energising the toroidal coil at the point of closest approach to produce within the ring core closed magnetic field lines that are at right angles to the field from the magnet, the permeability of the core as seen by the magnet is reduced, hence the magnetic attraction is also reduced. The net result is a positive drive torque. Using crossed magnetic fields is not new, there are many examples of flux gates that use the same principle. If a permeable core is driven towards saturation along one axis, the saturation will appear in the crossed axis thus reducing the permeability there. This works both ways, so any magnetic energy transfer taking place in one axis will have an effect on the other. Both Steorn and Naudin (who has replicated the effect) seem unaware of this and have been misled into thinking that the unusual properties of their motors indicate the possibility of gaining free energy. This paper discusses and analyses the system using data from Naudin's replication.

2. Discussion

Naudin uses a toroid of 67 turns wound on a core having a specific inductance (inductance of a single turn) of 87nH, which calculates to a total inductance of 390µH. Naudin also quotes this value as the *average* inductance of the toroid, but what he means by *average* is unclear. Certainly that is the value to be expected when the toroid is far removed from a rotor magnet, and we will use L_0 to depict this value. However when placed close to a NdFeB magnet the inductance is bound to reduce in value, and that reduction is a critical feature not considered by Naudin or Steorn. It indicates the feedback from the moving rotor that gives the motor its unusual characteristics, and cannot be ignored. The toroid is energised at the point of nearest approach of the magnet, and we will use L_M to depict this lowered value. The analysis is simplified if we assume that L_M is totally energised in a time which is very short compared to the rotor movement so that the magnet has not moved far and L_M has not changed (from Naudin's 'scope shots this is valid, the charging phase can be seen as a sharp spike on the leading edge of the voltage pulse). Thus the input energy E_1 needed to charge L_M with current i is

$$E_1 = 0.5 L_M i^2 \qquad (1)$$

The magnet now moves away from the toroid during which time the inductance rises to its normal value L_0. The current remains almost constant during this period (the DC resistance of the coil ensures that) but the voltage across the inductance does not (note the 'scope is seeing the voltage across the inductance *and* the series resistance so this small voltage is not readily discernible). This voltage V is given by

$$|V| = \frac{d(Li)}{dt} = i\frac{dL}{dt} \qquad (2)$$

Power P delivered to the inductor during this period is

$$P = Vi = i^2 \frac{dL}{dt} \qquad (3)$$

giving another input energy pulse E_2

$$E_2 = i^2 \int \frac{dL}{dt}.dt = i^2 (L_0 - L_M) \quad (4)$$

At the end of the current pulse where the inductance is now L_0 energy of value E_3 can be reclaimed.

$$E_3 = 0.5 L_0 i^2 \quad (5)$$

Thus the total non-reclaimable inductive energy E_{IN} into the system is given by

$$E_{IN} = E_1 + E_2 - E_3 = 0.5(L_0 - L_M) i^2 \quad (6)$$

It is convenient to represent L_0-L_M as an inductance change δL when (6) gives the satisfactory result

$$E_{IN} = 0.5 \delta L i^2 \quad (7)$$

Equation (7) is the input energy needed to drive the motor when resistive losses are ignored. If Naudin cared to measure the inductance change δL that occurs when a magnet is closest to the toroid he could determine that energy value, as it is its presence is completely hidden by the enormous resistive losses in the coil. If we cared to guess that the inductance change could be between 1% and 10% of its nominal value, we can establish the following possibilities. The repetition rate for E_{IN} is 122Hz, there are two toroids, and the average current during each pulse is 16.5A

% change	δL	E_{IN}	Average Power
1%	3.9μH	0.53mJ	0.13W
5%	19.5μH	2.65mJ	0.65W
10%	39μH	5.3mJ	1.29W

The actual average power supplied by Naudin is 77W.

It should be noted that the inductive input energy to supply the magnetic pumping action is a constant value per revolution, and that value is not dependent on the mechanical loading of the motor. Thus it cannot be expected that the input power will rise when the motor is loaded, in fact the converse is true. Because loading will reduce the revs, the input power can be expected to *reduce*. This reduction would not appear in the current waveform, but would be present on the voltage waveform were it possible to scope only the inductive component. As it is this is obscured by the high value of series resistance. Thus Naudin's observation When the rotor is manually braked, the supply current in the toroidal coils remains constant is to be expected and does not indicate anything anomalous.

When the motor is rotated by hand with the coils disconnected from their supply, there is no mechanism for the parametric pumping of the inductors to be seen. Thus the non-observance of CEMF is to be expected. If the coils were energised with DC current then the variation of inductance *would* be seen as voltage changes, and this would indicate the fallacy of the lack of CEMF argument. Naudin's observation There is no counter electromotive force (Back EMF) induced in the stator coils when the rotor is turned manually is to be expected and does not indicate anything anomalous.

The direction of current in the coils does not alter the saturation feature, hence Naudin's observation A reversal of the polarity of the coils does not change the direction of rotation is to be expected.

3. Conclusion

The Steorn/ Naudin motor is an interesting device that is worthy of investigation to see whether the use of crossed fields can produce any leverage in gaining energy. Neither Steorn nor Naudin seem to have grasped the parametric feature of the device and seem unable to perform useful analysis. Hopefully this paper will help to fill in some gaps and lead to useful experiments. From the author's own experience of solid state systems using crossed fields in toroidal cores, the parametric cross coupling does not provide the asymmetry needed to create an energy gain.