Experiments Exploring Remanent Magnetism Decay

1. Introduction

The SEMP Research Institute [1] is a South Korean Group that has a partnership with Global Solutions for Project Management in Abu Dhabi. Their AI Smart Electromagnetic Generator (AISEG) recently demonstrated at the COP28 Summit held in Dubai is claimed to have efficiency significantly greater than 100%, and a study of their patent applications [2] [3] [4] reveal they use within their transformers a unique core material, pure iron that has undergone a special form of treatment. They claim this treatment yields a demagnetization time that can be as little as 1/450 seconds (2.22mS), but they do not define what they mean by "demagnetization time". Also, they do not state how their system uses this feature, but further study of their patent applications shows that it relies on ephemeral remanence B_R where the magnetic field decays naturally with that order of demagnetization time. It seems that self-decaying remanent magnetization within a transformer core induces voltage into a coil to drive current into a load resistor that can deliver more energy to the load than that needed to magnetize the core. This extraordinary possibility needs further investigation, but this requires work to create the special core material as none exists except at SEMP. This paper suggests how experimenters can use readily available core material and give it the desired self-demagnetization characteristic, but first we must study the role of the Curie temperature in ferromagnetic material.

2. Curie Temperature

It is known that taking a ferromagnetic material above its Curie temperature has a detrimental effect on its magnetic characteristics, permanent magnet materials lose their magnetism, and soft materials lose their high relative permeability. This change from good to bad has led most teachings on the subject to present this like a sudden phase change (a liquid changing to a gas is a phase change). There has been no interest in teaching the actual way the characteristics change as the temperature approaches the Curie point, except for the specialist area of palaeomagnetism, the study of remanent magnetism in rocks. Ever since ferromagnetic materials have been used in electric motors, generators and transformers, such systems have been designed to work at temperatures far below the Curie point, any change of characteristic that takes place at raised temperatures has been considered harmful. But the Curie effect can be used to perform work. There are videos showing Curie pendulums continually oscillating as a form of perpetuum mobile where the ferromagnetic weight moves into and out of a flame. This is a crude and inefficient means of converting heat energy into mechanical energy where the material is cycled each side of its Curie temperature. But lack of knowledge of how ferromagnetic material moves from "good" to "bad" as it approaches its Curie point has inhibited the development of any other means for converting heat energy into something useful. Because of the SEMP claims, of significance is the way permanent magnets lose their performance over time, which is temperature driven. This is ***not*** a sudden phase change at the Curie point, the natural rate of decay, defined as an exponential time-constant (or relaxation time) τ, changes from many years down to fractions of a second as the temperature moves towards the Curie point, see next section.

3. Decay time v. temperature

Origins of Natural Remanent Magnetism [5] shows a chart of the natural self-decay time-constant *τ* against temperature for a magnetite grain of a particular size and shape, repeated here Figure 1. Note the log scale for *τ* in seconds and the huge range of relaxation times for a relatively small temperature span.

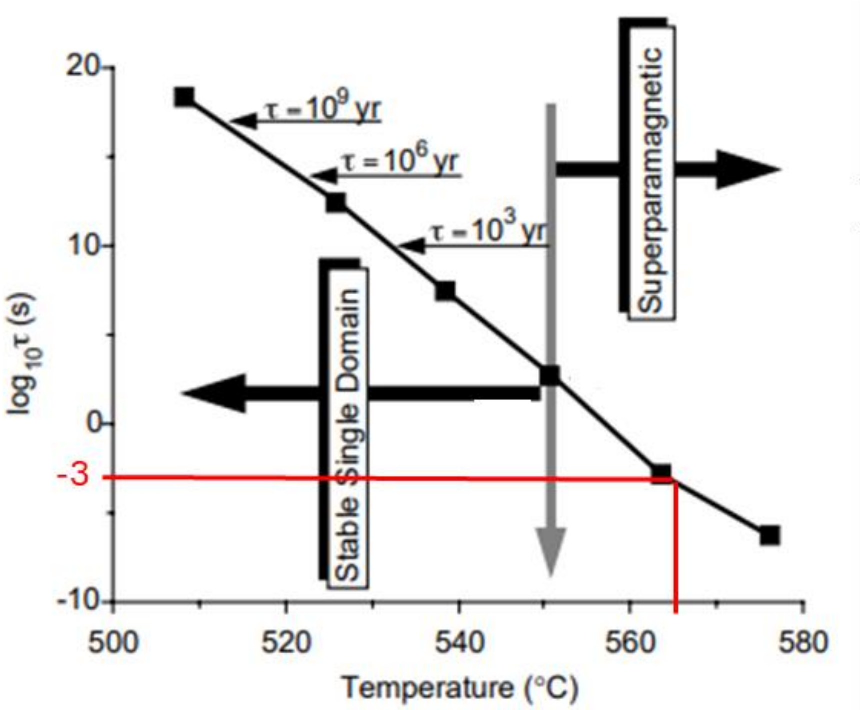

Figure 1. Relaxation time v temperature (taken from Ref [1])

The Curie temperature T_C of magnetite is 580°C. What is important for our consideration is that we could use this magnetite material as a core material that has "permanent" B_R at our ambient temperature and run it at a controlled temperature to have a relaxation time of our choosing. For instance, the red lines denote the situation for τ = 1mS that occurs at a temperature of 565°C, some 15° below the Curie point. At that temperature we could create the circuitry to pulse magnetize the core and extract energy in the manner of the SEMP device. Admittedly we must supply energy to heat the core, but if this does show the expected large COPs even that energy might be self-derived.

(It may be noted that the SEMP system runs at some unspecified high temperature and is within a temperature-controlled environment, see boxed text in Figure 2.)

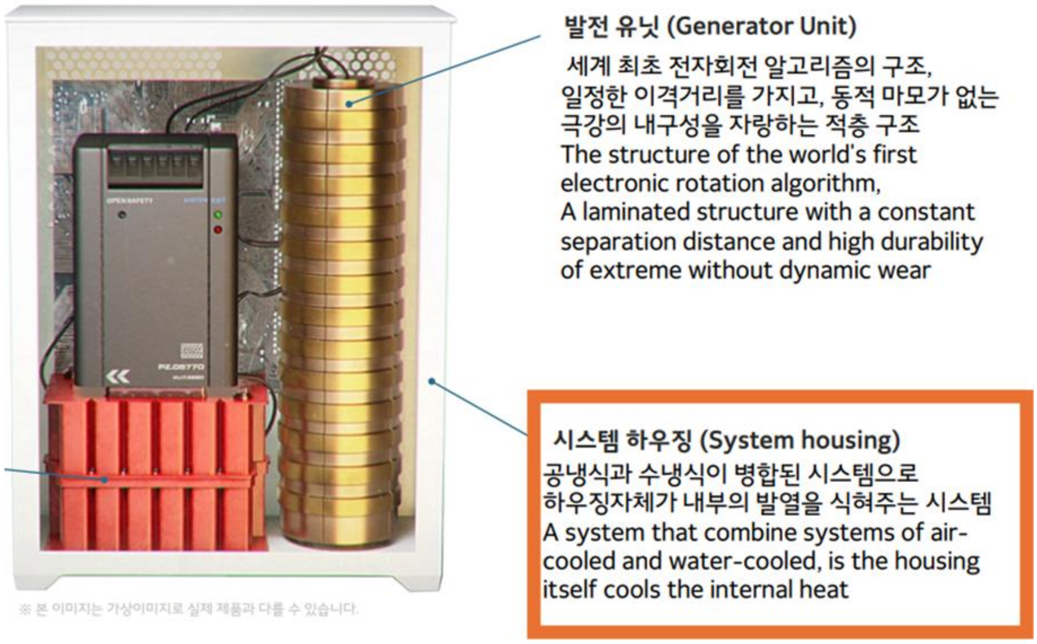

Figure 2. SEMP system (from their web site)

It is not practical to run a transformer at 515°C but there are materials that have a lower Curie point, and it is likely they would have a plot of τ v. temperature like Figure 1. Ferroxcube MR1 is a square-loop MnZn ferrite that has a Curie temperature rated ≥230°C that could be as high as 270°C. A transformer using this material could be heated in a ***domestic oven*** (250°C max) to be within 20°C of that upper value. This opens the door for home experimenters to try different circuits as described in the next sections.

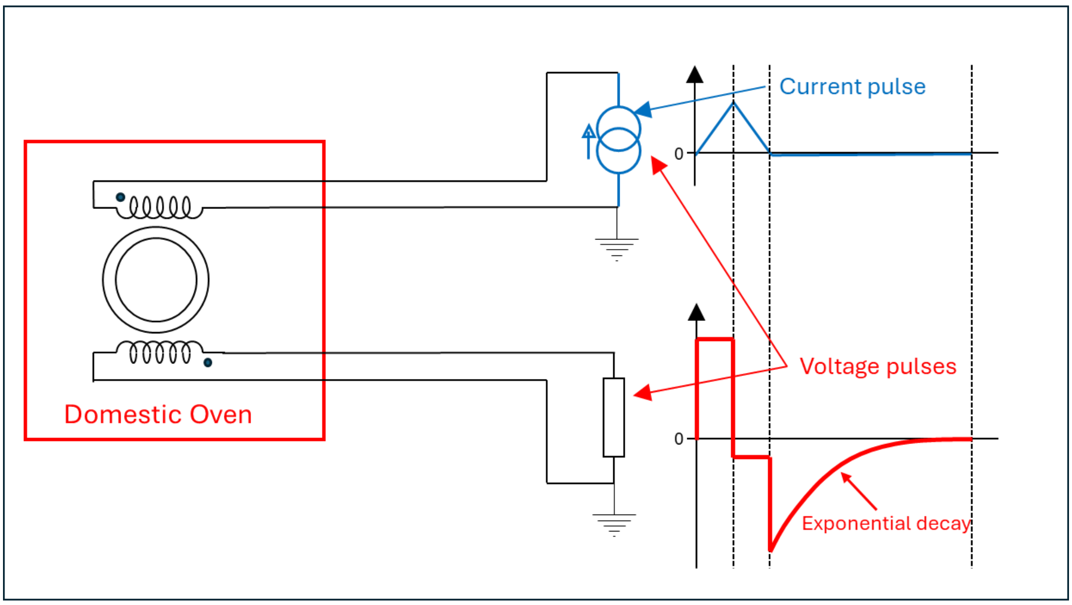

Figure 3. Layout

4. Suggested Experiments

a) Initial set up

It will be necessary to wind a transformer with wire insulation that can stand the high temperature. Long lead outs will enable the transformer to be placed in the oven while the electronics remains outside at ambient temperature. A toroidal core (ring core) of square-loop ferrite can be bifilar-wound with two coils covering the whole of the core. One coil (primary) is driven with repetitive unidirectional triangular pulses of current from a high impedance current source, while the other coil (secondary) is connected to an oscilloscope to display its induced voltage waveform. At ambient temperature, after the initial pulse the core will retain its remanent magnetism and will be driven around a BH loop in every pulse indicated in red in Figure 4 where the voltage waveforms for both coils are shown against the primary drive current.

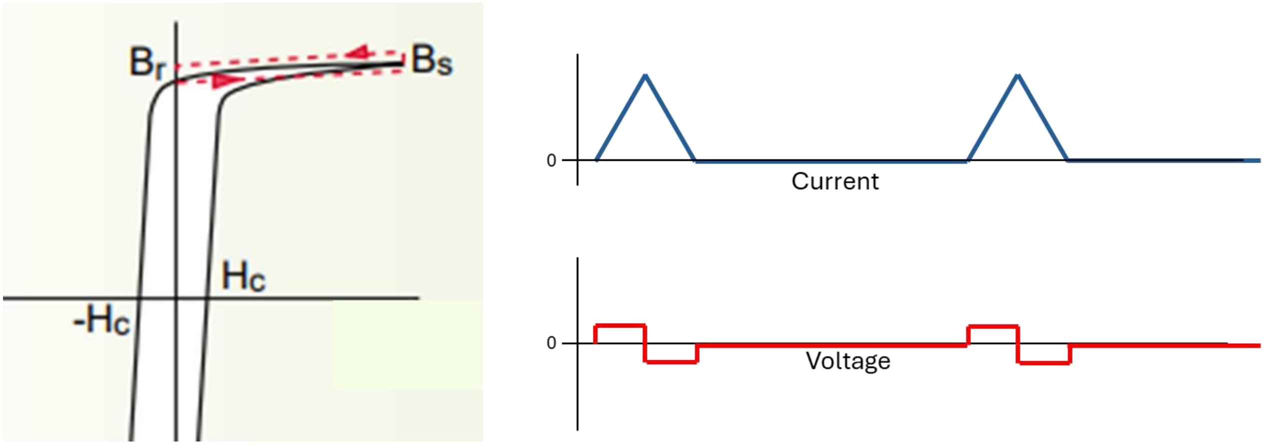

Figure 4. BH loop at ambient temperature

The B v. H slope of the primary inductance charge and discharge is close to μ_0 so the relationship between the voltage and current will be that for an air core, i.e. a small voltage for the given magnetizing current. During the pulse interval there is zero voltage at both coils.

When the core is heated and is temperature approaches the Curie point the primary BH loop will change to that shown in Figure 5. The vertical drop in B occurs during the pulse intervals where the magnetization decays naturally with a time-constant τ. The voltage during the rise of current increases to a higher level. During the pulse interval where the drive current is zero the fast demagnetization will induce a negative voltage spike with an exponential decay back to zero if the pulse interval is long enough. The input BH loop has greater area so the device now draws more power from the source that will add more heat energy to the core. It may take some adjustment of the oven controls to achieve a stable configuration for the next step.

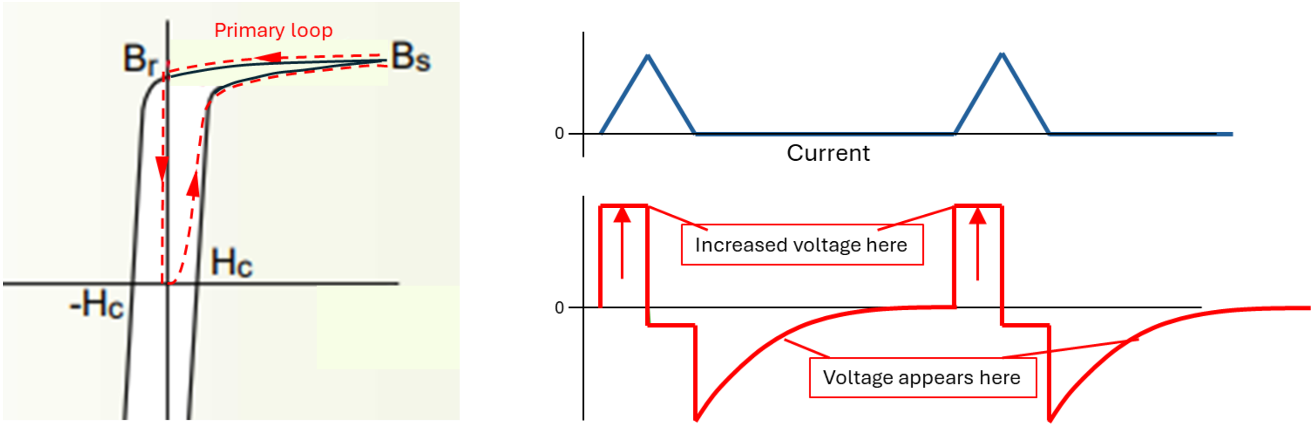

Figure 5. BH loop at high temperature

b) Add load resistor

With a load resistor permanently connected across the secondary the system will now operate in a manner like that of SEMP. Input power will increase as the input is now driving power to the load during the driving pulse. But the natural fast demagnetization will also drive current into the load during the negative spike, leading to a B v. H loop with the H from the secondary load current. It is this BH loop that is of interest since it occurs during the natural (temperature driven) demagnetization where the load current is in a direction that tries to stop that demagnetization. Unlike a normal transformer where the secondary power is determined by electrical input to the primary, here we have ***thermally driven*** secondary power. ***The electrical power output from the secondary can exceed the electrical power input to the primary***. This is illustrated in the secondary BH loop Figure 6 where the green area exceeds the area of the primary loop of Figure 5.

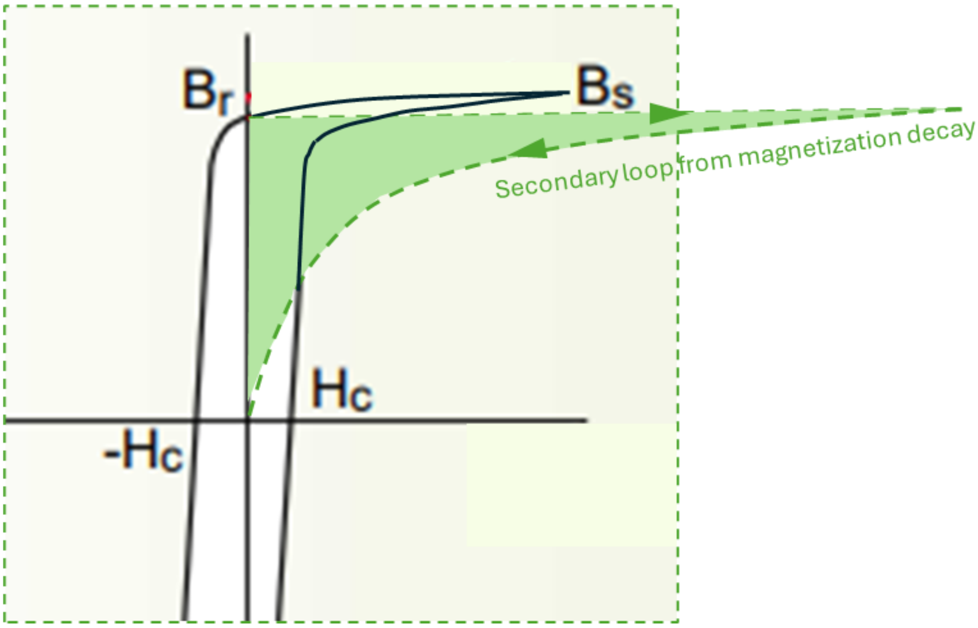

Figure 6. Secondary BH loop

It should now be possible to adjust the pulse repetition frequency to see how this effects the COP. Analysis performed to date shows the COP increasing as the pulse interval is reduced so that the magnetization decay does not reach zero for the next pulse. The remagnetisation starting from non-zero means the input pulse energy is reduced, but the output pulse energy is also reduced. It is expected that there will be an optimal repetition frequency giving a maximum COP.

References

[1] SEMP web site
https://www.semp.or.kr/en/%EB%B0%9C%EC%A0%84%EA%B8%B0%EC%9D%98-%EC%97%AD%EC%82%AC

[2] Korean patent application

https://www.overunityresearch.com/index.php?action=dlattach;topic=4563.0;attach=49839

[3] Korean patent application with English translation

https://www.overunityresearch.com/index.php?action=dlattach;topic=4563.0;attach=49838

[4] European patent application

https://www.overunityresearch.com/index.php?action=dlattach;topic=4563.0;attach=49864

[5] Origins of Natural Remanent Magnetism

https://www.geo.arizona.edu/Paleomag/chap03.pdf