5. Increasing Energy

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Contents

1 Abstract

[TODO rename file]

2 Background

In physics and chemistry, the law of conservation of energy[1] states that the total energy of an isolated system remains constant; it is said to be conserved over time.

This implies that the sum of all powers in the system equals to zero which is guaranteed by Kirchhoff's circuit laws[6] and Newton's 3rd law of motion[9].

But what about energy transfer? Is the amount of energy leaving one system always the same as the amount of energy entering another? Would double-entry[2] bookkeeping on power always balance?

For instance; consider the equation of a harmonic oscillator[5], a LRC-circuit driven by an AC-source expressed as a sum of voltages

$$Lq'' + Rq' + C^{-1}q - sin(\omega t) = 0 \tag{1}$$

Once solved we can change the equation from a sum of voltages to a sum of powers by multiplying with q'

$$Lq''q' + Rq'q' + C^{-1}qq' - sin(\omega t)q' = 0 \tag{2}$$

But two equations are missing; one that contains $-Rq'q'$ where the heat is going to and one that contains $sin(wt)q'$ where the power running the generator is coming from, now we have a system of equations:

$$other.terms - Rq'q' = 0 \tag{3a}$$
$$Lq''q' + Rq'q' + C^{-1}qq' - sin(\omega t)q' = 0 \tag{3b}$$
$$other.terms + sin(\omega t)q' = 0 \tag{3c}$$

We will ignore the heat and focus on the electro-mechanicals; a wheel with magnets and stationary coils. The two equations involved are Faradays Law[3] $V = Blv$ on the electrical side and Lorentz force[7] $F = BlI$ on the mechanical side. They eace replace one of the two $sin(\omega t)$ where B is now a function $B(\theta)$.

We get

$$Lq'' + Rq' + C^{-1}q - Bl\theta' = 0 \tag{4a}$$
$$J\theta'' + r\theta' + Blq' = 0 \tag{4b}$$

where J is the inertia of the wheel and r is the friction. If we change the equations to powers

$$Lq''q' + Rq'q' + C^{-1}qq' - Bl\theta'q' = 0 \tag{5a}$$
$$J\theta''\theta' + r\theta'\theta' + Blq'\theta' = 0 \tag{5b}$$

we have a system where the two equations communicate energy in a balanced way. In this paper we question that it is always so, experiments suggests that the two B-functions are usually but not always the same.

3 Simulations

To aid us in our research we have used a free simulator called FEMM[4] which can be scripted using Lua 4.0[8]. There is also a command-line version of FEMM called xfemm[10] that we have used heavily.

The femm programs allows us to create snapshots of set-ups with coils and magnets. The simulation then provides us with torque and flux-linkage.

[TODO check if still valid and rewrite for latex]

1: select a wire-diameter D 2: calculate number of turns N = 56% * coil-area / wire-area resistance R = pCu * 1000 * wire-length / wire-area where pCu = 1.72E-8 currrent for 1 W, I = sqrt(1 / R) 3: test the coil twice (with and without current) for each angle 4: get impulse T = the sum of all torque (with current minus without current) times delta-angle (integrate) 5: get the flux-linkage when no current 6: get the flux-linkage divided by delta-angle to get the voltage (derivate) 7: get impulse V = the sum of all voltage times delta-angle (integrate) 8: assuming linearity we calculate for each coil Tk = T/N*I Vk = V/N Rk = R/N$\hat{2}$ Nk = 56% * coil-area * 4/pi VpT = Vk / Tk 9: VpT $>$ 1 is a generator-coil and VpT $<$ 1 is a motor-coil 10: we can now choose any wire diameter D and calculate N = Nk/D$\hat{2}$ T = Tk*N*I V = Vk*N R = Rk*N$\hat{2}$ 11: for each pair of coils, mo and gen, with any wire, moD and genD, calculate a relative torque for comparisom between coil-pairs T = moT - genT = (moTk*moN - genTk*genN)*I where I = (genV - moV) / (genR + moR)

4 Algorithms

[TODO Check code and algorithms in Lua and FEMM] [Maybe by Odd Larsson?]

5 Experiments

[TODO Validate the simulations with experiments]

6 Conclusion

[TODO]

A In Plain English

[TODO]

B På Ren Svenska

[TODO]

C This Paper

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- `https://github.com/boherlin/elementary-physics/tree/master/pdf`

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Figure 1: 1B79p75vQw4Rb1GQdmGYpDapFwEytFJDqw

[TODO]

References

[1] *Conservation of energy.* URL: https://en.wikipedia.org/wiki/Conservation_of_energy.

[2] *Double-entry bookkeeping.* URL: https://en.wikipedia.org/wiki/Double-entry_bookkeeping.

[3] *Faraday's law of induction.* URL: https://en.wikipedia.org/wiki/Faraday%27s_law_of_induction.

[4] *FEMM.* URL: https://www.femm.info.

[5] *Harmonic oscillator.* URL: https://en.wikipedia.org/wiki/Harmonic_oscillator.

[6] *Kirchhoff's circuit-laws.* URL: https://en.wikipedia.org/wiki/Kirchhoff%27s_circuit_laws.

[7] *Lorentz force.* URL: https://en.wikipedia.org/wiki/Lorentz_force.

[8] *Lua.* URL: https://www.lua.org.

[9] *Newton's laws of motion.* URL: https://en.wikipedia.org/wiki/Newton%27s_laws_of_motion.

[10] *xfemm.* URL: https://github.com/REOptimize-Systems/xfemm.