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Response to curvature, gradients and temperature in a PPB-fuel cell, with a LED and a Li-B

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Abstract. For 2V and mA, the response to curvature and temperature gradients in a fuel cell device with a LED, is analyzed. Both experimental results and modeling are gathered, and beneficial configurations are deduced.

Keywords. mA, electricity, loads, heat, oscillations, heat-rod, experimental materials, modeling, non-linear, viscosity, flow-current equivalent, 3V, traveling waves, gradients, electro-magnetism, EM, Tti-memory.

1. Introduction

A device consisting of a PPB with capacitor, LED and a Li-B (Button-cell-battery 3V) [1], will be further analyzed. A PPB (Pot Plant Battery) consists of two electrodes in a pot with soil-electrolyte, Figure 1 and 2. Equivalents to electricity and currents, are assumed as fluid flows. Inputs resulting in gradients are scrutinized. The paper is organized as follows. First, an introduction with short summaries. Then, three sections on each experimental setup with models, followed by conclusions and discussion.

Heat and temperature gradients may contain energy beneficial to maintain a state where the LED shines. A linear fluid model is proposed to give oscillations of air velocity in surroundings and the adjacent foil in space.

The action of mechanical motions on contacts is found to restart light for a LED with a weaker Li-B. A non-linear fluid model with gradients is proposed and solved at certain assumptions.

Many electric devices e.g. lamps, produce heat along with its other applications, and that might be cost-beneficial since often, the power is much less than in a heater. Nowadays, somewhat more low powered resistors and materials producing heat when subjected to current are used in devices targeted for heating alone, but still, low range.

A method to get heat from an isolated electric line is to wire it around itself and a rod/tube. Then, a small amount of heat develops in the isolation material, but it may also be overheated. Here, this will be modelled with equations, showing that it is not always safe and within control. The test devices behaved more complex than predicted, and details are given in Section 2.3, below.

2. Experiments and Modeling

2.1. Adjacent heat and temperature gradient

A surrounding with a higher temperature underneath is found to stabilize, Figure 1. This can be modelled with Navier Stokes and a linear gas. Neglecting viscosity or velocity gradients, the resulting equation reads

$$u_{,t}=-r \text{ grad } H \quad (1)$$

where grad H is the temperature gradient, u,t is acceleration, and r is a material parameter. With H=H(x)sin wt, (1) admits solutions in terms of oscillations for u(t), superimposed on a constant solution. In fact, the light becomes stable to blowing on the foil, and this as well as the always present temperature gradient might be an energy input since the battery still works, after 24 weeks.

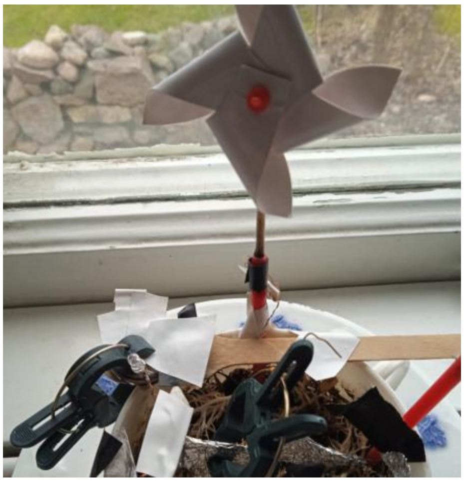

Figure 1. LED and Li-B at left. PPB on heated foundation (heat-element below, cold window at rear) and with foil capacitor not tightly attached. In operation for 24 weeks, since 16/10, (after 26/1, with a clamp, also on the foil)

2.2. Oscillation input due to periodic motion at contacts

Next, we will discuss models for how the energy from periodic (i.e. oscillatory) mechanical inputs are transferred to close the circuit that lights the LED.

An (organic) memory might be that they learn to shine when oscillations are applied as inputs. This can be cast into formula language by introducing configuration forces and material memory [2]-[4], and Tti-memory [5]. Then, to obtain more detailed explicit expressions, balance equations on different levels can be formulated. Modeling based on the stress tensor for a viscous fluid gives several options to describe transfer of action.

- With the pressure of an acoustic medium
- Balancing inertia
- As part of a (generalised) energy
- Viscosity coupling

The first 2 items give spatially waves being oscillations in a frame with relative motion.

Remark. Doppler shift, is a more indeterminate formulation, also within mechanics.

Here, viscosity coupling, will be used for the contacts: Applying motion on the foil, foil contacts or the other contacts may induce a local curvature, which initialize an action depending on viscosity. A constitutive equation for a non-linear Rivlin-Ericksen material reads

$$\mathrm{tr}\, T+3p= n(u_{,x})u_{,x} \tag{2}$$

where tr T is the trace of the stress tensor, p is pressure u,x is the velocity gradient and $n(u_{,x})$ is nonlinear viscosity. Nonlinear viscosity is found in modeling for ice [6]. Here, the introduction gives two solutions for the velocity gradient in that point. The static material counterpart are strain gradients. In the flow, a constant viscosity may materialise giving gradients such that the equation is linearised. The relationship to curvature is not direct, since rotations may be rigid, however in a viscous flow, layers and derives are moreoften present.

In details: Viscosity is assumed as

$$n=a+bu_{,x}$$

Insertion in (2), gives that $u_{,x}$ fulfils the algebraic equation

$$\mathrm{tr}\, T+3p=au_{,x}+nu_{,x}{}^{2} \; .... \tag{3}$$

Being a second order equations, $u_{,x}$ has 2 solutions, and the system displays a bifurcation.

tr T is considered as due to action on contacts and p as a more internal pressure, however possibly adapting to the input.

Figure 2. Large capacitor (foil and cup) from outside at ~0 Celsius to inside temp, and the wired rod on -side of battery and to the usual small foil capacitor at right. Led on + at battery and to the foil capacitor. The electrodes of the PPB and the large capacitor are also attached to the foil capacitor. Possibly super conductivity since the LED starts to shine after pumping on the rod-laps and adjusting onto the large capacitor, which has a temperature gradient.

2.3. Rod-device with curved isolated electric line

Increased temperature generated in a curved line provides a link between thermo-mechanics and electro-magnetism aka EM. Here, this is tested with a rod, Figure 2, denoted Heat-rod: An isolated cupper wire was twisted several laps around a rod to obtain a heater operated by magnetic self-induction and prevented expansion.

2.3.1. Model; heat and curvature

The same model as in 2.2 above, and an equation of state relating pressure to temperature, provides the constitutive equation

$$\mathrm{tr}\, T + 3p(H) = n\, u_{,x} \qquad (4)$$

In a balance, the left side ; tr T + 3p(H), is assumed proportional to an elevated temperature in the space outside and in the isolation (thus providing a 'BC-output'). Also, a connection to magnetic induction from outside or self-induced [7], could be invoked in this format. The latter may be assumed to contribute as rates of strain gradients which couple to the velocity gradients, or directly. Knowing the scales and geometry, fractal models are an option [8]. In [8], temperature enters in an energy ratio within a functional format, the formulation is Lagrangian, not specifically including strain rates due to EM.

2.3.2. Model with flow-equivalents

The large foil-capacitor, c.f. Figure 2, experiences a significant temperature gradient. For density, d, a dependence on configuration through a spatial average is assumed;

$$d = d\,(\mathrm{int}\,(M\,(x, m)\, u_{,m}\, dm),\, x,\, ai)) \qquad (5)$$

where M(x m) is a weighting function, e.g. representing attenuation, or gain due to input, and ai are internal variables . Here, we consider M=1, which gives d=d (u, x, ai).

Then, a model as in 2.1, with inertia balancing pressure, reads

$$d\, u_{,t} = -\,\mathrm{grad}\, p \qquad (6)$$

A linear equation of state p= r d H, (5) and (6) give solutions e.g., in terms of traveling waves & stream lines reading $u_{,t}+u_{,x}\, rHd'/d=0$ and $du^2/2+p=\mathrm{const}$, where d' denotes partial differentiation of d.

Wave velocity and characteristics.

Linearisation, i.e., assuming d'/d as constant, gives traveling waves, where the shape is constant on characteristics x-ct=K where c=rHd'/d is the wave velocity and K is a constant.

In a correspondence, u could be the velocity of loads (electron densities), on the foil. For a particle, e.g. electrons in a curved motion, a Tti-memory [5], could be valid. Then, an oscillation and an area measure are connected to the system.

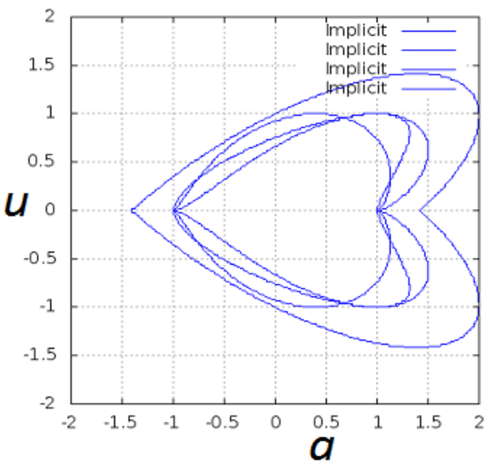

Figure 3. The function f(u,a)=u2+ (a-r*abs(u)s)2=c ...(7) for (r,s,c)= (0.4,0.7,1)&(1,0.7,1)&(1,0.95,2)&(1,1.5,1) with the code maximaonline given below

Draw2d(/* global options */ title = "..", xlabel = "x-axis", ylabel = "y-axis", grid = true, dimensions = [500,500], /* implicit function */ key = "Implicit", implicit(y^2=-(x-0.4*abs(y)^0.7)^2+1, x, -2,2, y, -2,2), implicit(y^2=-(x-abs(y)^0.7)^2+1, x, -2,2, y, -2,2), implicit(y^2=-(x-abs(y)^0.95)^2+2, x, -2,2, y, -2,2), implicit(y^2=-(x-abs(y)^1.5)^2+1, x, -2,2, y, -2,2));

Nonlinear analysis for the stream line.

With a nonlinear dependency for p, a certain format known as the Love formula is obtained. This reads $u^2 + (\mathrm{abs}(u)^{2/3}$-

$a)^2 = 1$. In Figure 3, with $2p/d = (a-r*abs(u)^s)^2$, the generalised stream line conditions

$$u^2+2p/d=c \tag{7}$$

are visualised for some values of parameters s,r and c .

2.3.3. Results

The experiments became more composed and this is what happened:

The actual rod-temperature is not known and the observables are composed: The rod behaves as a piezoelectric switch, i.e., when densified by compression, the LED starts, i.e., twinkles. After 'pumping up', 4 - 5 times, the LED shines steady by itself. Next day, it is off, and the same procedure gives only weak light. Instead, the system gets steady light when the - of the Li-B was attached to + of the PPB, i.e., a serial coupling, and keeping the other circuits similarly attached to the capacitors. At first, the reason for this was assumed to be a choice of another state. Measurements on the normally not rechargeable Li-B gave 1.6V, compared with 1.4V, previous, i.e., it recovered somewhat. Thus, it lights the LED by itself, which was not the case at the beginning of this heat-rod -test. Next day; no light, but the battery was additionally recharged to 1.7V. However, somewhat unusual, now that was not enough to light the LED. After evaluating the results for some days, low intense LED light is obtained when the Li-B, is somewhat compressed. The lines were again attached, and with some adjustment at the foil capacitor, the LED displayed more intense light. Once lighted, it reacts to compression of the rod, and shades, then starts to light when more tightly attached to the outer foil.

With one clamp on the battery and same clamp as before on the small foil, where lines from the led, the +PPB and from the heat-rod enter, it remained lighted next day, however decreased. The battery is now 1.5V.

The development of power in the heat-rod is not known, yet. The low intense trembling light indicates that an EM-heat state, in the coils of the rod, is active. The previously increased voltage on the battery, could have been gained from the PPB and or energy due to a temperature gradient. After pressurisation, the LED shined and decreased pressure is characteristic for super conductivity. However, after adding the clamp, next days this shines similar to the other devices which do not have a heat-rod and a larger outside capacitor, but more weakly needing adjustments, and cyclic, possibly prospering on the gradient once a day.

3. Conclusion

Experiments and modeling for a fuel cell with a LED and battery, are gathered. Descriptions for how mechanical input and observables interact with EM, were given. Balance equations with gradients give qualitative results, in agreement with the behaviour.

Nonlinear mechanical models with energy approaches are found within Hamiltonian mechanics, [9]. Interpretation of the variable a in the function (7), gives that f(u,a) can be a Hamiltonian energy. For example, a=x, and r small, brings a nonlinear elastic oscillation into the stream line, and the oscillation frequency may depend on temperature and material parameters. Such coordinate basis derived from other preliminaries are found in cosmology [10].

In the present context, equivalents to mechanics and flows were considered, to describe the response to input motions on electric devices. Nonlinear models for more realistic, observable flows are e.g., fluid dynamics in bubble pumps. Instabilities and oscillations are observed in various states, and so-called N-curves embraces the experimental observations. Here, possibly, jumps between solutions $u_{,x}$ to equation (3), provide dynamics, e.g. oscillations (and energy transformations).

4. Remarks and Discussion

• Mechanical input on the foil or contacts might induce a local curvature and gradients, which initialize an action depending on viscosity.

• The models give a large range for parameter values, i.e. possibilities for coupling to input. Experiments shows that it actually works.

• The oscillation input applied at foil contacts only, might save battery.

• Modeling with a stress tensor depending on kinematics, pressure and heat describes transfer of action (giving generalised energies), and this agrees with other observed results in larger applications.

• Couplings to particles were tacitly invoked, e.g., waves and electrons, 2.3.2, particles in curved motions, and in 2.1, heated molecules in the air adjacent to the EM-device.

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