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Models for Elasto-electricity and Photovoltaic Material in the Micropower Plant

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ABSTRACTS

In the present paper, the electrodynamic and photovoltaic devices were analyzed. The methods used were modeling of accumulated loads, differential geometry for Solitonials, and generalized Piezo-electricity. Models for dynamic capacitors in the WFB are derived. The analysis is based on observations and experimental results. The experiment was done by providing AC-power background and attaching an NPN-Sun-Catcher. Then, the designed equipment was evaluated in terms of the one-way elasto-electricity and photovoltaic process. The realizations of this designed equipment are suitable for educational purposes. And, this equipment with small encapsulated components operating in higher-power applications can be implemented as realistic solutions for solar-related uses.

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1. INTRODUCTION

This paper is based on our previous studies (Strömberg, 2021; Strömberg, 2022; Strömberg, 2023), in which the experiments were the analysis in terms of various modeling. With AC power, it is possible to magnify Voltage and to collect current with e.g., elastic wires and Sun Catchers, e.g., photovoltaic. In the present paper, a component for the latter will be focused on, as well as a method to obtain AC in a pot plant battery. With knowledge of the electric output, materials, and geometry for the construction, governing equations are proposed. In mechanics, such an equation is provided in terms of constitutive equations, and part of that framework is exploited. The measured current and voltage oscillate between zero and a top value. The frequency and amplitude depend on the geometry of the pot with electrodes, wind velocity and sunshine, and the structural electro-mechanics in the components. Technically, these properties are inputted, and the output is voltage and current in the circuits. Here, we consider interior models for a WFB and a Sun Catcher (see **Figure 1**) aligned to the electric circuits (Strömberg, 2021). Hence, the input will be mainly electric; then added by the electric response to sunlight and wind motion.

Figure 1. Wind Flower Beam (WFB) and Sun Catcher (the round metal Cup with content) in the circuit of a battery.

2. METHOD

The methods used were modeling of accumulated loads, differential geometry for Solitonials, and generalized Piezo-electricity. The experiment was done by providing AC-power background and attaching an NPN-Sun-Catcher. Then, the designed equipment was evaluated in terms of the one-way elasto-electricity and photovoltaic process. Detailed designed equipment is shown in **Figure 1**.

3. RESULTS AND DISCUSSION

3.1. Models for the Dynamic Capacitor in WFB

The functional dependency for the output can be derived from differential equations; e.g., a damped forced vibration. Such an equation is extracted from a system of integral and differential equations. This study used modeling into a differential equation of forced vibrations. The wrapped foil accumulates the loading, as a conductor. This varies with time, since the foil moves. The input and output are cast into Equation [1]:

$$i_{,t}+ci = F(int\ i\ dt) + K \quad (1)$$

where i is the current, c is the constant, F is the function of cumulative load described as an integration of i, and K is the local curvature. K depends on wind load input, elasticity, and material. The resulting time dependencies are due to wind speed, size of the devices, and the capacitance of the foil with two cupper line ends. Differentiation and linearisation give a damped harmonic oscillator with input K and t. Since no visible or detectable reversed action,

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the input is assumed as a Dirac pulse (δ). The Harmonic oscillators (with optional input to forced vibrations) are solutions to motions in piezo-electricity models (Seethaler *et al*.,2021).

Invoking details on spatial distributions for loads and densities give a nonlinear model with more indeterminacy. Also, it is the possibility of information for the frequencies and other responses. In the application where several entities are put together in a matrix (in a photovoltaic-panel and car batteries), the ensemble properties (due to periodic boundary conditions) probably rule the overall behavior (into an oscillation for the electric current). Therefore, a more detailed material model will not be outlined. Instead, the ramifications of a general nonlinear system will be scrutinized. Since there are loadings that travel in the foil and reach the cupper lines where they are measured as current, a solitonial model is analyzed.

3.2. Attraction Field Solutions to a Weighted Solitonial Model

A first-order system for the solitonial can be written in Equations [2] and [3]:

$$y'(x-ct) = 3f^2+cf+A \quad (2)$$

$$f'(x-ct) = y \quad (3)$$

where f is the function of x-ct, and c is the constant parameter. To emphasize dependency on the argument, the system is multiplied with x-ct on each equation. Then, a differentiation with a wedge product is applied. This results in the following system of Equations [4] and [5]:

$$dX/dy = X(6f+c)\ df/dX \quad (4)$$

$$dX/df = X\ dy/dX \quad (5)$$

where $X=x-ct$ is the wedge product. The same result, except for some signs, is obtained with linearised differentiation and bilinear products. In the proposition, by the combination of Equations [2]-[5], the solution $A = 0$ and $f = -c/(6X^2)$ are derived. In a moving grid with velocity c or for constant t, the solution is similar to Coulomb attraction in the vicinity of loads or charged particles. These are at periodic locations (x) when t is the proportional integer.

3.3. Sun Catcher

The Sun Catcher (see **Figure 1**) may collect both from photons and by heat perception. The foil and the cup act as a capacitor. Before the foil, there is a prestrained wrapped wire. If this deforms at heat expansion, the resistivity is changed, which might add loads and current to the device. For this, we will consider the modeling of piezo-electricity (de Bem *et al*., 2020), in a generalized interpretation. The equation can be written in Equations [6] and [7]:

$$e = S\,s_3+d_{31}E \quad (6)$$

$$D = d_{31}s_1+kE \quad (7)$$

where e is strain, s_1 and s_3 are the stress components (N/m^2), E is the applied electric field (V/m), and D is the electric displacement (C/m^2). S, d_{31}, and k are the material constants. Input action from sunlight is identified with s_3 and the in-plane stress-response is s_1. To extract dependencies, a case where the strain is zero will be analyzed. e is zero, the electric input from the lines can be eliminated and the amount due to solar energy reads (Equation [8]).

$$D=d_{31}(s_1-s_3kS/d_{31}^2) \quad (8)$$

An interpretation of the right side is that it may be due to both photons (s_3) and in-plane mechanical deformation (e.g., bending (s_1)). The factor on the out-of-plane response shows similarity with volume fraction for increased densities of 3d -particles in a plane flow. Assuming that s_1 and s_3 are the principal stresses ($s_1 > 0$ and $s_3<0$) and defined a rescaled area for either of the stress components or certain values of parameters, the right side will be the maximum shear stress. The latter will be cast into a theorem. In the theorem, for plane stress

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where 1 and 3 are principal directions ($s_1 > 0$ and $s_3 < 0$), the maximum shear stress (τ) can be written as $\tau = (s_1 - s_3)/2$, and it is located in a system rotated $\pi/4$ from 1 and 3. When the ratio $kS/d_{31}^2 = 1$, the right side in equation (8) is proportional to τ.

In the proof, the results are given by the algebra and geometry for stress states. The structure of the wire in the cup (see **Figure 1**) is twisted, and the measured resistance varies when subjected to torsion. In general, the response is unstable. Indeed, it moves snap-through or in buckling condition. This may be beneficial to collect current. In the preliminaries, assuming that the strain is proportional to E, a state of simple shear; $s_1 = \tau$ and $s_3 = -\tau$ will be analyzed. In the proposition, when $e = CE$ and the simple shear is in agreement with a state where the applied electric field fulfills, we can write Equation [9]. For a Sun Catcher or wire subjected to heat expansion, the shear stress may be considered input as the response of the material to sunlight. Then, a generalized interpretation of E may include gain and it is not only input. A constrained wire moving at wind load or in a water stream also responds in shear.

$$E=\tau S/(d_{31}-C) \qquad (9)$$

4. CONCLUSION

In the present paper, the electrodynamic and photovoltaic devices were analyzed. The methods used were modeling of accumulated loads, differential geometry for Solitonials, and generalized Piezo-electricity. The results gave an oscillating current, Solitonials coexisting with attraction field sources, and relations between electric field measures and mechanical stress components. In the operation of the designed equipment, the sun catcher cup was found to amplify the Current 5.7 times. It remains to quantify the contribution from each part, especially it depends on how sunlight multiplies the load density in the foil and metal or otherwise increases the value in the Cupper Lines, and the part due to heat expansion and 'piezo-electricity' of the wire.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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