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Theoretical Design of Lightning Panel

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Abstract. The light trapping device (LTD) was theoretically designed to suggests the best way of harvesting the energy derived from natural lightning. The Maxwell's equation was expanded using a virtual experimentation via a MATLAB environment. Several parameters like lightning flash and temperature distribution were consider to investigate the ability of the theoretical lightning panel to convert electricity efficiently. The results of the lighting strike angle on the surface of the LTD shows the maximum power expected per time. The results of the microscopic thermal distribution shows that if the LTD casing controls the transmission of the heat energy, then the thermal energy storage (TES) can be introduced to the lightning farm.

INTRODUCTION

An in-depth analysis of lightning electric and magnetic fields have been explained by few models like gas-dynamic models, electromagnetic models, distributed-circuit models, engineering models e.t.c. However, the errors noticed in the model have informed a proactive effort to address the shorting-comings of these models in practical application. Many of the anomalies in lightning models have been due to the global climate change. Primarily, most lightning electromagnetic models involve a numerical solution of Maxwell's equations to investigate magnetic effects and the corresponding change in the current distribution along the lightning channel. The argument on the validity of the current distribution has attracted arguments (1) especially as regards the transverse electromagnetic (TEM) and the non-transverse electromagnetic (NTEM). One of the vital advantages of the current distribution along the lightning channel is the investigation and prediction of deleterious coupling of lightning fields as it has-over the years affected various electric systems. Understanding the deleterious coupling of lightning fields is practically synonymous to the return stroke concept. From basic knowledge of lightning, the return stroke travels via a path known as channel. The return stroke channel acts as a conducting pathway for the current wave propagation, with the source being located at the ground. The theory of the return stroke concept has deluded most experimentalists as different measuring devices (2) had shown varying results. The sensitivity of the measuring devices are in no way relevant anymore as the prevailing global weather change alters charged particulate mobility both in the atmosphere and near earth surface (3,4). Therefore, the ab-initio concept of electromagnetism i.e. the Maxwell's equations needs to be revised to incorporate some salient global weather terms to capture-adequately the concept of return stroke. This feat-if achieved would enable the theoretical calculations towards developing a prototype which can collect power (one million kilowatts of electrical energy) from the ground area surrounding a strike. This is actually, the future of the next energy technology to utilize the natural lightning as a source of alternative energy. There are salient questions that must be asked to enable a theoretical lightning farm design. How shall the trapping device look like? In what array must this trapping device be placed to enable the maximum harvest

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of lightning strike? How should it be stored? From literatures, over 25% of lightning strike reaches the ground. The physics conveyance of the large power into the storage is quite hectic-judging from the simple principles. In this text, we shall be examining the theoretical trapping device that should be used to harvest the power from natural lightning. We shall not deviate into the storage techniques.

METHODOLOGY

The surface of the trapping device (shown in Fig. 1) is made up of three major components i.e. the trapping surface, conductive pillars and base. The base should be inserted in water ways to convey excess heat. The trapping surface is built like the photovoltaic module. The difference between the photovoltaic module and the trapping surface is the three extra layers it possesses (Fig. 2). The lightning trapping device (LTD) is expected to obey the Maxwell's electromagnetic model which is hinged on the following salient assumptions on the practical field

i. The particulates at each layer of the of the surface have a medium intermolecular force

ii. The particles in each layer absorb energy, transforms (electrical to kinetic energy) and excite more charges within the succeeding layers

iii. The excited charges conveyed through a highly conductive medium to the storage unit.

iv. The refractive main channel of lightning is dependent on the temperature, pressure, air density and moisture content of the air (see Fig. 1).

v. The topography of the location is negligible

vi. The number of main channel from cloud to ground is negligible.

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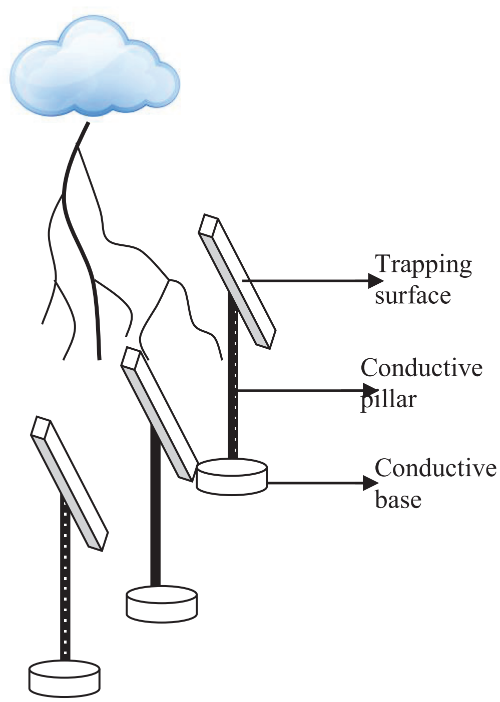

FIGURE1: The theoretical lightning farm

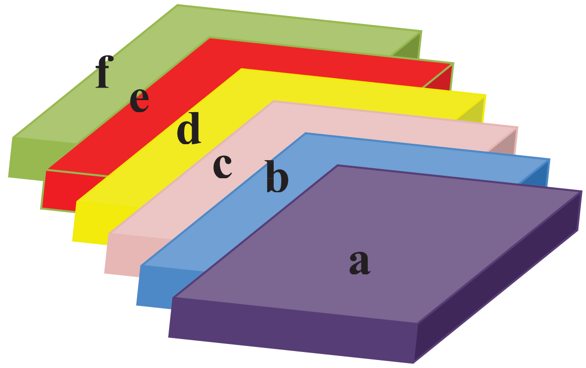

FIGURE 2: Layers in the trapping device

Layer 'a' is the transparent coating, layer 'b' is the transparent surface, layer 'c' is the transparent anode layer, layer 'd' is the hole transport layer, layer 'e' is the photoactive layer and layer 'f' is the hybridized cathode layer. Each arrangement is inserted into slots within the module like solar cells. The case coating (shown in Fig. 3) has a high thermal conductivity which harvests the excesses heat into the water ways.

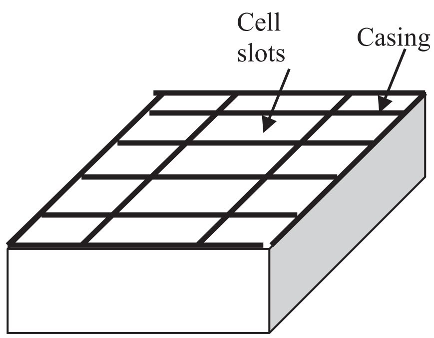

FIGURE 3: Casing of trapping device

The charged molecules are believed to spin. We propose that the nature of excited charge spin initiates the preliminary events of lightning. We therefore introduce the time- independent Schrödinger equation to account for its spins as

$$i\hbar\frac{\partial}{\partial t}\psi - \frac{\hbar^2}{2m}\nabla\psi + V\psi = 0 \tag{1}$$

We applied the Navier - Stokes equation into the Schrödinger on the assumptions that $\mathcal{F}$ is insignificant and $(u.\nabla)u = \nabla u^2 = u^2\nabla$

$$ia\hbar\frac{\partial}{\partial t}\psi - b\nabla\psi + Vc\psi = 0 \tag{2}$$

Here $a = 1 + vu + \frac{i\hbar}{2m}u$, $b = u^2$, $c = p + vu$

The langrangian density related to equation (1) is given as

$$\mathcal{L}_1 = \frac{1}{2}\left[a\left|\frac{\partial\psi}{\partial t}\right|^2 - b|\nabla\psi|^2 - Vc|\psi|^2\right] \tag{3}$$

We apply the minimum coupling rule to describe the interaction of ψ with the electrostatic field i.e. $\frac{\partial}{\partial t} \mapsto \frac{\partial}{\partial t} + ieV$, $\nabla \mapsto \nabla - ieA$ where $\phi = V_o + E_o(\frac{y^2}{x} - x)$

where V is the total potential across atmospheric surfaces, V_o is the potential on the surface of the charged air, E_o is the electric field and x is the width of the lightning strokes,

$(\frac{y^2}{x} - x)$ is the plasma potential, x is the Dybe length. Equation [3] transforms into

$$\mathcal{L}_1 = \frac{1}{2}\left[a\left|\frac{\partial\psi}{\partial t} + ie\psi\phi\right|^2 - b|\nabla\psi - ieA\psi|^2 - Vc|\psi|^2\right] \tag{4}$$

$$\mathcal{L}_1 = \frac{1}{2}\left[a\left|\frac{\partial\psi}{\partial t} + ie\psi V_o + iE_o e\psi\left(\frac{y^2}{x} - x\right)\right|^2 - b|\nabla\psi - ieA\psi|^2 - Vc|\psi|^2\right] \tag{5}$$

We Apply the solution of the standing wave $\psi(x,t) = e^{iS(x,t)}T(x,t)$ in equation (5)
where E, B : $\mathbb{R}^3 X\, \mathbb{R} \rightarrow \mathbb{R}$, the lagrangian density takes the form

$$\mathcal{L}_1 = \frac{1}{2}\left\{E_{rt}^2 - |\mathrm{E_z}|^2 + \left[b|eA|^2 + a|V_o e|^2 - a\left(\left|E_o e\left(\frac{y^2}{x} - x\right)\right|^2\right) + 2aE_o V_o e^2\right]{E_r}^2\right\} \tag{6}$$

Considering the lagrangian density of the particle in an electrostatic fields E_1-E_2 field of the atmospheric influence where $\mathrm{E_1 = E_z}$ and $\mathrm{E_2 = E_{rt}}$.

$$\mathcal{L}_o = \frac{1}{2}|E_1|^2 - \frac{1}{2}|E_2|^2 \tag{7}$$

Here the total action of lagrangian density is a linear combination given as

$$D = \mathcal{L}_1 + \mathcal{L}_o \tag{8}$$

From the basics of moving charge and the corresponding magnetic field they produced, we assumed that the charges mobility is maximum within the layer 'a' i.e. $B_{max} = \frac{\mu_0}{4\pi}\frac{qv}{r^2}$ and $E_{max} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$.

$$D = {B_{max}}^2{\varepsilon_0}^2{\mu_0}^2|eA|^2{E_r}^2 + a|V_o e|^2{E_r}^2{E_{max}}^2 - a\left(\left|E_o e\left(\frac{y^2}{x} - x\right)\right|^2\right){E_{max}}^2{E_r}^2 + 2aE_o V_o e^2{E_{max}}^2{E_r}^2 \tag{9}$$

Since lagrangian density is calculated as the difference of kinetic and the internal energy densities (5) i.e. $D = \frac{1}{2}mv^2 - qV$, therefore equation (9) becomes

$$\frac{1}{2}mv^2 - qV = {B_{max}}^2{\varepsilon_0}^2{\mu_0}^2|eA|^2{E_r}^2 + a|V_o e|^2{E_r}^2{E_{max}}^2 - a\left(\left|E_o e\left(\frac{y^2}{x} - x\right)\right|^2\right){E_{max}}^2{E_r}^2 + 2aE_o V_o e^2{E_{max}}^2{E_r}^2 \tag{10}$$

This yields three governing equations

$$
{B_{max}}^2{\varepsilon_0}^2{\mu_0}^2|eA|^2{E_r}^2 \tag{11}
$$
$$
-qV = a|V_o e|^2{E_r}^2{E_{max}}^2 + 2aE_o V_o e^2{E_{max}}^2{E_r}^2 \tag{12}
$$
$$
-a\left(\left|E_o e\left(\frac{y^2}{x} - x\right)\right|^2\right){E_{max}}^2{E_r}^2 = 0 \tag{13}
$$

Equations (11-13) is the linear form of electromagnetic model The internal energy is the varying energy – influenced by the heat energy transmitting alongside each stroke.

RESULTS AND DISCUSSION

The angular lightning strike on the on the LTD determines how much it can trapp within a stipulated time. We simulate the expected experiences of the LTD at varying strike angles(Figure 4)

Three strike nature expressed above shows the best position of the LTD in the proposed solar farm. The sine and total directional strike favours maximum yields. If the LTD is made-up of silicon compounds, then the expected microscopic thermal distribution is shown in Fig. 5.

It can be deduced from the above figure that the thicker the LTD layer the more active the microscopic thermal distribution. At macroscopic scale, we expect to see a higher thermal distribution. The LTD casing as shown earlier is expected to convey the heat generated down to the water ways. The transmitted heat energy can be incorporated into the thermal energy storage (TES). This idea enables an efficient utilization of transmitted heat energy which depends on the type of fluid used to convey heat from the LTD. The research into the comprehensive performance of the LTD is still ongoing.

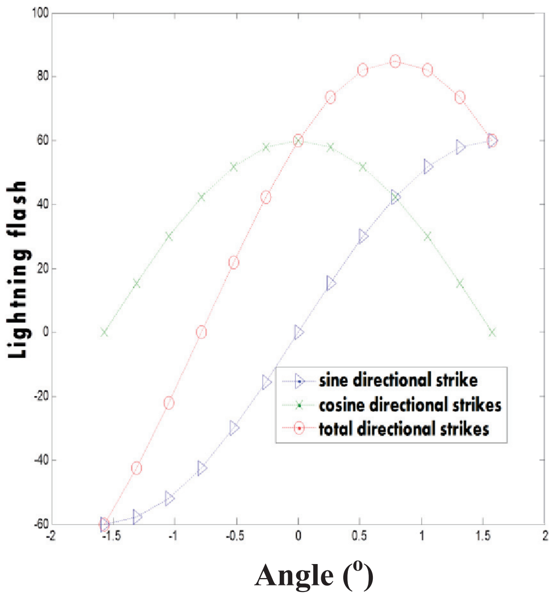

FIGURE 4: Lightning strike angular dependence

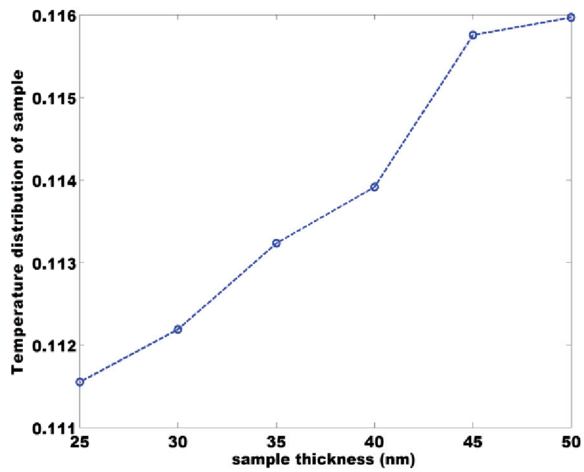

FIGURE 5: microscopic thermal distribution with respect to LTD layer thickness

CONCLUSION

The initial ratings of the LTD showed that it is a viable project. The directional strike position for maximum trappings of the power generated from natural lightning was proposed to be within the sine format. The microscopic thermal distribution simulation gave an idea on the importance of the thickness of each layer of the LTD. If the LTD casing controls the transmission of the heat energy, then the TES can be introduced to the lightning farm.

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