Time Domain Analysis of Electric Field on Wind Turbine Blade Under Salty Condition

Samer. S. Wahdain[1], A. I. Mohamed[1*], Mohd Mawardi Saari[1], Mohd Herwan Sulaiman[1], MRM Esa[2], ZA Noorden[2]
[1]Faculty of Electrical and Electronic Engineering, University Malaysia Pahang, Pekan Pahang, Malaysia
[2]School of Electrical Engineering, University Technology Malaysia, Johor, Malaysia
[*]Corresponding author's email: amirizzani@ump.edu.my

ABSTRACT: A wind turbine is a structure that converts the energy generated by the wind into electrical power by utilizing wind vans called wind blades. Thus, wind blades play an essential role in a wind turbine. Due to open and high terrain construction, wind turbines are continuously exposed to lightning strikes. Therefore, electrical field activity may vary during thunderstorms. Finite Element Method software with computational simulation and analysis was carried out to gain insight into the behavior of this electric field for wind turbine blades under different humidity conditions. Simulated module excitation and parameter based on natural occurrence will be implemented, and the findings of the results can be used in technological advancement.

Keywords: *Wind Turbine Blade; Electric Field; Finite Element Method*

1. INTRODUCTION

Lightning is one of the leading causes of severe damage to renewable energy farms, resulting in millions of dollars in annual losses [1], [2]. Wind turbines with a tall design and construction have a greater risk of being struck by regular cloud-to-ground negative lightning [3]. The electrical field charges are present in thunderstorm clouds. The average thunderstorm electric field in the atmosphere is roughly 2–3kV/cm [4]. Most earlier studies concentrated on the direct impact of lightning strikes on wind turbine blades at various blades and the efficiency of lighting protection receptors. Wind farms are typically located in offshore areas, which indicates an existing saline condition that leads to an increase in the electrical field on blades [5]. Therefore, understanding and analyzing the effect of salinity on electrical field charge is essential.

In this paper, we use time-dependent analysis of horizontal wind turbine blades to understand how electric field charges affect the wind turbine blade during salinity (Sodium Chloride) and compare without salinity environment.

2. METHODOLOGY

Finite Element Analysis (FEA) is used to obtain approximative solutions to boundary value problems in mathematics and partial differential equations.

Figure 1 represents the simulation domain with 1km×1km×10km. The height of the thundercloud is 10km above the blade.

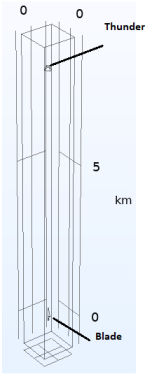

Figure 1 Simulation domain

The electric field is generated by a bolt of lightning using a Marx generator circuit to generate an electrical field with time-dependent data imported using MATLAB Simulink. The Marx generator circuit brings about 310 MV of lightning surge [6].

3. RESULT AND DISCUSSION

The factors contributing to changes in the electric field under salinity and without it. The salted condition was chosen by incorporating Sodium Chloride into the simulation settings.

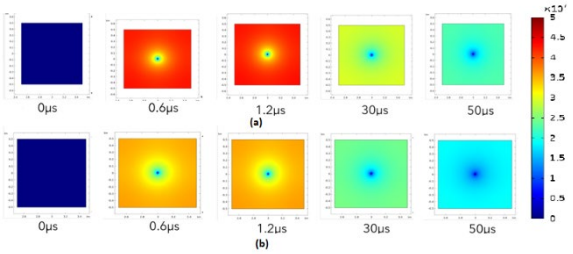

Figure 2 Electric field 2D plot result (a) without salinity (b) with salinity

Figure 2 represents the 2D result for the electric field with and without salinity under the time-dependent range of 0μs-50μs.

Hence, the result from the simulation shows that upward leader lightning propagated from the tip of the wind blade at t= 0.6μs and initiated a peak voltage lightning strike at t= 1.2μs. Simultaneously, according to Figure 3, the peak of the electric field in the simulation is at t=1.2μs is 5.51 MV/m.

Moreover, This result shows in Figure 3 the dielectric constant of sodium chloride [7] given the resistance or insulation to the flow of the electric field and electric potential. The difference of 16% in value for the condition at t= 1.2μs shows the environment also

impacts the electric field phenomenon synchronously with the lightning strikes events.

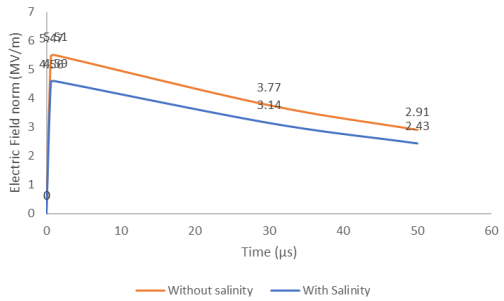

Figure 3 Electric field plot graph with and without salinity

4. CONCLUSION

The electric field changes are minimal, but as the times change, the flow of the electric field makes the lightning strike attracted to it. As another different atmospheric condition is applied, in this situation, salt condition, the experiments and project successfully observed the changes in the value of the electric field. Thus, successfully sync our equation about the permeability of material and electric field

ACKNOWLEDGEMENT

The authors would like to thank Universiti Malaysia Pahang for providing financial support under Research Grant (University reference RDU210320), and financial support under Collaborative Research Grant with Universiti Teknologi Malaysia (RDU192324, No. J130000.7351.4B483).

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