Computation Model of Electrostatic Spraying in Agriculture Industry

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Introduction: Agricultural chemical such as, pesticides are used to protect plants against insects and diseases. Electrostatic spraying can be used for an efficient use of pesticide [1][2]. In this project, electrostatic spray is investigated with intelligent sensors for efficient use of pesticides. As a part of this project, COMSOL model was developed to understand spray properties, in terms of electric field distribution. In particular, FEM model was developed to investigate electric field distribution for charged droplet and grounded targets. Five different shapes of targets (Conical, Spherical, Cylindrical, Flat and Ellipsoid) were investigated.

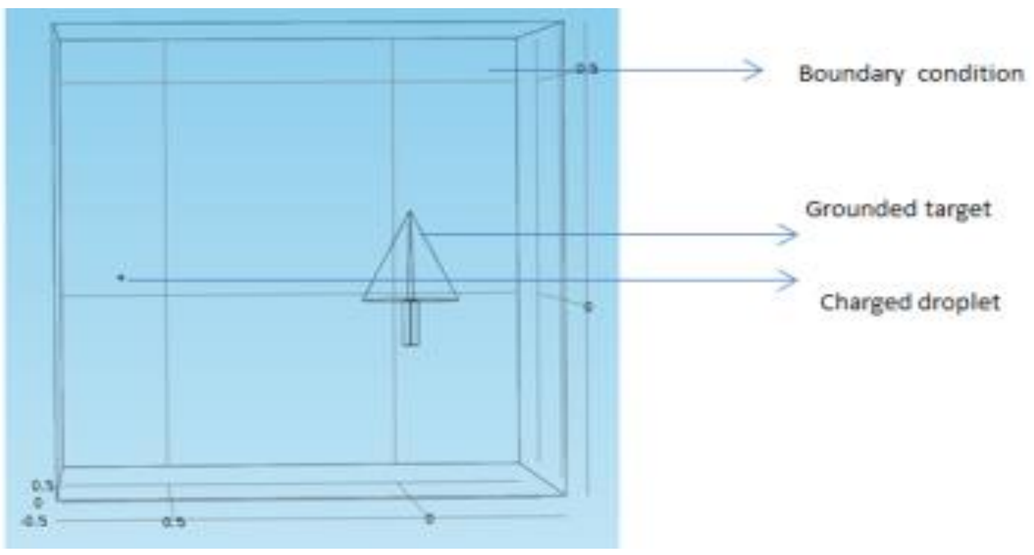

Figure 1. COMOL Model of Charged Droplet and Grounded Target

Computational Methods: Electric static model (es) in the COMSOL software was used to simulate our FEM model. The figure below shows the COMSOL model developed; showing charged droplet, grounded target and grounded boundary box. Size of charge droplet size is 33 µm and surface charge density is 137.5 E-12 C/m2. These parameters were obtained from our experimental work carried out in Brunel University, UK. The height of targets used is 20 cm and the volume of the boundary box is one cubic meter due representing the Faraday cage. COMSOL finite element model (FEM) was solved for the following equations:

$$E = -\nabla V \quad (1)$$

$$\nabla.(\varepsilon_O \varepsilon_r E) = \rho_V \quad (2)$$

Where: E= Electric Field (V/m), V= Electric Potential (V), ε_0 =Permittivity of free space = 8.854 X 10^{-12}(F/m) , ε_r =Relative Permittivity of the air 1.000589, and ρv = Density of Droplets= 10^3(kg/m^3).

Results: The electric filed distribution of the charged droplet-target model for Ellipsoid target is shown in the figure 2. The maximum electric filed achieved, charged-to-mass ratio and induced current in the targets are summarized in the Table 1. Conical shaped target generates highest electric field and a rounded target generates the least electric field. These results will be used in our intelligent sprays so that amount of pesticides can be controlled based on the shape and size of targets.

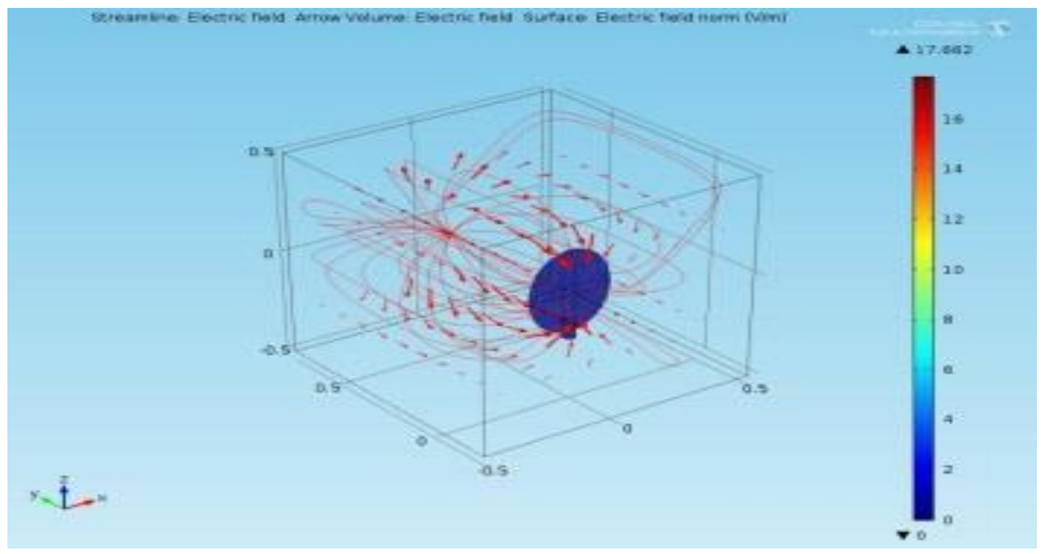

Figure 2. Electric Field Distribution

Type of target	Maximum electric field (V/m)	Charged mass ratio (mC/kg)	Current in the target (µA)
Conical	61.524	14.6	14.892
Flat	24.932	14.2	13.206
Cylindrical	19.928	13.700	11.645
Ellipsoid	17.662	11.8	8.968
Spherical	17.255	8.3	5.694

Table 1: Various Targets and Their Parameters

Conclusions: COMSOL FEM model was developed and simulated to identify the electric field distribution and induced current on different five shapes of grounded targets for a fixed charged water droplet. The results obtained in this work will be used to design and implement smart sprays with sensors to improve the efficiency of the use of pesticides.

References:

[1] Mamidi, V.R., Hanshyam, C., Kumar, P. M. and Kapur, P. “Electrostatic hand pressure knapsack spray system with enhanced performance for small scale farms”. J. of electrostatic. 1 (1-6). (2013).

[2] Roten,R.L., Hewitt,A.J., Ledebuhr, M., Thistle,H., Connell,R.J., Wolf, T.M., Sankar,S and Woodward,S.J.R. “Evaluation of spray deposition in potatoes using various spray delivery systems”. New Zealand Plant Protection 66: 317-323 (2013).