Application and Characteristics of Typical Model of Electromagnetic Field Based on Ansys Simulation

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Abstract. As we all know, in the electromagnetic field model analysis and simulation, Ansys as large general finite element analysis software, has a very important role. In order to better use the ansys model to solve the problem, we build a model on the basis of a uniform electric field. The model is a uniform electric field of the electric field distribution. In the model 2, we add an equipotential body on the basis of it, and compares the analytic solution and the numerical solution of ansys finite element by theoretical approximation. Model 3 is to increase the source area, fill the different media to analyze the different circumstances of the uniform electric field changes.

Uniform Electric Field Model

Basic Description of the Model. As shown in the figure, define a 5m * 5m area, and the region is the same medium and the internal passive area. Set the upper and lower boundaries for the first class boundary conditions, the voltage is 100V, 0V. This can be simplified as a one-dimensional electric field, the potential U is only related to the total coordinate Y, and uniform changes.

According to

$$E = \frac{du}{dy}$$

(1)

It can be seen that the electric field intensity is equal in this region and the electric field intensity E is 10v / m.
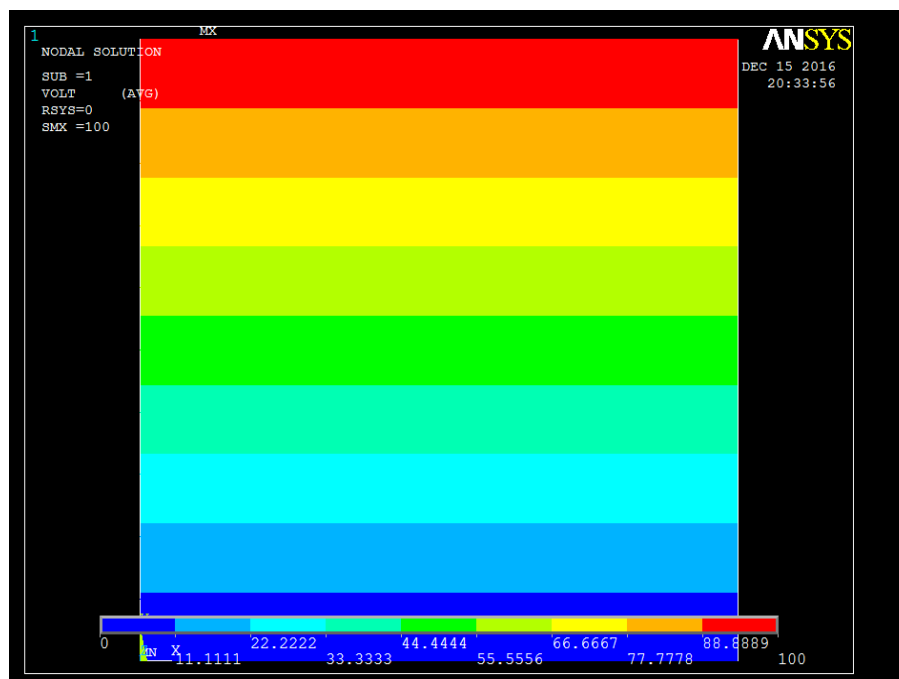
Ansys Simulation and Model Solution Display.

Figure 1. The result of model one

Add a pure conductive cylinder to the 1 model

Basic Description of the Model. On the basis of model 1, model 2 inserts an equal precision conductive column with a radius of 1m in the middle of the region and equals the potential of the equipotential at 50V.

Now the theoretical calculation is used to derive the potential electric field distribution of the model II because the boundary conditions are specified on the cylindrical surface, where we use two-dimensional polar coordinates.

$$x = r\cos\varphi \tag{2}$$

$$y = r\sin\varphi \tag{3}$$

Let the original uniform electric field strength E, only consider the component along the X direction, the cylindrical radius of R. Because at the infinity, the impact of conductive cylinders can be ignored, we are not difficult to get

$$\phi(r \to \infty) = -Er\cos\varphi \tag{4}$$

In order to satisfy the equipotential at r = R, the potential is set to zero. It is necessary to find a solution and the equation Ep.3 to cancel each other and have no effect on the potential at infinity. We take $\dfrac{\cos\varphi}{r}$ as the another solution of the potential ϕ, and its influence at infinity is barely.

And we finally get

$$\phi = -Er\cos\varphi + \frac{A}{r}\cos\varphi \tag{5}$$

It's obvious that the parameter A is an arbitrary coefficient. When we bring into the boundary conditions

$$r = R(\phi = 0) \tag{6}$$

We find that

$$\phi = -ER[\frac{r}{R} - \frac{R}{r}]\cos\varphi \tag{7}$$

According to the equation Ep.6 for the gradient to get the electric field intensity distribution

$$E = i_r E\left[1 + \left(\frac{R}{r}\right)^2\right]\cos\varphi - i_\phi E[1 - (\frac{R}{r})^2] \quad \sin\varphi \tag{8}$$

It can be seen that the electric field is concentrated in the surface of $\varphi = 0, \varphi = \pi$. The electric field in these two places is the largest, and is equal to twice the applied electric field.

Ansys Simulation and Model Solution Display. The model is numerically calculated by ANSYS simulation and finite element method. As shown in the figure, define a 5m * 5m area, and the region is the same medium and the internal passive area. Let the left and right boundary be the first class boundary condition, the voltage is 100V, 0V respectively. Dig a circular hole in the middle, as the potential for the 50v isothere. For its meshing, where the quadrilateral free grid is used. We mainly study the electric field near the circumference of the change, so in the vicinity of the circumference of the grid is more dense, in order to reduce the error.
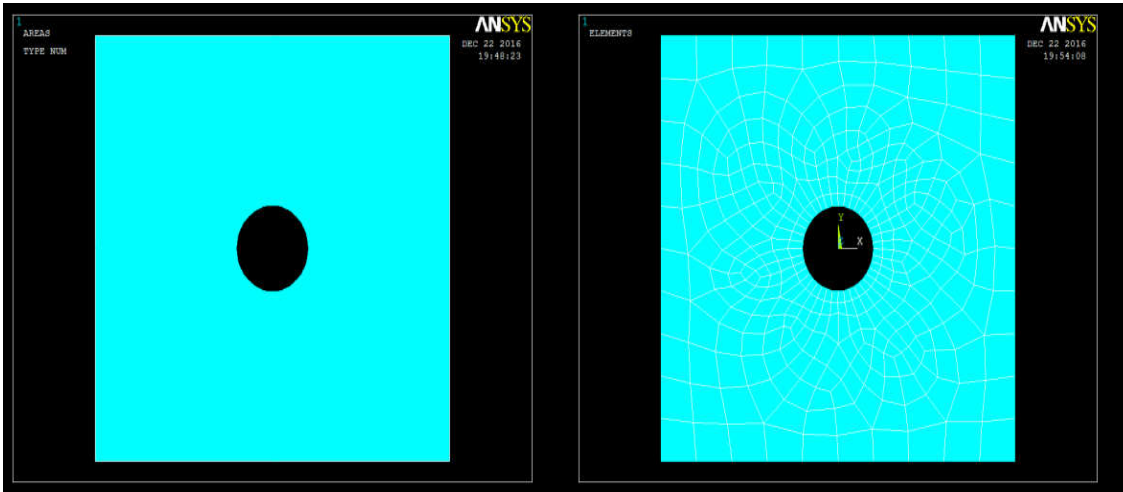
Figure 2.   Model two initial state settings

According to the equipotential map, it can be found that the potential is evenly changed in the area away from the circumference, which is consistent with the pattern of the model. Therefore, the above calculation assumes that the uniform electric field is still valid at infinity. From the figure can also be seen closer to the circle, the greater the degree of linear bending, the more obvious impact.
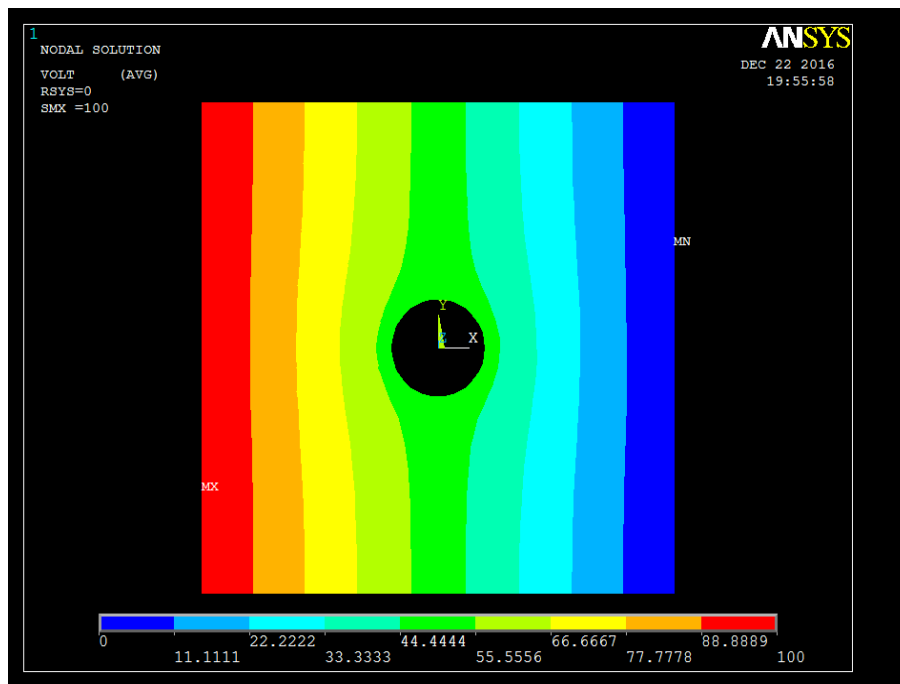

Figure 3.   The result of model two

Comparison of Simulation Results with Calculation Results. Now analyze the intensity of the electric field, from the following figure can be found, the maximum and minimum electric field strength are found in the circumference. According to the above theoretical calculation and numerical results,

Table 1 Comparison of related results

	0°	90°
calculation results [v/m]	20	0
simulation results [v/m]	18.5914	0.018174

Theoretical calculation and the actual solution of the error is very small, especially in the 90 degrees, the error is basically negligible.
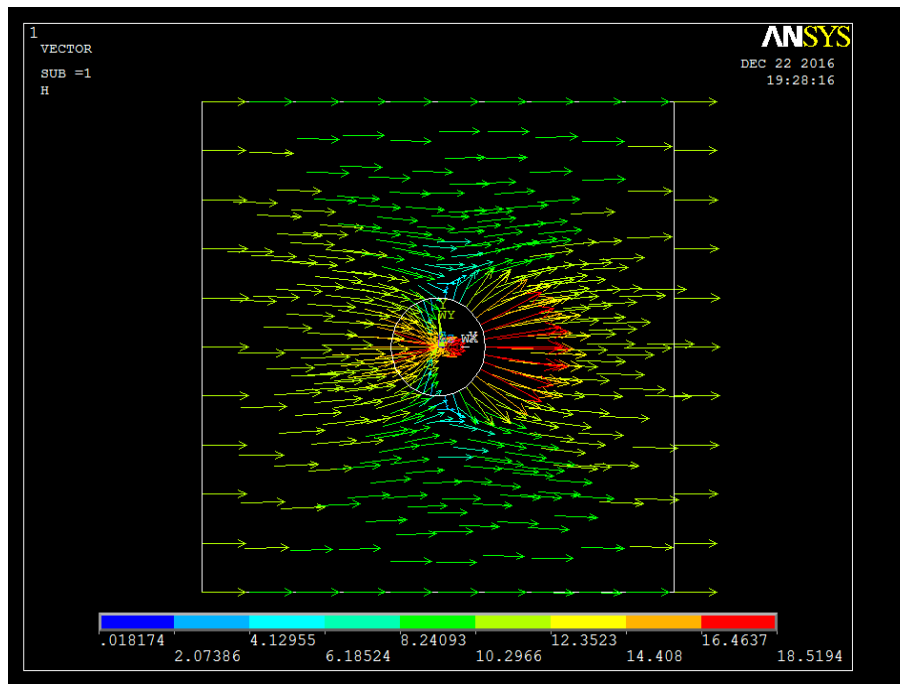

Figure 4.   The result of model two

Changes of Electric Field Potential in Different Media and Presence Source Regions in Uniform Electric Field Research significance

Basic Description of the Model

Still on the basis of the model one to improve, the region is no longer a medium, is also no longer a passive field. The model three discusses the change of the uniform electric field in the presence of the dielectric interface and the source region.

Let the electric flux is the same at the interface of the different media, so the dielectric constant of small electric field strength. And there is a charge density in the vicinity of the source region, the electric field strength becomes larger.

Poisson equation and its boundary condition are expressed as

$$-a\nabla^2 u = f \tag{9}$$

$$U = u_0 \tag{10}$$

$$a\frac{\partial u}{\partial n} = bu + c \tag{11}$$

Where U is the bit function of the space; U0 is the known bit function on the boundary; the parameter a is the equation coefficient (related to the field material); the parameters b and c are the known boundary condition coefficients: the parameter f is the field known source function of the source region in the domain.

Ansys Simulation and Model Solution Display. In the following figure, add a radius of 2 to the circular source area, the upper half and the lower part of the charge medium. Set the boundary to 100V and the lower boundary to 0V. The upper part of the equation coefficient a = 1, the lower part of the equation coefficient a = 2, the source function of the middle area f = 1.
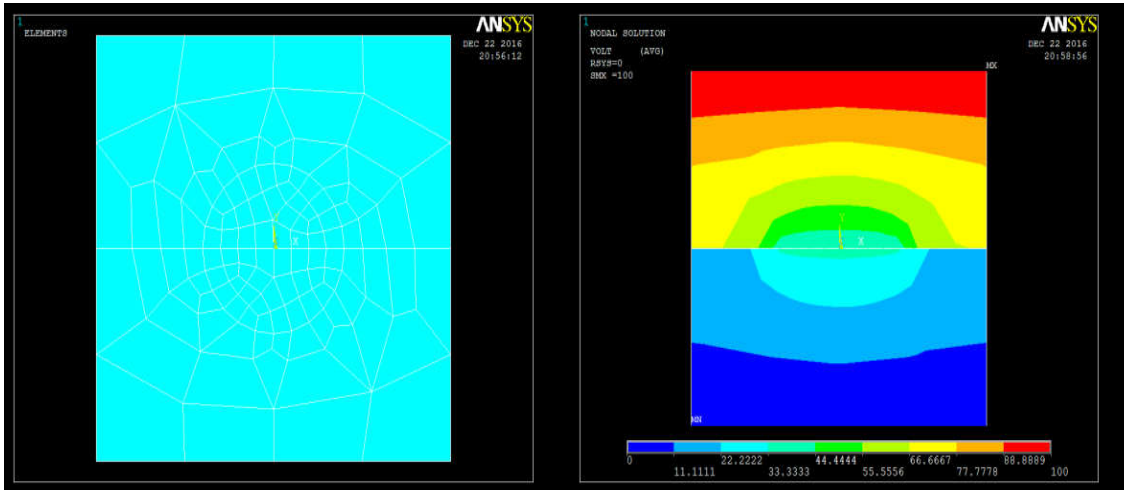
Figure 5.   Model three initial state settings

Through the potential map and the electric field diagram can be found, the potential at the interface of the mutation occurred, the source area of its surrounding a great impact. And the electric field intensity of the upper part is obviously larger than that of the lower part. Compared with the previous theory, the maximum electric field intensity is 28.6344V / m, which is much larger than the maximum value of model two, and the influence of the source region can be found.
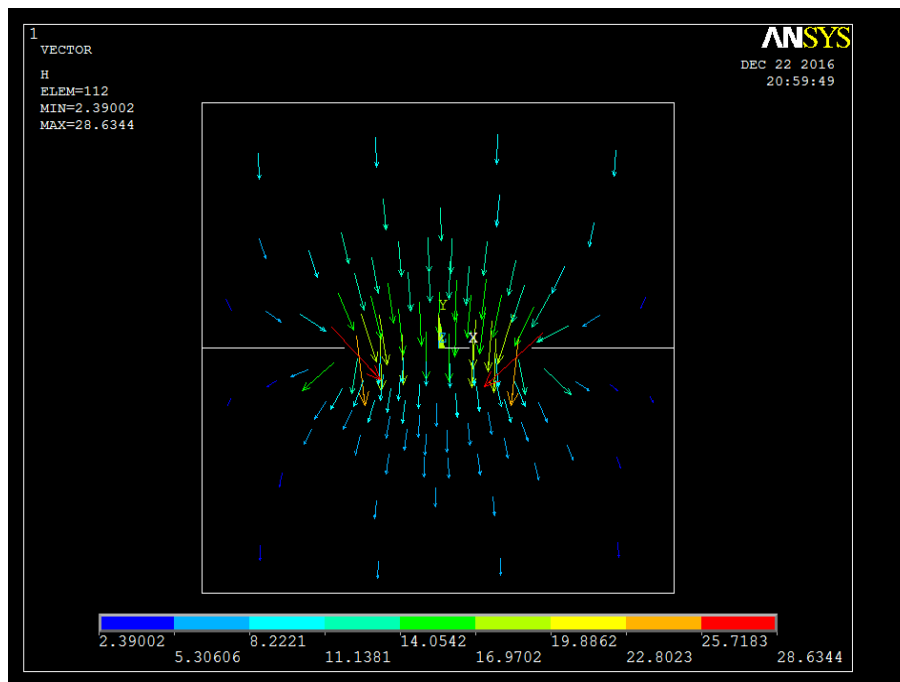

Figure 6.   The result of model three

Conclusion

In the above discussion, we focus on the typical electromagnetic field model, step by step to enrich the model, the first is the theoretical analysis of the corresponding results, followed by the use of professional software Ansys which is to simulate the model. Then we make a comparison, draw the images, and compute the data. Then we compare the simulation results with the calculated results to analyze the errors. And finally get the corresponding results.

Reference

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