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Electromagnetic Analysis of different metallic plates

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Abstract

This paper presents a method for electromagnetic analysis of different metallic plates like parallel elliptical plates, parallel circular plates and parallel square plates. The charge distribution on the conductor is found by solving differential equation by applying finite element method. Numerical results on the capacitance of geometrical parameters are presented. The results for different conducting shapes are compared with other available results in literature.

Keywords: Capacitance, Charge distribution, Circular plates, Elliptical plates, Geometrical parameters, Square plates

1. Introduction

The estimation of the capacitance of different shapes is significant to the study of electromagnetic analysis. The analyses of three dimensionalparallel square, parallel circular and parallel elliptical plates are examined using finite element method. In this paper, the capacitance of the different geometrical assemblies was achieved by subdividing the structure into triangular subsection and computing the charge distribution on each triangular subsection. The usage of triangular subsection to conform basically to several geometrical surfaces or shapes. The capacitance of different conducting structures such as parallel elliptical plates, parallel circular plates andparallel square plates are compare with otherexisting data in literature. Finding the capacitance of a metallic assembly has been a difficulty of historical significance [1-4].

The aim of this paper is to compute the capacitance of simple geometries approximatingparallel square plate, parallel elliptical plate and parallel circular plate by using finite element method. The first geometry to study is a parallel square plate with that there is validated the mesh and the computation of capacitance. The second geometry is parallel circular plate with a radius of 1m designed and the capacitance calculated. In the third geometry parallel elliptical plate is validated the mesh and the capacitance computed [5].

We use COMSOL multiphysics software for designing parallel elliptical plates, parallel circular plates and parallel square plates. COMSOL is a software package used in modelling and simulation of electromagnetic analysis. The finite element method is appropriate for computation of electromagnetic fields [23]. The finite element method has high accuracy and fast computation speed.

The finite element method is simpler and easier process compare to other techniques like the finite difference method (FDM) and the method of moments (MOM). The finite element method is suitable in solving differential equations. Finite element method is a more powerful and useful numerical technique for handling electromagnetic analysis including difficult geometries and inhomogeneous media. The simple models of the finite element method is that the behaviour of a function may be complex when viewed over anenormous region, a simple evaluation may be appropriate for a minor subregion. The entire region is separated into amount of non overlapping subregion named finite element and the function of each element is approximated by the algebraic expression. The algebraic representations are providing continuity of the function [22]. The efficient generalization of the method makes it possible to build general-purpose computer programs for solving a wide range of difficulties.

A simple and effective finite element method is present for electrostatic problem comprising complex geometrical calculated planar conducting bodies. Electrostatic calculation delivers a good summary to numerical results since they are relatively easy to understand. The goal is to find electric forces that act in regions containing distributions of charge. The charge can be distributed in free space, on metal electrodes, or in dielectric materials. In this paper, we concentrate on three-dimensional simulation using finite element methods with triangular elements. This method of capacitance approximation by dividing the conductingsurface into triangular subsection may be extended formon-planar geometrical bodies.Also this method may find significant application for thedetermination of equivalent circuit models of multiconductoror multiwire arrangements used in electronicsystems [21].

The finite element method is nowadays usually used in industrial applications, including aeronautical, aerospace, automobile, naval and nuclear construction. A number of general-purpose computer codes are obtainable for industrial users of the finite element method [20].

2. General Analysis

2.1 Parallel Square Plates

In this paper, Finite element method is used for calculating the capacitance of parallel square plates. Figure 1 shows an identical parallel square plate with a dimension of $1m^2$ and the distance between the parallel plates is 0.05m. We select the parallel plate material as aluminium for simulation. The model is calculated in three dimensional environments in order to compare our results with some of the other available results. The topmost of the square plate has a specified voltage of 1V and the bottommost of the square plate is specified as ground with a voltage of 0V. It is undertake that parallel plates are finished of extremely conductive substantial. When the unit voltage is applied to the object the charge densities nearby the edge of the bodies are much higher than those far away from the edges [19].

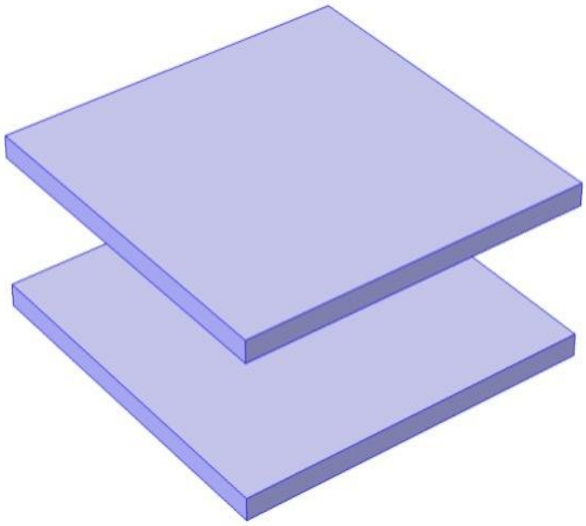

Fig.1 Parallel square plates.

From the model, we produce more number of subdivision like the finite element mesh with 1856 domain elements and 152 boundary elements as shown in Figure 2. The potential distribution simulations agree the better understanding of potential distribution of metallic object [6].

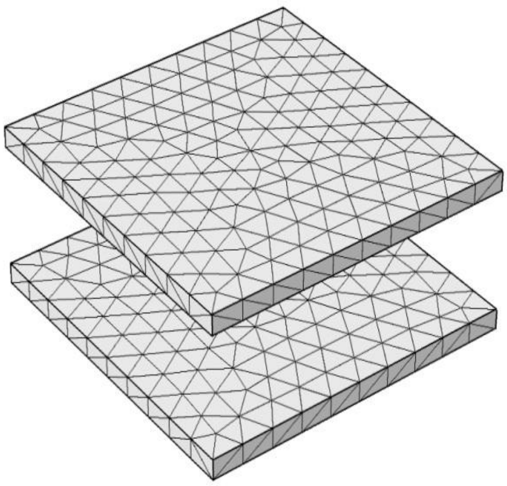

Fig.2 Parallel square plates with triangular subsections.

Figure 3 shows that three dimensional surface potential distribution of the metallic parallel square plates. The potential distributions of inhomogeneous media of metallic parallel square plates are simulated. The potential distribution is uniform between the plates, but variances are seen at the ends of the plates. The potential distribution demonstrations that topmost edge of the square plate having more current flow compare to bottommost of the square plate.

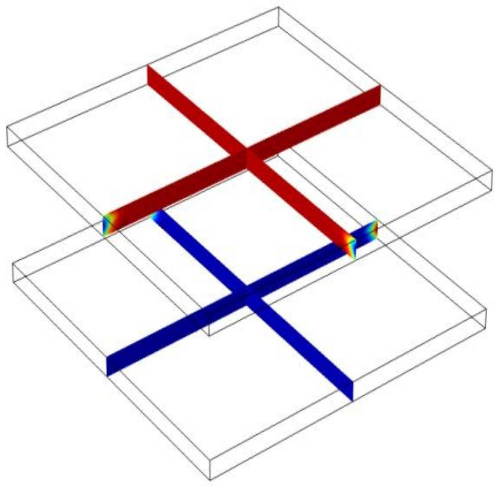

Fig.3 Charge distribution on parallel square plates.

The capacitance values are calculated for some cases such as with respect to variation in number of domain elements and boundary elements. The results are tabulated in Table 1. The capacitance value 28.84pF is obtained for the total number of 1856 triangular subdivisions is equated with the value obtained from the earlier result. As understandable with the increase in number of sections, the results tend to converge and the deviation in analytical and numerical results decreases.

Table 1 Capacitance of square plates

Number of domain elements	Number of boundary elements	Capacitance (pF)
332	64	21.23
536	80	23.51
1156	120	26.81
1856	152	28.84

In this paper we study four different subsections are analyzed. In this study the values are good matching with the available results [9].

2.2 Parallel Circular Plates

In this section, we demonstrate the modelling of parallel circular plate by finding capacitance of the unit length. The capacitance values are calculated for some cases such as with respect to difference in number of domain elements and boundary elements in parallel circular plates. Figure 4 shows an identical parallel circular plate with a radius of $1m^2$ and the distance between the parallel plates is 0.05m. The model is calculated in three dimensional environments in order to compare our results with some of the other available results.

The topmost of the circular plate has a specified voltage of 1V and the bottommost of the circular plate is specified as ground with a voltage of 0V. It is assume that parallel plates are finished of extremely conductive material. When the unit voltage is applied to the body the charge densities nearby the edge of the bodies are much advanced than those extreme away from the edges [10].

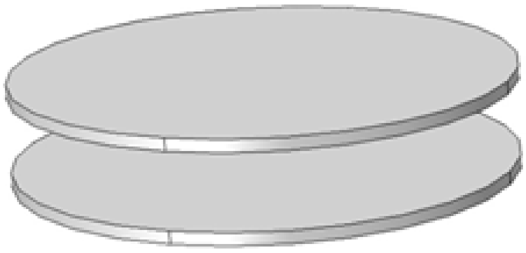

Fig.4 Parallel circular plates.

From the model, we produce the finite element mesh with 1852triangular subsections and 120 boundary elements as shown in Figure 5. Figure showthat three dimensionalview of the parallel circular plates with triangular subsections.

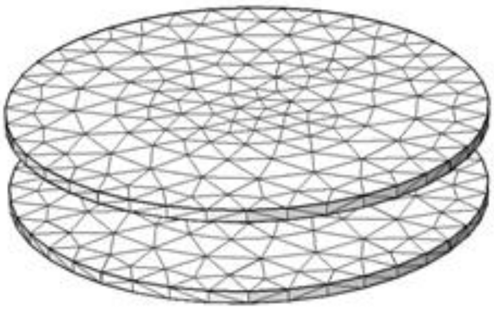

Fig.5 Parallel circular plates with triangular subsections.

Figure 6 shows the potential distributions of inhomogeneous media of metallic parallel circular plate. The potential distribution is constant between the plates, but variances are seen at the ends of the plates. The potential distribution shows that topmost edge of the circular plate having more current flow compare to bottommost of the square plate.

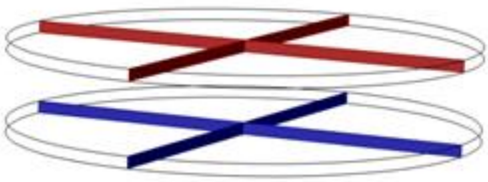

Fig.6 Charge distribution on parallel circular plates.

Table 2 shows the finite element method outcomes for the capacitance per unit length of parallel circular plate compare with the earlier work. The results are good agreement with earlier results. The capacitance worth 45.18pF is obtained for total variety of 1852 triangular subdivisions.

Table 2 Capacitance of circular plates

Number of domain elements	Number of boundary elements	Capacitance (pF)
500	64	41.23
1092	96	43.51
1852	120	45.18

In this paper we study three different subdivisions are analyzed. In this study the values are good matching with the available results [10].

2.3 Parallel Elliptical Plates

In this section, we validate the modelling of parallel elliptical plate by finding capacitance of the unit length. The capacitance values are calculated for some cases such as with respect to variation in number of domain elements and boundary elements in elliptical plate. The outcomes are tabulated in Tables 3.We select the parallel plate material as Aluminium for model. The model is considered in three dimensional environments in order to compare our outcomes with some of the other available outcomes [7-9].
The uppermost of the elliptical plate has a specified voltage of 1V and the bottommost of the elliptical plate is specified as ground with a voltage of 0V. It is assume that parallel plates are finished of extremely conductive material. When the unit voltage is applied to the body the charge densities nearby the edge of the bodies are much advanced than those extreme away from the edges [11].

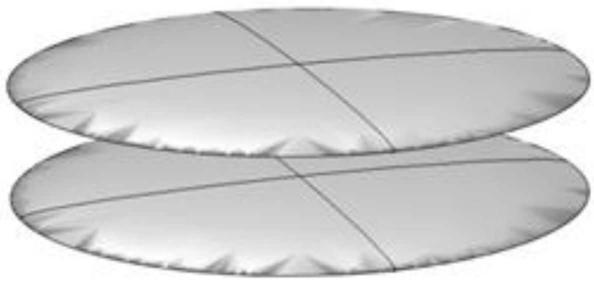

Fig.7 Parallel elliptical plates.

From the model, we produce the finite element mesh with 532 triangular subdivisions and 120 boundary elements as shown in Figure 8.

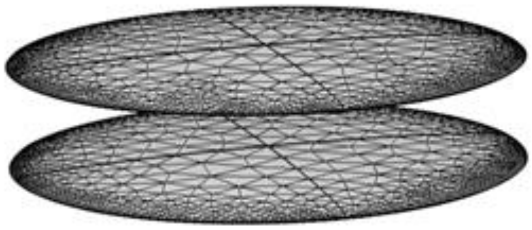

Fig.8 Parallel elliptical plates with triangular subsections.

Figure shows the potential distributions of inhomogeneous media of metallic elliptical plate. The potential distribution is equal between the plates, but some changes are seen at the borders of the plates. The potential distribution shows that top edge of the elliptical plate having extra current flow link to end of the elliptical plate.

The capacitance values are computed for some cases such as with respect to variation in number of domain elements and boundary elements. The capacitance value 39.18pF is obtained for total number of 532 triangular subdivisions and compared with the value obtained from analytical formula for variation in number of segments.Figure 9 shows three dimensional surface potential distributions of parallel elliptical plates.

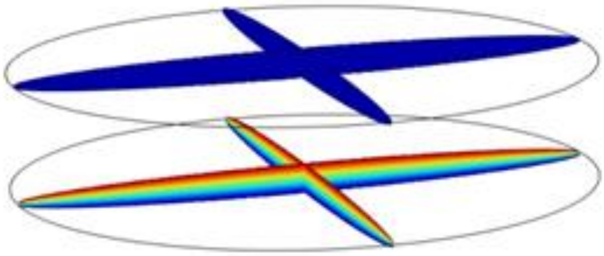

Fig.9 Charge distribution on parallel elliptical plates.

The results are tabulated in Table 3. As obvious with the increase in number of subdivisions, the results tend to converge and the deviation in analytical and numerical results decreases.

Table 3 Capacitance of elliptical plates

Number of domain elements	Number of boundary elements	Capacitance (pF)
328	48	35.23
428	96	37.51
532	104	39.18

In this paper we study three different subdivisions are analyzed. In this study the values are good matching with the available results [11].

3. Results and Discussion

In the present study, the parallel square, parallel elliptical and parallel circular plate models are calculated in three-dimensional (3D) modelling using electrostatic environment in order to compare our results with some of the other existing methods. The results of several geometry are summarized in Table 4 and compare with the earlier results [11-13]. Using finite element method most accurate value achieved. The process outlined using triangular subdivision most accurate value obtained.

Table 4 Comparison of Capacitance

Geometry	C in pF (Present Method)	C in pF
Square plate	28.84	29.34 [9]
Circular plate	45.18	45.37 [10]
Elliptical plate	39.18	39.26 [11]

4. Conclusion

In this paper, a simple and effective numerical method established on Finite Element Method is obtainable for the estimate of capacitance of dissimilar conducting parallel plates analysed. The conducting bodies are separated into triangular subdivisions. We calculated the capacitance per unit length of parallel square plate, parallel rectangular plate and parallel circular plate for model. Some of the results obtained efficiently using finite element method with COMSOL multiphysics software. The result found from software having good equivalent with previous results. So Finite element technique is more suitable for Electrostatic modelling.

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