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Estimation of Electrical Field Distribution in many Dimensions via non Uniform Dielectric

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Abstract:-Insulation systems of power transformers comprise materials of different dielectric constants it has been assumed that in A.C.units only dielectric constants of each dielectric are decisive in distribution of currents and stresses. Charge simulation method has been used in the computations .This paper make a simulation for a cylinder with boundary surfaces containing dielectric materials. For simulating cylinder and boundary surfaces between dielectrics. Infinite line charges have been applied for two dimensional and finite line charges for three dimensional systems.

Keywords*: - Simulation, Electrical field, Distribution, Transformer, dielectric, Computations*

I. INTRODUCTION

The full list comprises three programs for the following arrangements: - cylinder with insulations – plate

- Two not contacting cylinder with single insulation layer each- plate.
- Three contacting cylinders of equal radii and single insulation layer each plate. The following are input data for the programees:

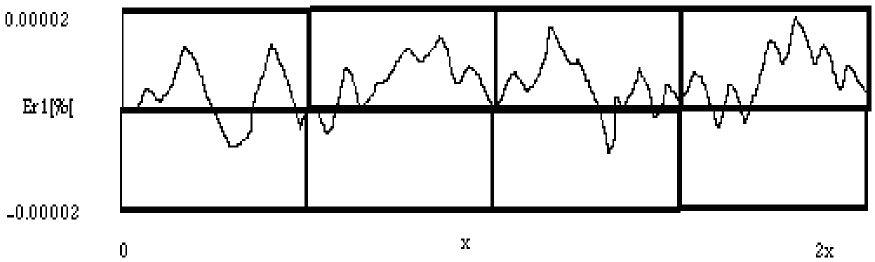
1. Radii of cylinders
2. Radii of insulation
3. Insulation dielectric constant
4. Environment dielectric constants
5. Gap between insulation and plate
6. Potentials of cylinders

To assess accuracy of the selected arrangements the following two indexes have been introduced:
a. Er_1- error due to inaccuracy of the electrode approximation – defined by equation (1)

$$Er_1 = v_1 - v_2 / v_2 * 100\%$$

(1) Where: V1 –calculated potential on the electrode surface, V2 – set value of electrode potential
b. Er2 – angular displacement of field strength vector expresses in radians vector displacement (calculate on cylinder surface) from normal on the cylinder surface

The indexes are calculated along the cylinder circumference and are indicative for the shape of simulated cylinder surface. To give an idea of the results. The Er1 and Er2 values for an arrangement of three cylinders with insulation – plate of the following input data radii of cylinders 5mm, radii of insulation is 10mm, gap between insulation dielectric constant is 3.5, environment dielectric constant 2.2, potential of cylinder are 1000 kV, 900kV and 800kV respectively has been shown in Fig. No.1.



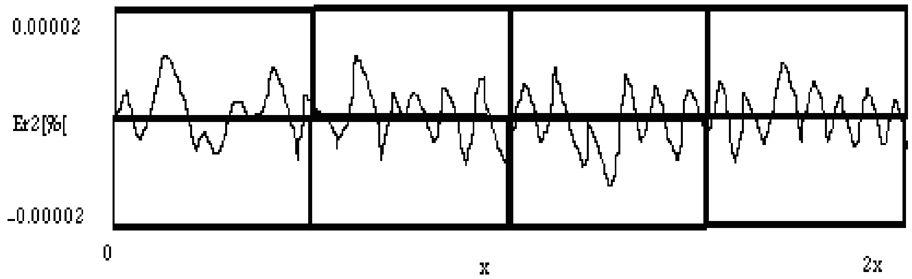


Fig.1. Er1 and Er2 for highest potential cylinder

A comparison of maximum field strength computed Emax1 and calculated analytically Emax2 [2] for several cylinder- plate arrangement has been made (Table 1). Input data of these arrangements cylinder radius (Rw), insulation radius (Ri), gap between insulation layer and plate (D), insulation dielectric constant (3.5), environment dielectric constant (2.2), cylinder potential (400 kV).

1. Emax1 and Emax2 for several cylinder- plate arrangement

lp	Rw [mm]	Ri [mm]	D [mm]	Emax1 [kV/mm]	Emax2 [kV/mm]	Error [x]
1	5	10	100	12.3	12.3	**0.195**
2	5	10	90	12.7	12.7	**0.055**
3	5	10	80	13.2	13.3	**0.099-**
4	5	10	70	13.9	13.9	**0.288-**
5	5	10	60	14.6	14.7	**0.509-**
6	5	10	50	15.7	15.8	**0.790-**
7	5	9	100	13.5	13.5	**0.535-**
8	5	8	100	14.8	14.9	**0.671-**
9	5	7	100	16.6	16.7	**0.538-**
10	**5**	**6**	**100**	**19.1**	**19.1**	**0.198-**

Table 1. Error = Emax1 – Emax2/ Emax2*100% **(2)**

An image of the equipotent lines of selected spacing (relative to maximum potential) in selected arrangement parts is available by means of the programmes. It is also possible to determine potential or components and resultants of the electric field strength at any field points Fig.2 is an illustration of Equipotent lines in the presented arrangement of three cylinders.

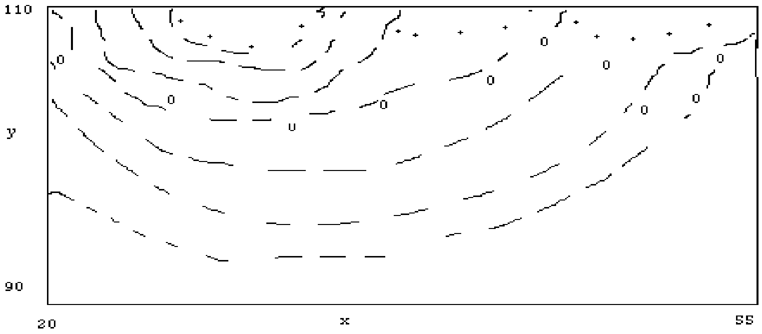


Fig.2. Electric field distribution in a three cylinders-plate arrangement. Equipotent lines are spaced with a step of 2.45% max. potential * , - cylinder surface outline, 0 - dielectric boundary outline.

II. PROGRAMME FOR COMPUTING ELECTRICAL FIELD DISTRIBUTION IN THREE DEMENSIONAL YSTEM

The computations have been performed for the arrangement of two cylinders with single insulation layer each. Any radii of cylinders, insulation and insulation dielectric constants may be specified position of the cylinders in OXYZ Cartesian coordinates are defined as: first cylinder axis coincides with OY, - second cylinder axis is perpendicular to and crosses OX and is at an angle a to OXY plane (skew angle)

The presented arrangement is simulated by finale line charge of variable length, spaced on cylinder surfaces of radii dependent of the radii of cylinders and insulation. The following are input data for the program:- radii of cylinder. – insulation layer radii and dielectric constant, - gap between insulation layer determined along OX axis, - potential of cylinders.

Estimation of accuracy of electrode approximation has been based on an analysis of the above defined error (Er1).

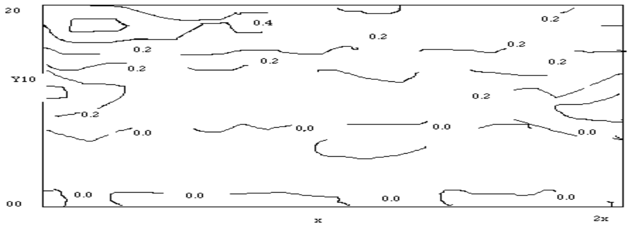


Fig. 3. distribution of electrode approximation errors [%] for the first cylinder surface.

Three dimensional character of the arrangement calls for special presentation of the index. The error has been determined for points spaced on the cylinder circumferences at $0.05{*}x$, for Y coordinates from 0 up to 20, in 0.5mm steps. The arrangement under consideration is characterized by the following input data: first cylinder radius is 2.45 mm, radius of insulation on first cylinder is 3.45 mm second cylinder radius is 3 mm, radius of insulation of second cylinder is 4.45 mm, gap between insulation layer is 12 mm, skew angle of cylinders is $2/9{*}\pi$, insulation dielectric constant is 3.5, environment dielectric constant is 2.2, potential of first cylinder is 98 kv, potential of second cylinder is 0.00 kv,

Fig.3. presents distribution of electrode approximation error in form of equivalent error lines. The X axis corresponds to points along the circumference (0.0 coordinate corresponds to points on generating line of the cylinder, passing through OX axis. The Y axis corresponds to points along the cylinder height. Error exceeding 0.59 is confined to limited areas only, but in the area of the maximum proximity of the cylinders the error does not exceed 0.2%.

An a result of the computation it is available to get an image of Equipotent lines in any arbitrary selected to dimensional area. Fig.4. is a presentation of the distribution of equipotent lines for the arrangement in question and for the planes determined by y = 0.0, Y = 2.45 and

Y = 5. It is also possible to determine for any point of the arrangement the potential or three components and resultants vector of the electric field strength.

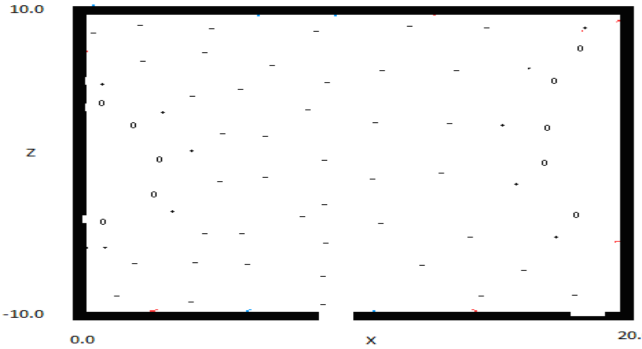


Fig.4A

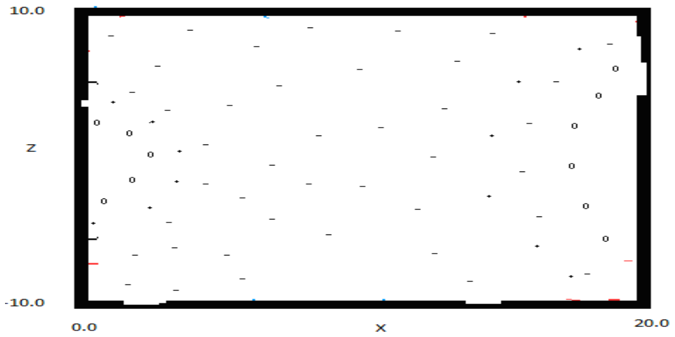


Fig. 4B.

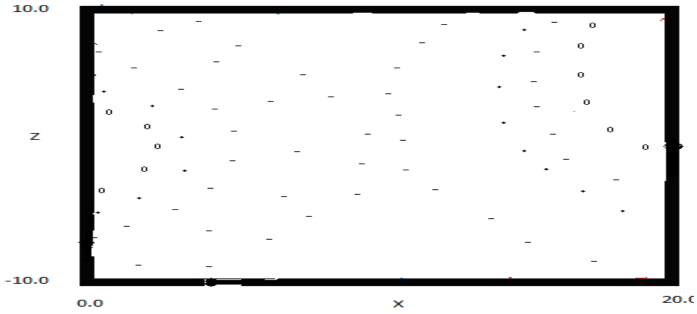


Fig. 4 C,

Fig.4. Electrical field distribution on place A, y = 0, in place B, y = 2.5, and in C = 5 for skew cylinders in space with 10% potential difference between cylinders * , - cylinder surface outline, 0 dielectric boundary outline..

III. CONCLUSION

The presented programmers may applied for the estimation of withstand abilities of outlet insulation systems of power transformers. Accuracy of field approximation of three dimensional systems is better than 0.58% for potentials and is lower by an order for field intestines', as large number of liner equations is involved, the computation time is strongly affected by configuration of the computer hardware involved.

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