The Analysis of high-Voltage Electric Field Stress in L_p and L_s coils of Tesla Transformer for studying the efficiency design

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Abstract

This article presents The Analysis for high-Voltage Electric Stress in Lp and Ls coils of Tesla Transformer for studying the efficiency design. The tesla transformer is designed at 350kV rating Voltage and 120 kHz resonant frequency. The effect of high voltage when we designed the coil has impact to Electric Stress between primary and secondary coil because the tesla transformer uses air core. The insulator of coil also has problem on the reason as flashover on the 2 coils. The best dimension among coil has to present in this paper by using optimal mathematical solution. The simulation results show performance of the solution and ensure the methodology with positive way.
Keyword: Insulation, Electric Field Stress, Tesla Transformer

1. Introduction

High Voltage High Frequency Transformer is the Tesla transformer that created the high voltage high frequency in the moderate. Assemble with the 2 sets of coil that in the central. There are Primary Coil which is only few winding and Secondary Coil which would wind with the PVC tube and would have more winding than Primary Coil. Another component of circuit is the distributors of High Voltage (HV) which can be use both electric direct current and electric alternating current. It can adjust the value of the high voltage around 0-15kV.

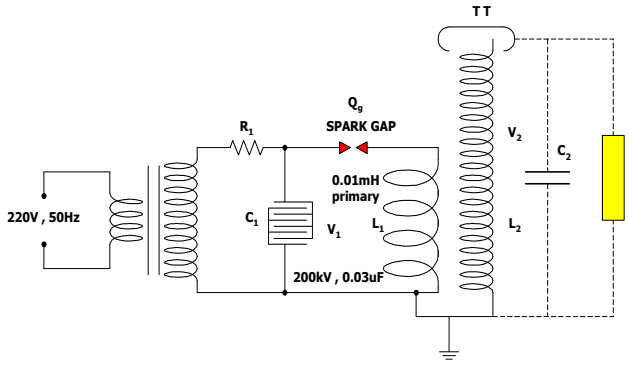

Figure 1:The base circuit working of Tesla Transformer

Therefore the creation of Tesla Transformer design in each time, it cannot notice the value of the electric field stress which is occur between high voltage at the cuping or induce between primary and secondary coil. The design it should has analysis finding the electric field stress in the coil that pulling one another which would find the value of the distance of the 2 coils that would suitable for bring to created the Tesla Transformer. For the Electric Field Stress Analysis in this research will analyze finding the value of parameter model. According to the Tesla Transformer size 350 kV Frequency 120 kHz

2. The model and electric field analysis

The analysis finding the value of eclectic field stress from this research will use the FEMLAB analysis program or Finite Element Theory for analyses. By reproduce from the Tesla Transformer which has high voltage size 350 kV Frequency 120 kHz. Reproduce the Electric Field Stress at 2 set of coils in tesla transformer which would lead to the arrangement or the suitable point of the coil arrangement so that it could be efficiency for the prevention installation.

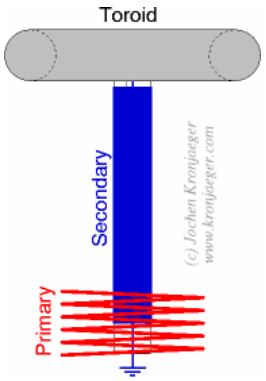

Figure 2:The Arrangement of 2coils set of Tesla Transformer

To wind the high voltage winding, it would wind as the table by using tube which has a real diameter that equal to 6 inches. Therefore while compare the ratio it will high 24 inches. It would use wire winding for the whole tube without the insulation at the central which can find the value of induce by equation 1

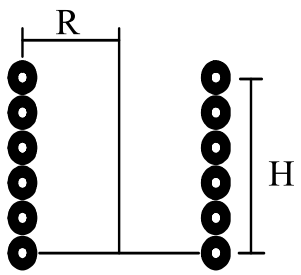

Figure 3 : Showing the High Voltage Winding of Tesla Transformer

Figure 4 :High Voltage Winding which winding with the 6 inches PVC Tube

To create the low voltage at 90 degree by bringing the copper tube size 5/16 inches. The copper is thick 0.03 inches. There would winding on the vertical floor by has a distance from the central of the tube. Each one would wind ½ inches.The distance between low voltage and high voltage will high equal to 3 inches. The distance R is equal to 6 inches. Distance H is equal to 7.5 inches and it would wind totally 10 rounds which would find induce from:

$$L = \frac{(NR)^2}{9R + 10H} \qquad (1)$$

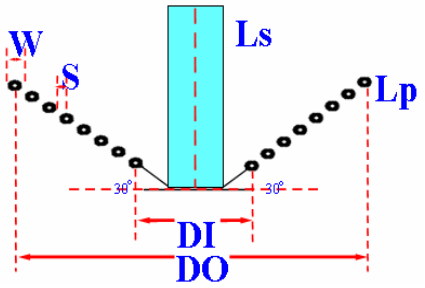

Figure 5 :Show the Primary Coil of the Tesla Transformer in the row 30,45 degree

To create the low voltage of tesla transformer in the row 30, 45 degree by bringing the copper tube this is size 5/16 inches. The copper is thick 0.03 inches. There would winding on the spiral floor by has a distance from the central of the tube that would wind ½ inches. The distance of first low voltage and high voltage will high equal to 3 inches. The distance DI is equal to 14 inches. The distance W is equal to 0.31 inches ,S equal to 0.5 inches and it would wind totally 10 rounds which would find induce from:

$$L = \frac{(NA)^2}{30A - 11DI} \qquad (2)$$

When $A = \frac{DI + N(W + S)}{2}$

Figure 6 :Show the Primary Coil Winding in the corner at 0 degree

To create the low voltage on the flat at the 0 degree which will bring the copper tube that size 5/16 inches. The copper is thick 0.03 inches. There would wind on the flat floor by the distance from the central of the tube that would wind ½ inches. The distance of first low voltage and the high voltage will high equal to 3 inches. The distance R is equal to 9 inches. The distance W is equal to 5 inches and it would wind totally 10 rounds which would find induce from:

$$L = \frac{(NR)^2}{8R + 11W} \qquad (3)$$

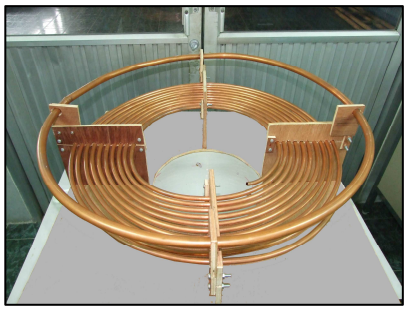

Figure 7 :Show the Model of Primary Coil Arrangement at the 0 degree

Figure 8 :Show the Model of Primary Coil Arrangement at the 30, 45 degree

The model of electric field distributor at the high voltage frequency insulation using the rule of finite element method. FEMLAB program will specify the electric voltage at the low voltage which has electric voltage 15kV and the high voltage winding has the electric voltage at 350 kV and permittivity value (ε_r) of PVC tube equal to 3.5. By the model of electric field compare the corner at the low voltage winding and high voltage winding at 90, 45, 30 and 0 degree. The result of electric Field Model which is show on figure 9-12

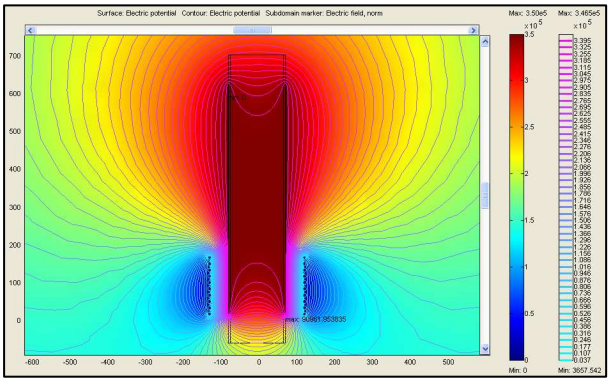

Figure 9 : The Result of Electric Field Distributor by the corner at the low voltage winding meet with the high voltage winding at 90 degree. There would has the most high value of electric field equal to 90.961 kV at the beginning of the high voltage winding

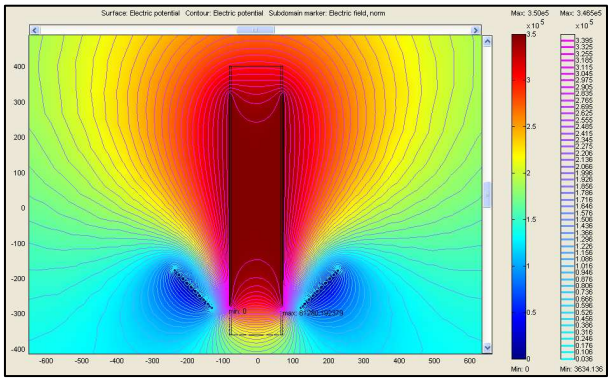

Figure 10: The Result of Electric Field Distributor by the corner at the low voltage winding meet with the high voltage winding at 45 degree. There would has the most high value of electric field equal to 61.280 kV at the beginning of high voltage winding

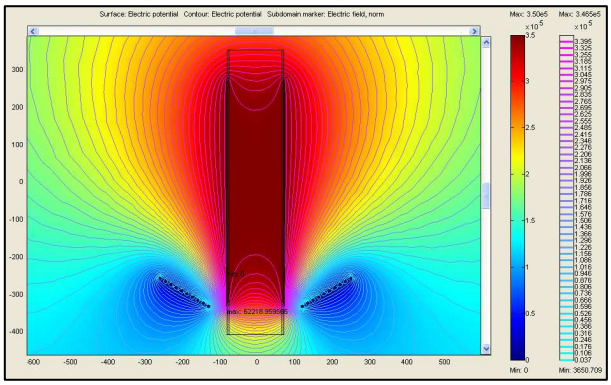

Figure 11:The Result of Electric Field Distributor by the corner at the low voltage winding meet with the high voltage winding at 30 degree. There would has the most high value of electric field equal to 62.218 kV at the beginning of high voltage winding

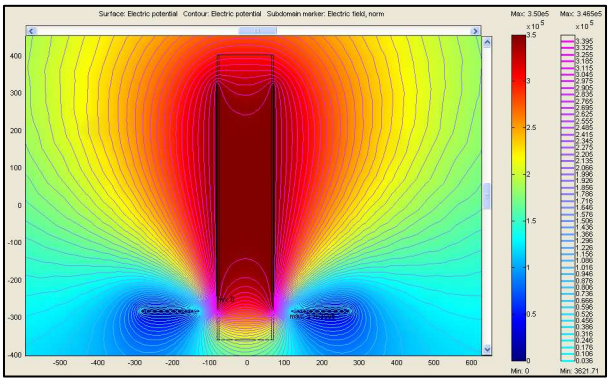

Figure 12:The Result of Electric Field Distributor by the corner at the low voltage winding meet with the high voltage winding at 0 degree. There would has the most high value of electric field equal to 216.390 kV at the beginning of high voltage winding

3. The Result of Tesla Transformer Model

From the calculation which is using the equation. When replace with the value it would get induce 7.04 mH and while we bring the wire coil to measure with the measure equipment. It would be induce at 6.801 mH which is the value will less than model that has create before but it would not has bad result. In another hand, it would be a good result because it would create more frequency distributor in the high voltage winding. It would contain electric which can find from the 3rd equation is

$$C_S = 0.29H+0.41R+1.94\sqrt{\frac{R^3}{H}} \qquad (3)$$

When

C_S= Electric Contain

R = The radius of axle to the central of the wire, inches

H = The high of the distance which is winding, inches

Instead

$$C_S = (0.29\times 24)+(0.41\times 3)+1.94\sqrt{\frac{3^3}{24}}$$

$$= 10.248 \quad pF$$

A Part of Electric Distributor, it would enter from the low voltage model by using the electric transformer with neon lamp at size 220/15kV. It will distribute the electric from the primary coil by bring it to parallel so that it will give more electric power by:

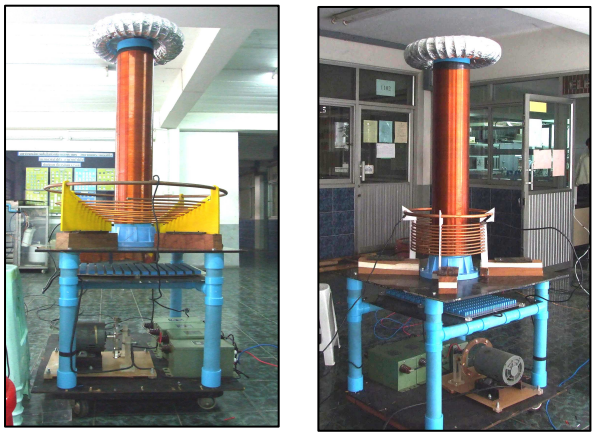

Figure 13 :The Model picture of Tesla Transformer from the Electric Field Analysis for the Primary Coil Arrangement (L_p) in several characters. Assemble 4 dimensions by create to be the Tesla Transformer Model size 350 kV 120 kHz

4. The Summary of the Analysis Result

From the Electric Field Analysis in the 2 arrangement design of tesla transformer. In summary, the arrangement of wire coil which would be safe for the Flash Over on the wire coil. The wire coil would corner to the high voltage 0 degree but the Electric Field Stress that happen in this field will occur high at the beginning of the coil which would result to create Flash Over around base or in the other point. The wire coil that put in the 90 degree would has a chance to create Flash Over from the wire coil. From high coil to the low coil which would get only the electric field stress. The analysis will has high value in the 30, 45 degree that is the result for the suitable point for putting the wire coil. The coil should at the right corner which would more safety.

5. References

[1.]Boonseng, C.;Apiratikul, P., “A low cost approach to the design the Tesla Transformer for testing of insulating materials”, Electrical Insulating Material, 2001.(ISEIM 2001). Proceding of 2001 International Symposium on 19-22 Nov.2001 Pag (s) : 332-335

[2.]Boonseng, C.;Apiratikul, P.; Phanomsarnrin, C., “A low cost approach to design the Tesla Transformer for testing of insulating materials and industrial application”, Electrical Insulation,2002. Confernce Record of the 2002 IEEE International Symposium on 7-10 April 2002 Pag (s) : 248-251

[3.] Kuffel,E.,&Abdullah,M.,High-Voltage Engineering, Pergamon Press, 1977.

6. Biographies (Optional)

Somkieat Thongkeaw received his B.s.Tech (Electrical Technology) and M.s.Tech (Electrical Technology) degrees from King Mongkut’s Institute of Technology North Bangkok (KMITNB.) and M.Eng (Electrical Engineering) student at RMUTT.,Thailand. He has worked as lecturer at the Department of Electrical Power Engineering of RMUTP.,Thailand. His main research interests are applications of high voltage Technology and high voltage applications

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