Analysis Of Corona Ring with FEMM along with insulator hardware testing in 400KV Transmission Network.

Jayshree.A.Pipare
Department of Electrical Engineering
G.H Raisoni College Of Engineering
University of Nagpur, India

Prashant.P.Jagtap
Department of Electrical Engineering
G.H Raisoni College of Engineering
University of Nagpur, India

Pawan P. Khandalkar
(Department of Electrical Engineering)
Marketing manager
Ramelex pvt.ltd Pune, India

Abstract – This paper represents, Prototype development of 400KV Corona Ring suitable for ACSR Moose conductor. It contains analysis on prototype of corona ring . PD activities from the insulator end is the results of improper design of the corona ring. Here Corona ring installed on Insulator hardware fitting , is designed to reduce Corona discharge on Insulator string as well as on Conductor. Performance of corona ring must be within the safe range of corona discharge which depends upon amount of electric field. This paper includes study of analyzation of Static,temperature –windload effects on the body and analyse material properties. Along with this, Mechanical and Electrical test are carried out on Suspended Insulator Hardware fitting in the NABL Accrediated Laboratory.Corona Ring functions are to intensities on the Fix on Conductors should be reduced by optimizing their surrounding wind load effects on structures. Corona ring is design in order to avoid Sound wave effect and electric field, improve the reliability and flexibility of the transmission network. In this study 3-D computational models of Insulated Corona ring have been constructed to calculate the fatigue strength and electric power loss distributions .

Index Terms – Corona Ring, Static Analysis, FEM Analysis using HYPERMESH, Disc Suspended Insulator, Fatigue Strength.

I. Introduction

According to today's power system scenario power demand is increasing day by day. So to meet the demand, effective generation and supply of electricity is required. When it comes to healthier and stronger power system, it is very required to consider the transmission system with minimum losses of energy, In order to minimize transmission line losses the power transfer at **higher** voltage level is to be done. Along with the transmission losses, corona formation is to be considered, since corona is more effective to high voltage transmission system. Corona formation takes place due to the voltage gradient near to the conductor exceeds the breakdown strength of air, for which Corona ring plays a one of the major role in Insulator Hardware fitting and it is used to improve the performance of insulator string. It reduces electric field stresses and minimize the corona discharge on insulator string. For non-ceramic insulators, the maximum electric field suggested by IEEE task force is 0.45kV/mm which is adapted as a criteria in this study. Corona ring distributes the electric field values such that the maximum electric field value is below corona inception limit of air. Corona rings are essential to be installed in transmission lines with system voltage of 230 kV or above.

For static analysis, 3D modelling is done using solid works and Thermal conductivity, Electrostatic analysis is figured out using FEM analysis using HYPERMESH. Mainly , it involves parameters to be considered as input to the product by using element node analysis. Temperature and wind loads are given as a input to the corona ring while doing analysis. Secondly, Indoor test involves testing of insulator hardware fitting suitable for ACSR Moose conductor used to figured out Mechanical test as Tensile strength test, Slip strength test and Electrical test as Magnetic power loss test to ensure the performance of insulator hardware which is coordinated with corona ring in the context for Insulator and Conductor to fulfil requirements as Mechanical strength, Protection to conductor, Power system efficiency , Reliability and performing trouble free continuous operation of transmission network.

II. SCOPE OF THE STUDY

This paper covers the overall setup for design of Corona ring including Single suspension hardware suitable for ACSR moose conductor, requirement for mechanically and electrically tested Substation hardware installed on transmission network. It is mainly intended to cover Analysis on Corona ring, along with this Type testing of insulator hardware. It may be applied to Substation hardware in order to fulfil manufacturer's and end user's requirement and to reduced the corona loss on Surface of Insulator and Conductor.

III. METHODOLOGY

This paper represents need of Static Analysis of the Corona Ring for the proper mechanism of Transmission Network. So by using Hypermesh software, Corona ring is design and material properties are studied and analysis as a simulation to find the effect of various parameter on real time performance of Corona ring. Due to which we can predict the critical zone which may can occur by applying variable load to the system. This analysis help in determining outcomes for future scope of studying regarding corona ring.

It also covers overall development of product including laboratory testing performed in NABL accridiated lab of Insulator hardware used

in 400 KV Transmission Network. For the development of product, conductor and insulator properties are made to be considered.

PROPERTIES OF CONDUCTOR

Steel reinforced aluminium conductor is comparatively light and is usually strung to fairly high tensions, so it is quite susceptile to give mechanical strength and support, therefore this type of conductor requires special protection by the use of insulator hardware.

CONDUCTOR:	ACSR, 3.53 mm
DIAMETER:	31.77 mm
STRANDS	AL-54,ST-7
MASS PER UNIT LENGTH	2.0015 kg/m
R.T.S	159.71 KN
TENSION	25% R.T.S
CURRENT CAPACITY	600 A/CONDUCTOR FOR 400 KV.

PROPERTIES OF INSULATOR :

Insulators are required to support the line conductors attached to the hardware fittings provides support and holding mechanism to the conductor.

DESCRIPTION	TECHNICAL PARAMETER
RATED VOLTAGE	400 KV
INSULATING MATERIAL	BROWN COLOUR GLAZED PORCELAIN DISC
IMPULSE WITHSTAND VOLTAGE	1425 KVp
CORONA EXTINCTION VOLTAGE	320 KV rms
TYPE	SOLID CORE
MAXIMUM RADIO INTERFERENCE VOLTAGE	500 KV

A] DESIGN PROCEDURE

Single suspension hardware is designed to persue the need to provide mechanical characteristic to support the conductor and insulator to fulfil their working operation in transmission

Network as well as Corona ring is design to Minimize corona effect on insulator surface. Proper design helps us to meet demand to actuate the transmission line operation. Need of design functions to acquire accurate result for analysing the real time performance of insulator hardware fitting and Corona ring. Hardware fitting including corona ring are designed using tools such as AUTO-CAD (2007 version) and SOLID-WORKS (ST9).

AUTO-CAD contributes in 2D modelling of the hardware where as SOLID-WORKS is required for 3D modelling to provide overall details of product for reference.

Design of Product shall be such as to ensure uniformity , high strength , and freedom from corona formation and high resistance against corrosion. Along with this design of fittings should be furnished surface of all parts .

. In this way Development and Design are to be done to ensure that the product can be made in the most cost effective way while meeting customer requirements and technical specification and to increase .longlife span of transmission line by minimizing causes of failure .

PROTOTYPE DESIGN

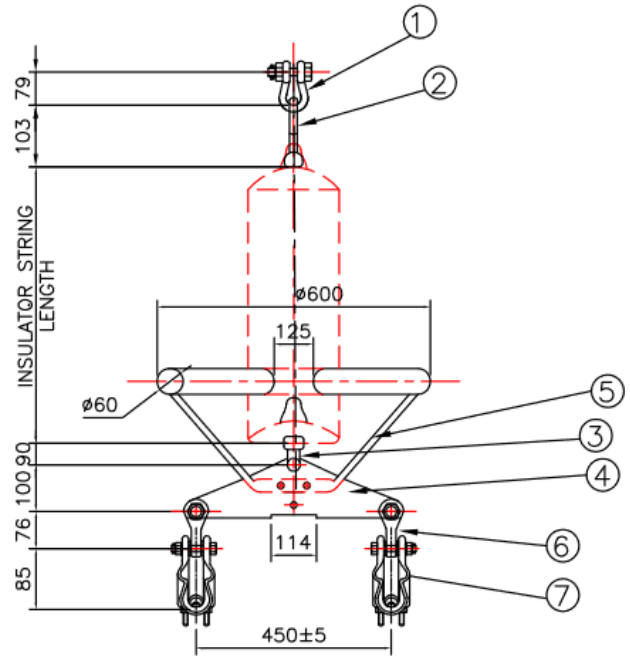


Fig. Single Suspension Insulator Hardware assembly.

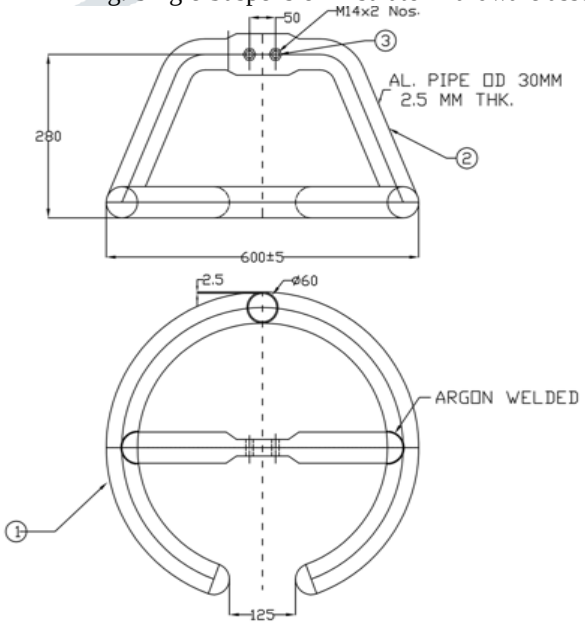


Fig. Corona ring for insulator hardware assembly.

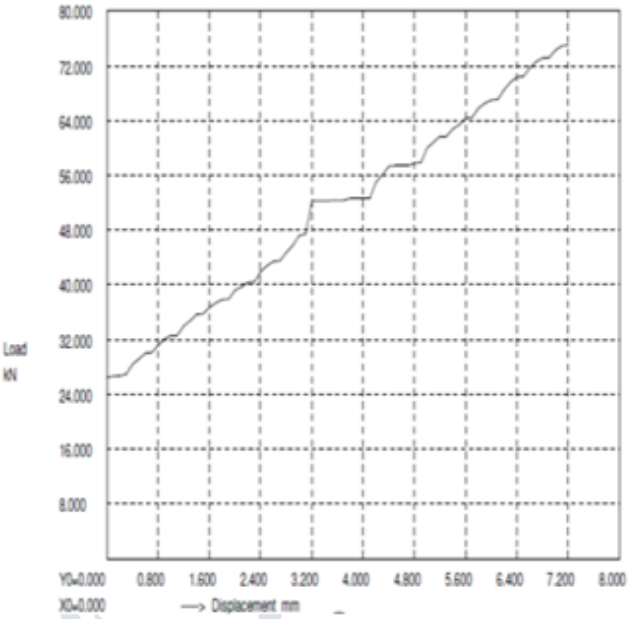
B]. MANUFACTURING PROCEDURE :

Material Selection :
Material required for suspension hardware must be forged type to withstand necessity of providing mechanical strength which is an critical aspect for development of product. As well as yield strength of the material shall not be less than maximum working load then only it is possible to sustain the load due to environmental causes and defective errors.

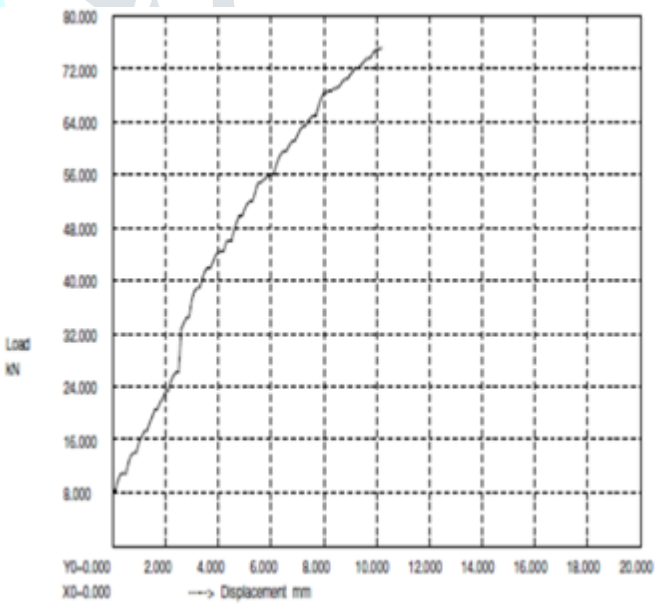
Material used for Corona Ring:
Corona ring is made up of Aluminium Alloy 6063. Aluminium alloy 6063 is a Aluminium alloy, with magnesium and silicon as the alloying elements. It has good mechanical properties and is heat treatable and weldable.
6063 is the most common alloy used for aluminium extrusion.

Properties of aluminium alloy 6063:

Density	2.69 g/cm
Young's Modulus	68.3 GPa
Tensile Strength	145-186 mPa
Elongation at break	18-33%
Volume resistivity	30-35 n-ohm
Aluminium	98%
Alloy	2%



LOAD Vs DISPLACEMENT FOR SAMPLE -1



LOAD Vs DISPLACEMENT FOR SAMPLE -2

IV.LABORATORY TESTING Of INSULATOR HARDWARE FITTING

Type test should be carried out on hardware components according to IS 2486 (PART-1) are offered conforming to technical specifications and relevant IS . Three samples are needed for Mechanical test carried out in NABL accrediated laboratory. Mechanical tests are carried out to find tensile strength,slip strength, ultimate strength to analyse the performance with quality to withdraw experimental results suitable in all index provided.

Tests held in the laboratory are such as

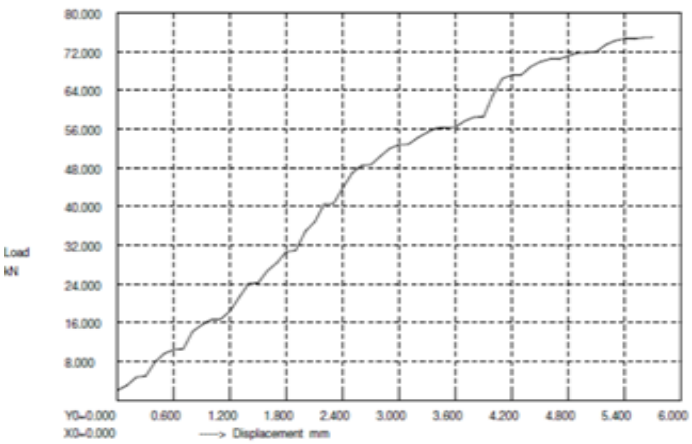
MECHAICAL STRENGTH TEST

For Insulator string fitting according to IS (2486-part 1)

The fitting should be held in a tensile testing machine in a manner approximating, as nearly as possible, to arrangement to be used in service. A tensile load equal to 75 percent of the specified minimum failing load should be applied and increased at a steady rate. Failure of the fitting should not occur at a load less than the specified minimum failing load.

Experimental results of Mechanical Slip Strength Test

MECHANICAL STRENGTH TEST	LOAD CAPACITY	NO BREAKING OBSERVED	REMARK
SAMPLE-1	70 KN	75.05	CONFORMED
SAMPLE-2	70 KN	75.12	CONFORMED
SAMPLE-3	70 KN	75.04	CONFORMED



LOAD Vs DISPLACEMENT FOR SAMPLE 3

- SLIP STRENGTH TEST

Experimental result of Slip Strength Test

TEST NAME	TEST REQUIREMENT	TEST RESULT	REMARK
SLIP STRENGTH TEST	Clamp should be slip in between 12.5 % to 20% UTS of Conductor at specified Torque. (19.95KN to 31.92KN)	26.67 KN (Slippage is observed, in between conductor and clamp at this load)	CONFORMED

V. Hyperwork Software based FEM Analysis

In this work Finite Element Method analysis using hypermesh software is done which is based on wind load, Electric field and temperature effect on whole body of Corona Ring.
3D modified design is used for the compensation to the vertical clamped 3D Corona ring. Corona ring having an great impact on Conductor through the wind load, Electric Load, Temperature and also having a various atmospheric factors which produces adverse effect on it. So ultimately it affects on Conductor and on surface of insulator and therefore such severe factors decreases the service life of Product. In this way to achieve a proper result Hyperwork analysis is done on 3D model of corona ring by considering 3 samples of same dimensions at various parameters.

C]. Hyper Meshing Process:

Mesh controls are used to automate and streamline the meshing process. Mesh controls can be saved and reused across different models by exporting them to a template file (*.xml) and then importing them into a new Hyper Mesh session from the Mesh Controls Create a mesh in the Mesh Controls tab by right Mesh, or Volume Mesh folders and selecting independently created for Refinement Zone controls. Surface Mesh, Adaptive Mesh, or Volume Mesh folders and selecting Mesh from the context menu. A mesh cannot be independently created for Refinement Zone controls. Once you are finished creating mesh controls, generate the mesh from the Mesh Controls tab. clicking on the Batch Esher Surface is Mesh, .
The different colors represent different Electric field intensities, for instance red represent high electric field and dark blue represents low ones.

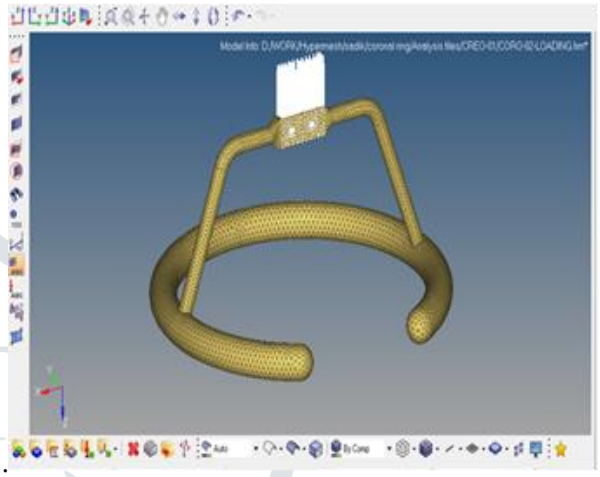


Fig. Meshing of product

Brief description of Hypermesh study:

One sample of the Corona ring is supplied with 50-120 KV of variable electric loads is shown in Fig. 1. A 3-D model, including Corona ring, was built according to the actual sizes, shown in Fig.. The conductor indicates white core have about 15.5 m of ground clearance, and the bundle spacing is 0.4 m. The diameter of the Corona ring is 30 mm & 300 mm
The highest line-to-line voltage of 350-kV lines is 400 kV, And discharges often occur at the moments of voltage Peak, so the conductor and Corona ring were loaded with the peak of the highest phase voltage for calculating.
Um= 350x $\sqrt{2}/\sqrt{3}$ = 285.7738

The Displacement distributions on the surface of the Corona ring in the surrounding air are shown in Fig The different colors represents different E -field intensities, for instance, red represents high E-field intensities, and dark blue represents low ones.

From fig.1 The corona ring can be seen to have higher intensities on their surfaces; especially the highest E-field intensity on the second end temp is increases of 67-70º. E-field intensity on the small end reaching up to F=5.326+00 V/mm.

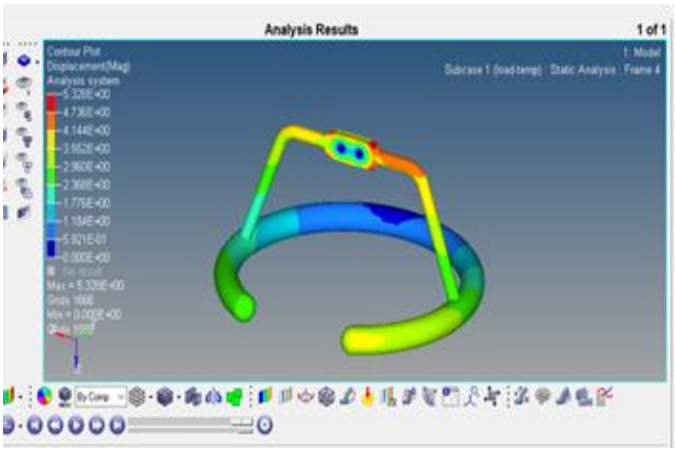


Fig.1

Hyperwork 50-120 KV

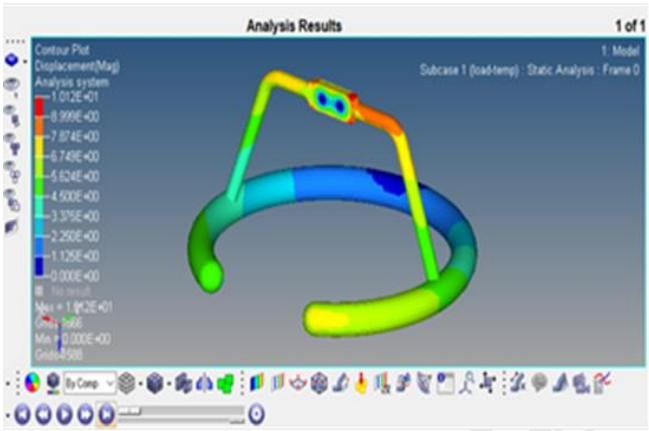


Fig. 2. Hyperwork 350-400 KV

From fig 2.The corona can be seen to have higher E-Field intensities on their surfaces; especially the highest E-field intensity on the center load temp is increases of 71-74 º for F=1.01E+00 V/mm.

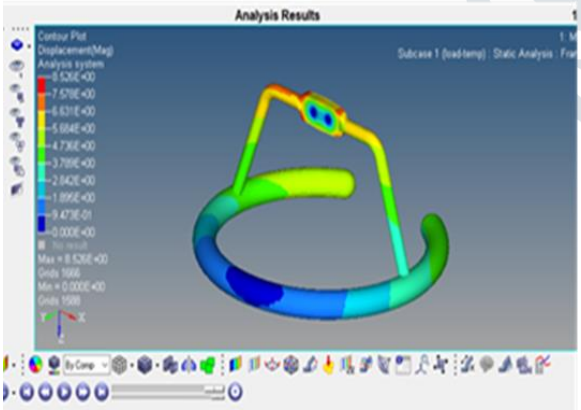


Fig.3 Hyperwork 250-300 KV

From fig 3 the corona can be seen to higher E-field intensities on their surfaces ,especially at the load of 250-300 kv for temp is increases of 57-62 deg, When F= 8.526E+00 V/mm.

Sr.no	Test parameter	Maximum displacement
1	50-120KV	F=5.328E+00
2	250-300KV	F=8.526E+00
3	350-400KV	F=1.012E01+00

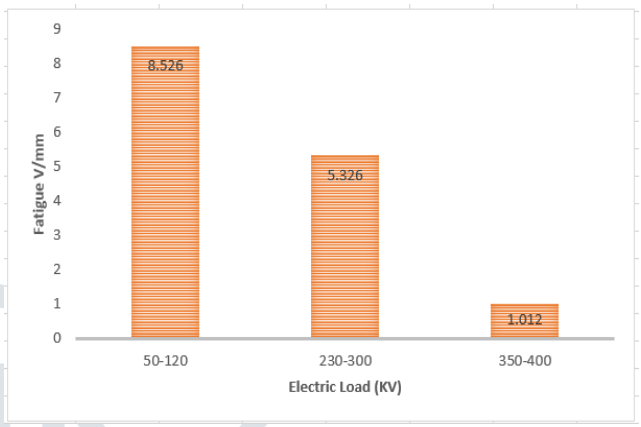


Fig. Graph of different displacement.

D] .TOOLS AND SOFTWARE :

1. AUTOCAD (2007)
2. SOLIDWORKS (ST9)
3. UTM (For mechanical testing)
4. HYPERMESH SOFTWARE (for FEM analysis)

V. ACKNOWLEDGEMENT:

I would like to give thanks to Mr.Pawan Khandalkar, Mr. Vishal Vankudre and team of Ramelex pvt ltd, Pune for their proper guidance & supervision, for providing information regarding Project & also thanks and appreciation to my collegue in completing the project & people who have willingly helped me out with their abilities.

VI. CONCLUSION

In this paper, As per the growing need of electrical energy, the importance of increasing voltage of transmission line and their advantages that can be solve various problems are focused. Hence Simplified methodology for Proto-Type development of Insulator hardware fitting and Corona ring used for high voltage system was studied in order to establish designing , manufacturing and testing of product. Due to the laboratory testing according to indian standard hardware fitting are beneficial in the aspects of economically, reliability and efficient suspended hardware which is used for Insulator and Conductor. Along with this, the work is done to get static behavior of corona ring mounted on insulator hardware of transmission network to minimize the corona effect and its loss using Fem analysis. From analysis it is calculated that red zone shows more thermal effect witch is dangerous. By applying various loads with temperature and wind load taken as input due to which weak zone are determined helps in recognizing the critical condition of design and their material properties and also it can modify by taking measures. Blue shed of ring shows strong portion of ring where electric field obtained is minimum. In this way analysis is obtained.

REFERENCES

[1] IS 2486 (Part 1-General requirements and tests) -1993, " Metal fittings of insulators for overhead power lines with nominal voltage greater than 1000v Specification".

[2] IS 2486 (Part 2-Dimensioal requirements) – 1989, "Insulator fittings for overhead transmission lines with nominal voltage greater than 1000 v specification".

[3] IEEE Std C135.61- 1997, "IEEE Standard for the Testing of Overhead Transmission and Distribution Line Hardware",(2006).

[4] IEEE Std C135.62™-2009, "IEEE Standard for Zinc-Coated Forged Anchor Shackles".

[5] Sima W., Espino-Cortes F.P., Edward A.C. and Jayaram H.S., Optimization of Corona Ring Design fo Long-Rod Insulators Using FEM Based Computational analysis IEEE International Symposium on Electrical Insulation, Indianapolis, in USA, (19-22 September 2004).

[6] Jaiswall V., Farzaneh M., Lowther D.A., Impulse flashover performance of semi conducting glazed station insulator under icing conditions based on field calculations by finite-element method, Generation, Transmission and Distribution, IEEE Proceedings Volume 152, Issue 6,(4 November 2005).

[7] "Technical specification of hardware for 400kv/220kv substation",(GETCO/E/TS–HW017/R0 DT.26/10/2007).

[8] IS 2486 (Part 3-Locking devices) "Insulator fittings for overhead transmission lines with nominal voltage greater than 1000v specification".

[9] Transmission line design manual(1980), "A guide for the investigation, development, and design of power transmission lines".