

## Optimization of the Surface Electric Field of Transmission Line Fitting On 500kv Line in High Altitude Area

Qin Li<sup>1, a</sup>, Wang Jing<sup>1, b</sup>

<sup>1</sup>College of Construction Engineering, Northeast Dianli University, jilin, 132012, China

<sup>a</sup>jilinql@163.com, <sup>b</sup>459906526@qq.com

**Keywords:** Hing Altitude, Fitting, Electric Field Optimization, Transmission Line

**Abstract.** The corona discharge of EHV transmission lines in high altitude area is very serious. Based on the Jiantang-Yulong 500kV power transmission project, we using Ansys software to calculate the surface electric field of 500 kV double circuit AC transmission line insulator and fittings. We get the voltage distribution of upper and middle and lower phase insulator string and the surface electric field distribution of fitting. According to the method of standard recommend, we get the corona electric field of fittings in high altitude (4km) are and compared with the result of the calculation. Then, we gives the optimization scheme of equalizing ring is rotated by 90 DEG and diameter increased to 55mm. The results show that the optimization scheme can effectively reduce the maximum electric field strength of the pressure ring and below the corona electric field value of fittings in high altitude.

### Introduction

Transmission line running is directly related to external insulation design of safety and economy, is a very important work in circuit design. Higher in southwest region, with the increase of altitude, air density is reduced, transmission line hardware up to faint from stress intensity decreases, corona discharge phenomenon obviously increased [1-3], so in the high altitude in the circuit design of hardware is required to further optimize design, to ensure the corona of circuit has good characteristics and insulation and safety.

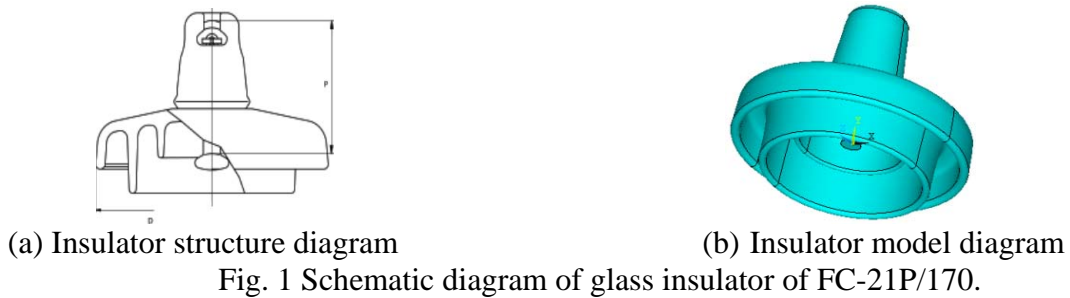
In recent years, many scholars have conducted in transmission line hardware corona features a lot of research, such as wuhan university Cao Jing et al. [4] using ultraviolet imaging of 330 kv ac transmission line hardware, experimental study on discharge characteristics obtained with the typical up dizzy voltage test values; Hong-ying wang et al. [3] of 500 kv substation are also studied by use of Ansys software mother tube v-shaped insulator string corona characteristics of equalizing ring; The SAN SAN and others [5] use ultraviolet imager on 500 kv transmission line corona discharge characteristics of jump line interval rods were studied; Fan Jianbin et al. [6] for different elevation of the transmission line hardware discharge up to faint from stress under strong was studied, the altitude correction formula is put forward. The related research work for high altitude insulator in power transmission project and the structure of the hardware design has a positive meaning.

Due to the high elevation transmission projects, with double line towers trailer string (double I string) insulator and hardware has been widely used, and the related parameters for the tower head size, has a great influence on line corridors. Therefore, in this paper, by using Ansys software, the simulation calculation for the pond to yulong 500 kv ac with double circuit transmission line towers overhang and hardware electric field distribution in detail, the equalizing ring installation optimization Suggestions, in order to better for reference for the design of 500 kv high elevation transmission lines.

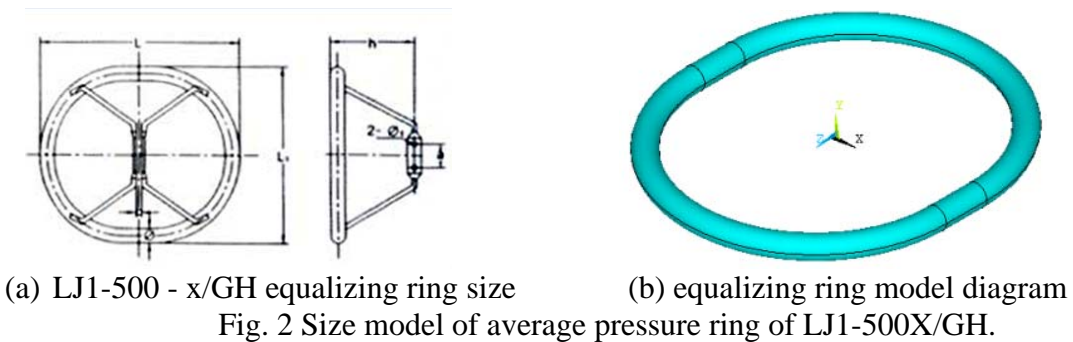
**500 kv with Double Circuit Transmission Line Towers Trailer String Model is Established in this Paper.**

### Trailer String Related Calculations.

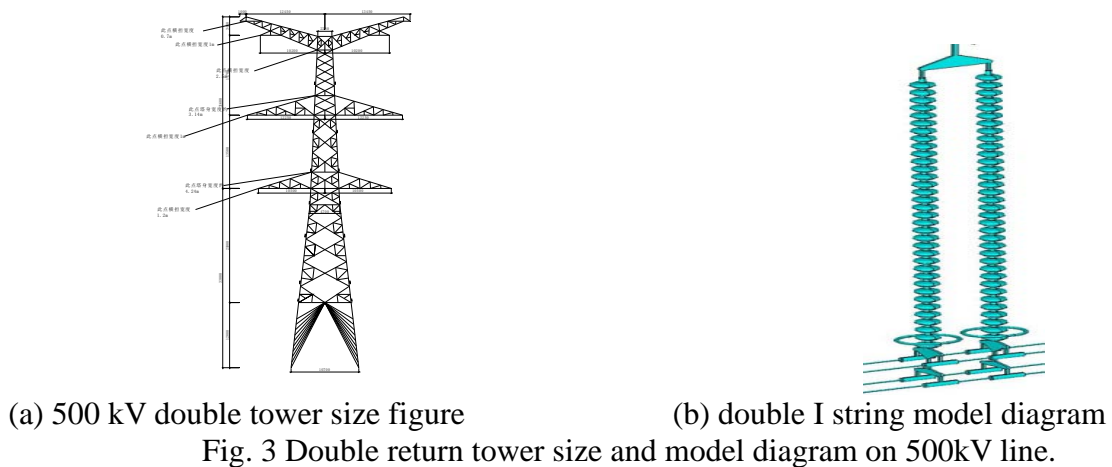
**Insulator.** 500 kV with double trailer double towers I strung together, string together the FC - 21 with 35 pieces of p / 170 glass insulator, disc diameter 280 mm, the structure height 170 mm, creepage distance of 450 mm, as shown in Fig. 1.



**Equalizing ring.** Two series of 35 pieces of FC - 300/195 glass insulator string the high-voltage side alone, the installation of a pressure ring, models for LJ1-500 - x/GH. Size is shown in Fig. 2, the diameter of 600 mm, 700 mm long, diameter of 50 mm, cover depth is 290 mm (from the top bottom allied board).

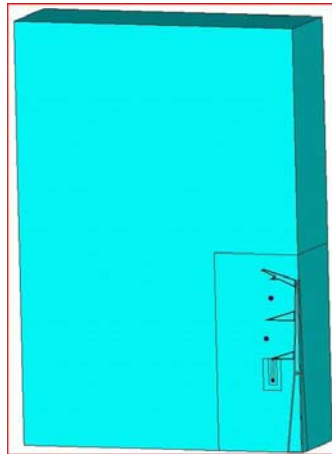


**Tower.** 500 kV with double circuit line towers models for SZ452 tower. As shown in Fig. 3 to 500 kV line double tower entity model.

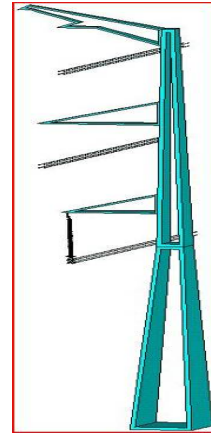


**Conductor.** 500 kV lines using four split conductor, wire type for LGJ - 500/45, a diameter of 30 mm, divided spacing is 450 mm.

**Double Trailer String of Calculation Model** Integrated computation accuracy and efficiency requirements, established 500 kV with double circuit line towers with phase sequence A, B and C phase double I string analysis model. Three-dimensional electrostatic field 1/4 model is established according to the asymmetry, according to the double towers, insulator, equalizing ring and split conductor is actual size entity model is set up. Of connection hardware, al plate and hanging clamp for the appearance of reasonable simplification. Relative dielectric constant of insulator glass umbrella skirt is 7.0, conductor length of 30 m. All entities is surrounded by two air cube, the first layer of air length of 30 m, 30 m wide, 70 m tall; The second floor is 100 m long, 30 m, 150 m tall. The overall model as shown in Fig. 4, 5.



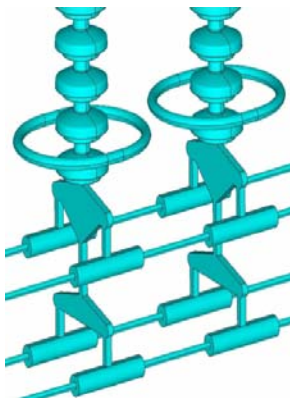
(a) the overall model diagram



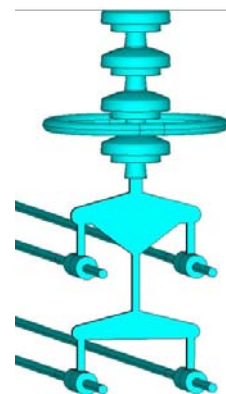
(b) the tower model diagram

Fig. 4 Integral model of double tower of 500kV.

For A double trailer string, insulator, connection hardware and equalizing ring set up only A part, the peak load voltage  $U_n$  ( $U_n = U_m / 1.1$ ), as shown in Fig. 5. The other two phase conductor model is set up, according to the phase sequence voltage -  $U_n / 2$ , respectively. Phase in the high pressure side, equalizing ring, connecting hardware and its connected steel foot loading high potential for  $U_n = 500 \times \sqrt{3} = 408.25$  kV, low pressure end insulator iron cap, tower and hardware load on zero potential. The ground and outsourcing air boundary loading zero potential. Unknown potentials in the calculation model of steel and iron cap for suspension potential conductor by adopting the method of coupling degrees of freedom. Phase B, C phase model and loading process are similar.



(a) connection hardware model diagram

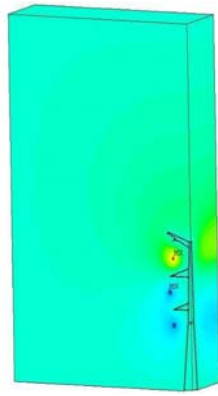


(b) connection hardware section

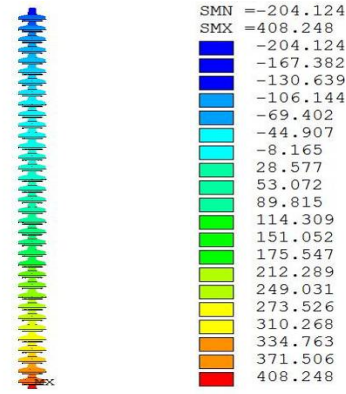
Fig. 5 Model of double I series.

### Double Line Hanging String of Results.

**The Simulation Calculation.** Trailer string photogenic, for example, the insulator string, equalizing ring, plate surface field strength calculation, the simulation result is shown in Fig. 6.



(a) Potential distribution in whole model



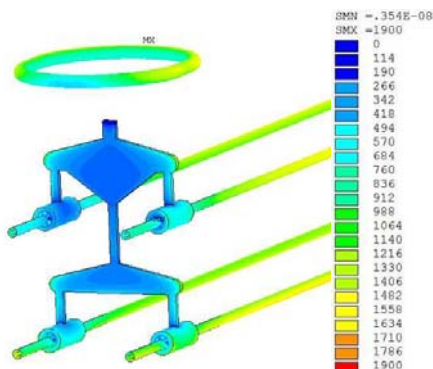
(b) the potential distribution of insulator string

Fig. 6 Integral model of the upper phase and the potential distribution of insulator strings

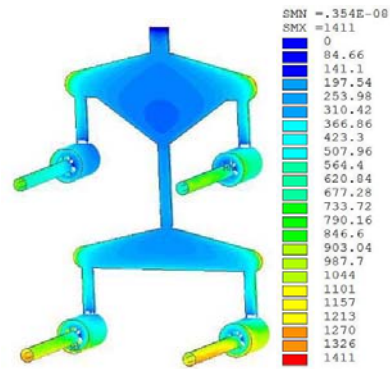
Table 1. Percentage of voltage of insulator strings.

Serial number	The voltage distribution (peak)	Valid values	Serial number	The voltage distribution (peak)	Valid values
1	23.60	16.69	19	7.33	5.19
2	23.01	16.27	20	7.15	5.06
3	22.46	15.88	21	7.00	4.95
4	21.14	14.95	22	6.92	4.89
5	19.44	13.75	23	6.89	4.87
6	17.75	12.55	24	6.92	4.89
7	16.16	11.43	25	7.02	4.96
8	14.75	10.43	26	7.17	5.07
9	13.48	9.54	27	7.42	5.25
10	12.40	8.77	28	7.76	5.49
11	11.43	8.09	29	8.21	5.81
12	10.61	7.50	30	8.80	6.22
13	9.89	6.99	31	9.56	6.76
14	9.27	6.55	32	10.55	7.46
15	8.74	6.18	33	11.85	8.38
16	8.29	5.86	34	13.60	9.62
17	7.90	5.59	35	16.16	11.43
18	7.60	5.37	total	408.2	288.6

To Table 1 for insulator voltage percentage points, from the table, the insulator string for the first piece of insulator to assume the highest voltage, the peak of 23.60 kV, effective value is 16.69 kV, about 5.78% of the whole string of voltage. Equalizing ring and field intensity on the surface of the al plate calculation results are shown in Fig. 7. From Fig. 7, photogenic equalizing ring surface maximum field strength for 19 kV/cm, al plate surface maximum field strength of 14.11 kV/cm.



(a) equalizing ring surface field strength



(b) plate surface field strength

Fig. 7 The plate of average pressure ring and surface field strength distribution.

Similarly, the phase, the phase in the surface of the insulator string and its hardware field simulation calculation, available: in the first piece to assume the peak voltage 24.97 kV insulator, RMS 17.66 kV, equalizing ring surface maximum field strength of 17.82 kV/cm, al plate surface maximum field strength of 14.20 kV/cm; Phase under the first piece of insulator to the peak voltage is 24.93 kV, RMS 17.63 kV, equalizing ring surface maximum field strength of 17.59 kV/cm, al plate surface maximum field strength of 13.68 kV/cm.

**The Result Analysis.** According to the national grid company in the enterprise standard Q/GDW550-2010 surface field strength of high altitude hardware is put forward by the corona threshold elevation correction formula is:

$$E = E_0 / (K_1 \times K_2) \quad (1)$$

Type: E peak for the elevation of the surface field strength of the revised hardware (kV/cm); Strong E0 to zero with the elevation of the surface up to faint from stress peak (kV/cm), according to previous research results, reduced to zero with the elevation of the surface up to faint from stress is strong control over 40 kV/cm; K1 as the altitude correction coefficient; K2 for safety margin coefficient, take 1.4.

Due to build a pond to yulong line maximum altitude of 4000 m, so took a 4000 m above sea level in the calculation of correction factor, take 1.57 [7, 8]. According to the type (1) to 4000 m altitude to faint from stress intensity of 18.2 kV/cm, this article in an 4000 m altitude maximum field strength threshold limit.

This article calculate the load voltage peak  $U_n = 500 \times / = 408.248$  kV, in the actual operation voltage peak for  $U_m = 550 \times / = 449.073$  kV,  $U_n = U_m / 1.1$ , so in the calculation results are superior to 1.1. Thus available equalizing ring and al plate surface maximum field strength value, as shown in Table 2.

Table 2. The max field strength of pressure ring and plate (kV/cm).

Applied voltage		Calculate the peak load (408.248 kV)	The actual peak (449.073 kV)
Equalizing ring	photogenic	19.00	20.90
	middle phase	17.82	19.60
	bottom phase	17.59	19.34
yoke plate	photogenic	14.11	15.52
	middle phase	14.20	15.62
	bottom phase	13.68	15.05

Can be seen from Table 2, the same direction, the three-phase equalizing ring under the surface, which, in turn, reduce the maximum electric field intensity, the peak value were 20.90 kV/cm, 19.60 kV/cm and 19.34 kV/cm; Are higher than 18.2 kV/cm up to faint from stress strong critical threshold. Therefore need to optimize the equalizing ring structure analysis.

## Conclusion

(1) based on building pond to yulong ac transmission line, established the high altitude (4 km) 500 kV with double circuit line towers trailer string and its calculation model of hardware, simulation by use of Ansys software, calculated the insulator, equalizing ring, plate the surface of the electric field distribution, the maximum field strength over the high altitude maximum up to faint from stress intensity value (18.2 kV/cm);

(2) the proposed equalizing ring rotated 90 °, increasing the equalizing ring diameter to 55 mm, the optimized plan for the field intensity on the surface of a hanging string and its hardware is optimized, the results prove the effectiveness of the scheme;

(3) in this paper, the research of the electric field distribution of the surface of the hanging string and its hardware and the optimization solution is suitable for high altitude (4 km) area 500 kv power

transmission and transformation project, can provide a reference for the future of high altitude power transmission and transformation project design and proposal.

## References

- [1] C. Gu, J. B. Fan, Y. Yan, etc. 1000 kv uhv dc transmission system equipment corona characteristics. *High Volt. Technol.* 38(12) (2012) 3182-3188.
- [2] Q. Y. Ceng, Uhv transmission lines. *Electr. Corona Charact. Res. Grid Technol.* 31(19) (2007) 1-8.
- [3] H. Y. Wang, J. X. Xia, D. C. Huang, et al. High altitude 500 kv substation insulator string equalizing ring of corona characteristics. *High Volt. Technol.* 39(3) (2013) 661-667.
- [4] J. Cao, Q. Zhang, Y. J. Yang, et al. High altitude with the ac transmission line corona discharge characteristics. *High Volt. Technol.* 37(12) (2011) 2924-2929.
- [5] S. San, J. Cao, L. L. Gu, et al. 500 kv transmission line corona discharge characteristics of jump line hardware. *Water Electr. Energ. Sci.* 30(12) (2012) 146-148.
- [6] J. B. Fan, C. Gu, Y. Yan, et al. Uhv dc transmission equipment corona characteristics of altitude correction. *High Volt. Technol.* 35(9) (2009) 2881-2885.
- [7] GB/T2317.2-2008 power test method for part 2: corona and the radio interference test.
- [8] GB 311.1 2012 insulation coordination Part 1: definitions, principles and rules.