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Research on safety protection for live working on ±800kV DC transmission line with AC and DC multi-circuit transmission lines

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Abstract. In recent years, in order to save line corridors and reduce the scope of demolition, some new transmission modes for high voltage AC and DC power transmission line are proposed. According to the characteristics of the parallel transmission line, this paper studies the distribution characteristics of the electric field intensity of multi circuit parallel transmission lines and the single circuit transmission line. Comparing and analysing the simulation results of the electric field strength, the safety measures for live working of ±800kV DC transmission line with multi circuit parallel transmission lines is put forward. That is the electric field protective equipment and measures used in the live line work of the ±800kV UHDC single circuit line can meet the requirements of the live operation of the ±800kV UHDC multi-circuit transmission line.

1. Introduction

With the rapid development of AC and DC transmission project construction, the transmission voltage level is higher. The number of extra high voltage and ultra-high voltage AC and DC transmission lines are increasing, and the transmission line corridor is becoming more and tenser. Meanwhile, the transmission line construction must also meet the requirements of the environment.[1-2] In recent years, in order to save line corridors and reduce the scope of demolition, some new transmission modes for high voltage AC and DC power transmission line are proposed, such as multi loop, parallel erection and so on.[3-4]

There are four parallel erection of high voltage transmission line in the province, including: two ±800kV extra-HVDC transmission lines, ±500kV double circuit ultra-HVDC transmission line, and 1000kV extra- high-voltage AC transmission lines.

According to the characteristics of the parallel transmission line, this paper studies the influence of the electric field on the human body, and verifies the safety and feasibility of the live line work on the multi circuit transmission line. And compared with the single tower with the voltage level of live working methods, the safety measures for live working on ±800 kV transmission line is put forward.

2. Calculation and analysis of electric field

Because of the low frequency electric field of operating transmission line, the electric field can be regarded as an electrostatic field when the finite element method is used to calculate the electric field.

The field of each tower in typical operations is calculated based on multi circuit transmission lines running at the same time. [5, 6]

For the analysis of parallel multiple loop circuit of HVDC transmission lines on the same tower space field intensity level, the simulation calculation model is considering the tower and the DC line operation mode of the electric field, and ignoring the effect of insulator effect on electric field distribution and ion current on DC electric field. The conductor is equivalent to single conductor to be calculated. The tower surface is considered as a conductor plane. The earth is considered as an infinite conductor plane. Finally, the calculated results are compared with the spatial field strength of single circuit.

2.1. Calculation parameters

When the electric field intensity is calculated, the related calculation conditions are as follows. The electric field of 1000kV transmission line is calculated by reverse order, and the maximum operating voltage of the system is 1100kV. The voltage of B is $1100/\sqrt{3}*\sqrt{2}$ kV, and the voltage of A and C were respectively loaded with $1100/\sqrt{3}*\sqrt{2}*\cos(0+120)$kV and $1100/\sqrt{3}*\sqrt{2}*\cos(0-120)$kV. The polarity of the DC transmission line is set to the left as the negative pole and the right as the positive pole, and its voltage is calculated in accordance with the rated operating voltage.

2.1.1. Structure of towers

Figure 1 shows the tower section model of multi circuit transmission line with same corridor. Figure 2 shows the structure of transmission line tower.

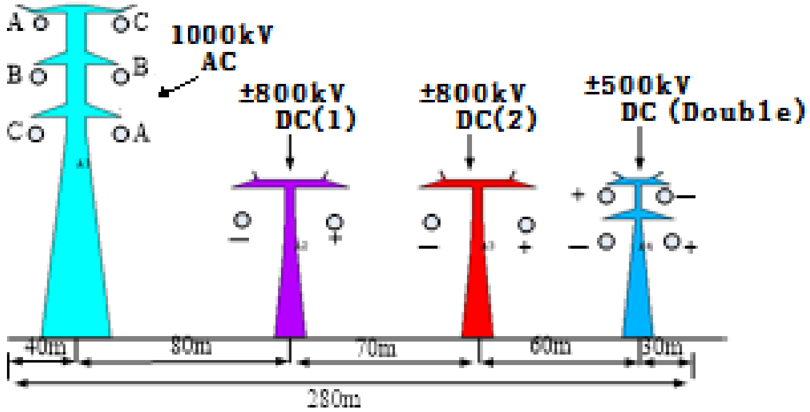
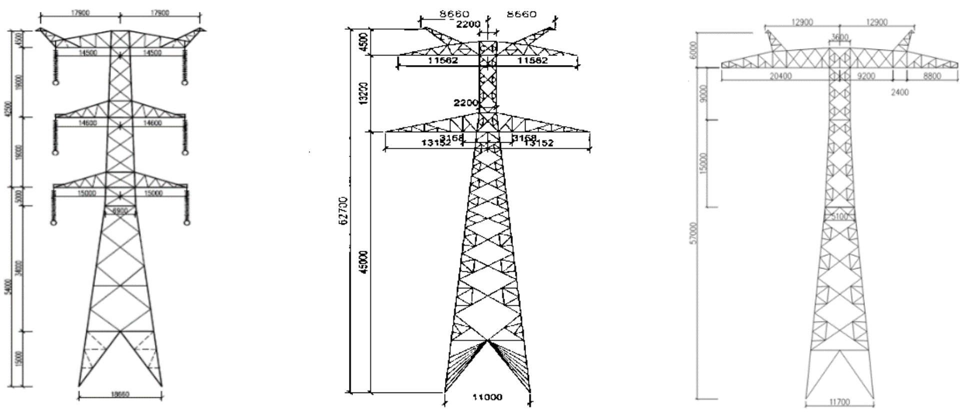


Figure 1. Location map of the tower with transmission corridor.



(a) (b) (c)

Figure 2. Structure of AC and DC transmission lines tower.

2.1.2. Transmission lines parameters

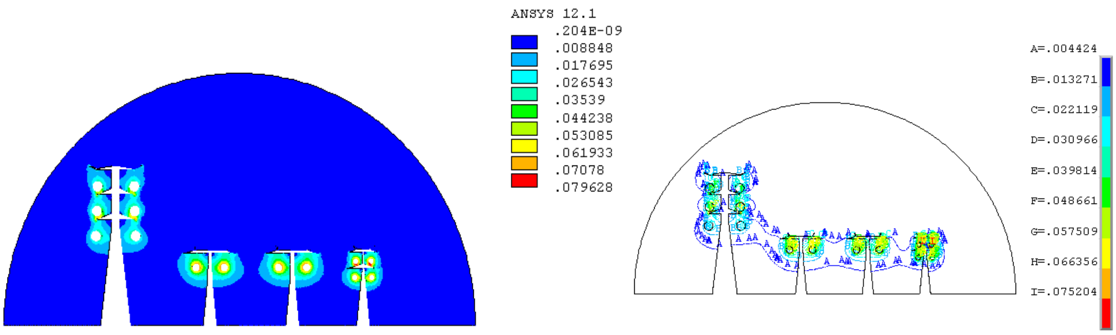
Transmission line parameters are set as shown in table 1.

Table 1. Transmission lines parameters.

Line name	1000kV AC	±800kV DC(1)	±800kV DC(2)	±500kVDC
Wire type	8×ACSR-LGJ630/45	6×ACSR-720/50	6×JL/G3A-900/40	4×ACSR-720/50
Split interval/mm	400	450	450	450
Sub wire radius /mm	16.8	15.14	16.93	15.14
Calculating radius/mm	441.21	344.66	351.14	258.2
Hanging point distance/m	13	11	11	7

2.2. Results of calculation

The electric field distribution on the vertical cross section of the tower and the conductor is shown in Figure 3(a). Figure 3(b) shows the contour map of the electric field strength on the plane.



(a) (b)

Figure 3. Distribution map of space electric field and its contour

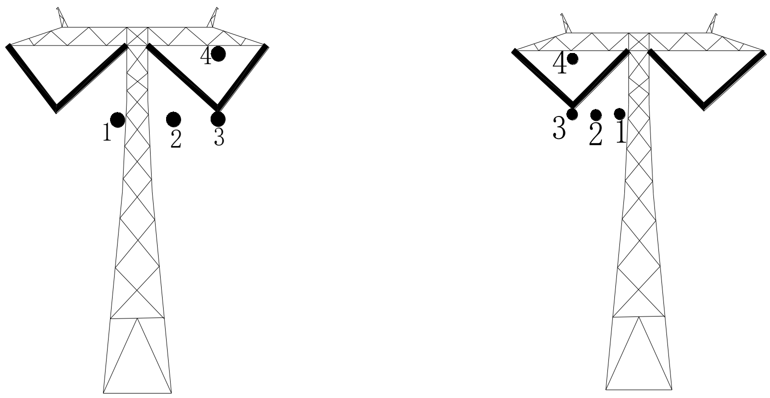
From Figure 3, it shows that the electric field distributions on the right side of ±800 kV DC (1) transmission line, on the left side of ±800 kV DC (2) transmission line and the double direct current transmission line are obviously distorted.

3. Safety protection for live working on ±800kV DC high voltage transmission line

Comparing the electric field intensity of ±800 kV DC transmission line key points under multi circuit transmission line parallel erection condition with the electric field intensity of ±800 kV DC single circuit transmission line with the cathead tower, safety protection measures for live working of ±800 kV DC transmission line with AC and DC multi-circuit transmission lines can be obtained.

3.1. Analysis of space electric field of multi circuit transmission line tower

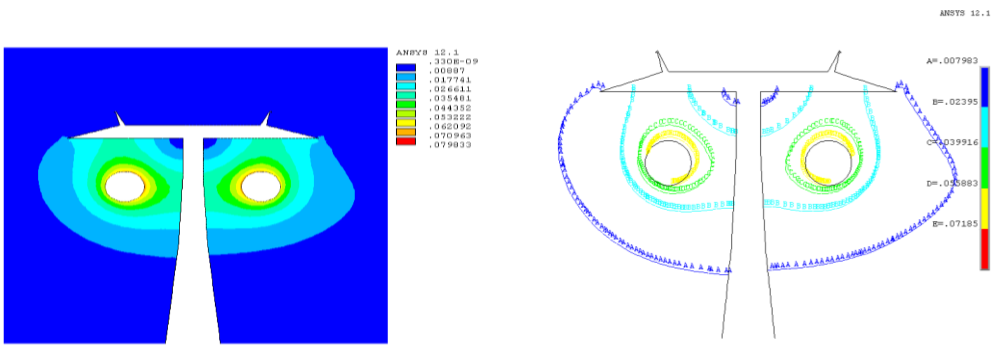
Figure 4 shows the location of the point where the electric field intensity is calculated.



(a) DC (1) transmission line (b) DC (2) transmission line

Figure 4. Position distribution diagram of calculation points of ±800 kV DC transmission lines

The electric field distribution of the central section of the DC (1) transmission line tower is shown in Figure 5(a). Figure 5(b) shows the contour map of the electric field strength.



(a) (b)

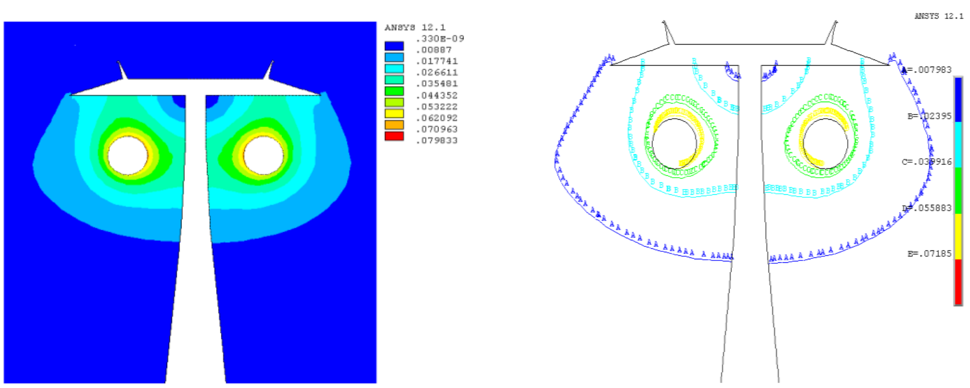
Figure 5. Distribution map of space electric field and its contour of DC (1) transmission line

Table 2 shows the simulation results of the calculation of the electric field strength of the tower of ±800 kV DC (1) transmission line.

Table 2. The effective value of the electric field strength of ±800 kV DC (1) transmission line

Calculation point	electric field intensity (kV/m）	Calculation point	electric field intensity (kV/m）
1	35.0	3	709.0
2	65.0	4	22.0

The electric field distribution of the central section of the DC (2) transmission line tower is shown in Figure 6(a). Figure 6(b) shows the contour map of the electric field strength.



(a) (b)

Figure 6. Distribution map of space electric field and its contour of DC (2) transmission line

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Table 3 shows the simulation results of the calculation of the electric field strength of the tower of ±800 kV DC (2) transmission line.

Table 3. The effective value of the electric field strength of ±800 kV DC (2) transmission line

Calculation point	electric field intensity (kV/m）	Calculation point	electric field intensity (kV/m）
1	24.0	3	699.0
2	81.0	4	11.0

As can be seen from the table 2 and table 3, the distribution of the electric field intensity has the following characteristics.

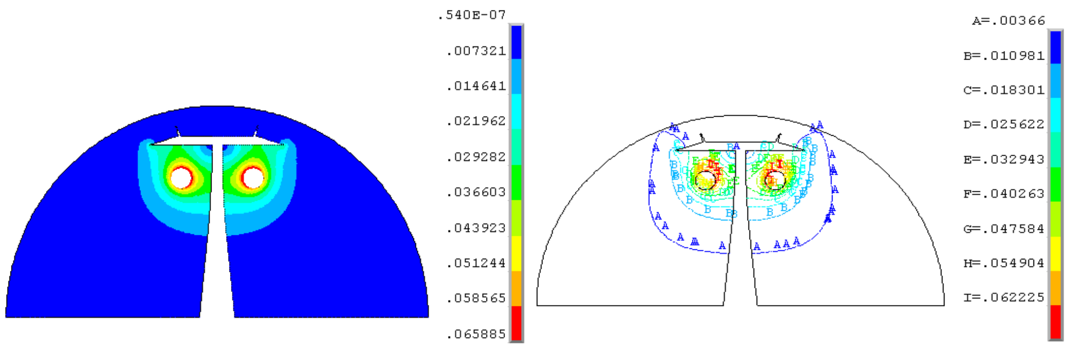
1) The electric field intensity on the surface of the conductor is maximum. Along with the increase of the distance of the conductor, the electric field intensity decays rapidly.

2) The electric field intensity of tower surface with the same height of the conductor, the insulator strings on the cross arm and the lower of the conductor is relatively large because they are close to the conductor.

3) The electric field intensity at the corner intersection with the tower of tower cross arm is relatively small.

3.2. Analysis of electric field of single circuit tower

For the convenience of analysis and comparison, the single circuit tower with ±800 kV DC transmission line is selected as the research object. Figure 7 shows distribution of space electric field and its contour.The electric field distribution of the central section of the line tower is shown in Figure 7(a). Figure 7(b) shows the contour map of the electric field strength.



(a) (b)

Figure 7. Distribution map of space electric field and its contour

Table 4 shows the simulation results of the calculation of the electric field strength of ±800 kV DC transmission line.

Table 4. Electric field intensity of ±800 kV DC tower calculation point

Calculation point	electric field intensity (kV/m）	Calculation point	electric field intensity (kV/m）
1	12.0	3	852.0
2	38.0	4	12.0

From the results in Table 4, we can know that the maximum electric field strength of the wire surface. Along with the increase of the distance to the wire, the electric field intensity is quickly fading.

3.3. Comparison and analysis of results

Comparing the electric field strength of the typical operation line tower working position of multi loop parallel charged transmission line and independent single tower corridor, the calculation results show that electric field strength has the following characteristics and rules for ±800 kV UHDC electrification circuit tower.

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The electric field strength of the surface of the conductor is the largest for the two kinds of transmission lines, and the value of the field strength is basically equivalent. The maximum value of electric field strength on the surface of the conductor of the single tower transmission line is slightly larger than that of the electric field strength on the surface of the conductor of the multi loop parallel tower transmission lines.

4. Conclusion

By the above analysis, it can be known that the electric field protective equipment and measures used in the live line work of the ±800 kV UHDC single circuit line can meet the requirements of the live working of the ±800kV DC transmission line with AC and DC multi-circuit transmission lines. That is live working personnel (including the ground potential conditions of live working personnel) should be wearing a full set of ±800kV special shielding clothing. Special shielding clothing is made of shielding clothing cloth , the maximum electric field inside it is not more than 15kV/m, and the current flowing through the human body is not more than 50μA. In order to ensure the shielding clothing has high shielding efficiency and ion current blocking ability, the design of shielding clothes uses integral structure, conductive material and flame retardant fibre mesh mask to reduce the surface area exposed.

Because the domestic manufacturers have developed 1000kV AC shielding for live working clothes, the type of shielding clothing used in the research and application of ±800kV live working is the same as the use of 1000kV shielding clothing model. It can meet the relevant technical standards, so it can be directly applied to ±800kV live working.

References

[1] Research Status and Development Trend of Live Working Key Technology, HU Yi, LIU Kai, PENG Yong, SU Ziming, WU Tian. High Voltage Engineering,2014.07

[2] Live Woeking on EHV/UHV Transmission Lines,HU Yi,LIU Kai,LIU Ting,XIAO Bin,PENG Yong, SU Zing. High Voltage Engineering,2012.08

[3] Safety Protection for Live Working on Transmission Line, HU Tao , HU Yi , LI Jing lu , Long lihong. High Voltage Engineering,2006.05

[4] Safety Hazard and its Prevention for Hot-line Work of 500 kV Transmission Line, XIE Yu-gan. Industrial Technology Innovation,2016.05

[5] Simulation Analysis of Electric Field Protection for Live-Working on 1 000 kV and 500 kV AC Four-Circuit Transmission Lines on One Tower, SU Zi-ming, PENG Yong, LIU Kai, LIU Ting, XIAO Bin,WU Tian, TANG Pan. Electric Power,2014.02

[6] Computation of Body Surface Electric Field during Live Working on 1 000 kV AC Compact Transmission Lines, FANG Yaqi, PENG Yong, SU Ziming, TANG Pan, LIU Kai,WU Tian,WANG Linong. Electric Power,2015.10