CIRCULAR-DISTRIDUTION OF THE CORONA CURRENT ON THE MULTIPLE-CONDUCTORS-TRANSMISSION LINE. (I)

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1. Introduction

The multiple conductors system in the transmission line of extra-high voltage is preferable in many points to the single conductor system,

Especially, the characteristics of corona loss and noiss are improved by adopting the multiple conductors system. Therefore the ultra-high voltage transmission line uses this system in most cases. But there are many unsolved problems in this system. Especially, the calculating formulas of the corona loss and noise level are not determeind in the form for the practical purpose. The reason is ascribed to the unexplainable state of circular distribution of the corona current on the multiple conductors.

About the circular distributing characteristics of the corona current on the double conductors, some theori tical formulas are proposed by F, Cahen[①], y. Sato[②], and , Hirano[③]. And the equivalent angle of corona loss, θm is determined. θm is the radial angle at the point on the conductor, where the value of corona loss from the field intensity is equal to the mean value of corona loss of the double conductor. These values of θm are deduced from Peek's formula of A. C. corona loss and from the comparison of corona loss of double conductor with them of single conductor.

In this experiment we used a special coaxial cylindrical-electrodes as a model of the transmission line of multiple conductors and suppressed D. C. voltage. From the experimental results with the above mentioned model, we obtaind the characteristics of circular distribution on the multiple-conductors transmission-line and the value of θm at the various conditions.

The circular distribution of corona current of the double conductors changs the shape of curve, when only one of the doulde conductors is coated by poly-vinyl-acetate or other material.

2. Equipment and measurment

In this report (1) we described only the characteristics of D, C voltage. Fig1 shows the equipment of coaxial cylindrical-electrods and the arrangement of the apparatus used in this research. The model wires of multiple conductors transmisson line are set in the center line of the coaxial cylindrical-electrode and insulated from earth by the two post-type-insulators fixed on the floor of this system, which is shown in fig 1.

The inner side of sbove cylindrcal electrode is divided into thirty-six segmental electrods, which are insulated from each other by the small gaps, and also from the earth by the layer of insulated paper.

Each segmental electrode is connected with lead wire. Therefore, if one-electrode is connected to micro-ammeter, and the other electrodes to earth, we can obtain the corons current of a specified direction and a small range of radial angle. The size of the above model electrode is shown in fig 1.

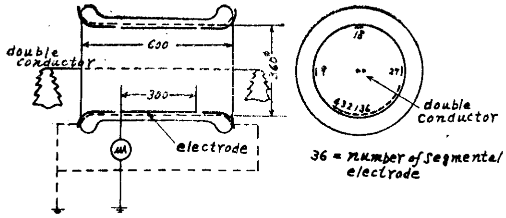


Fig 1 Coaxial Cylindrical electrode

3. Experimental Results

3-1Circular Distribution of Corona-Current on Double-Conductors at D. CSource

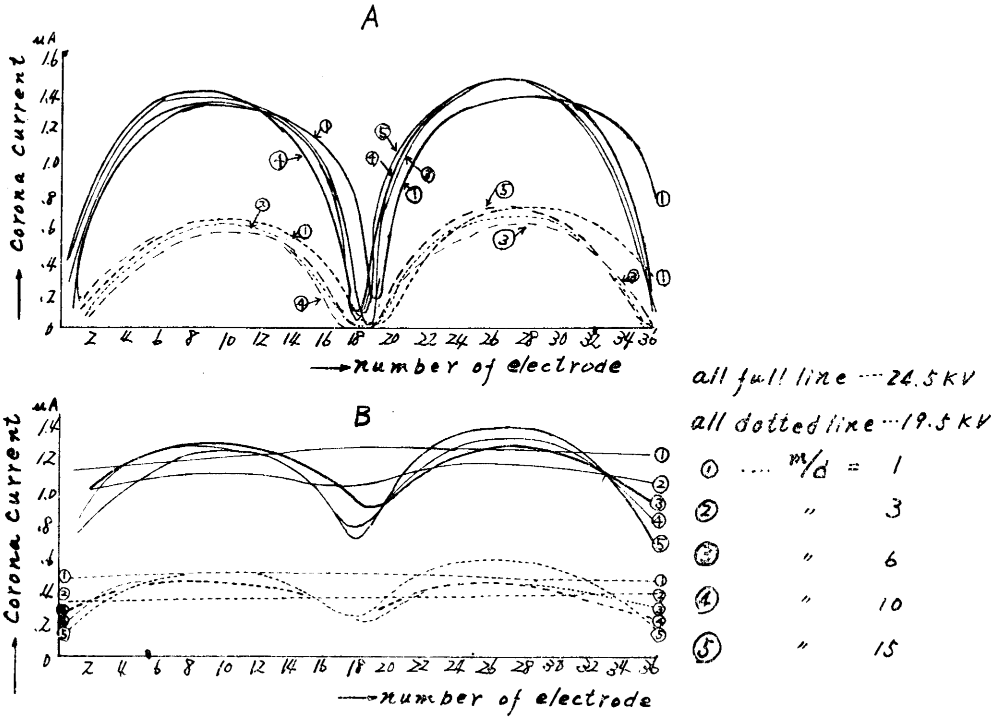


Fig 2 Circular distribution of Corona Current on the double Conductor in Coaxial-Cylindrical electrode
A … Case of Supplied positive Voltage
B … Case of Supplied negative Voltage

Fig 2 shows the circular distribution of corona current on the double conductors in coaxial cylindrical-electrode at two different applied voltages, DC. 19. 5kv and 24. KV

Here, m indicates the distance of centerlinesbetween the double conductors, and d indicates the diameter of conductor.

And these curves show the relationship between the radial angle and the corona current by the parameter of the value m/d(taked m/d=1, 3, 6, 10. 15)

Figure A in the fig2 shows the characteristics of the conductor kept positive and the inner surface of the cylindrical electrode kept negative at high voltage.

Figures B in fig 2 show the same characteristics when the conductor was kept negative and cylindrical electrode positive.

From fig 2, we know that in the case of positive conductor, the sharpness and symmetry of these curves are more evident than those of the negative conductor.

To calculate the corona loss of double conductor-transmission line, we must determind the valve of field intensity of the point P in fig 3, the radial angle being θm, that is above the equivalent corona angle.

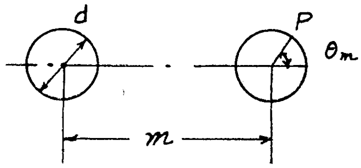
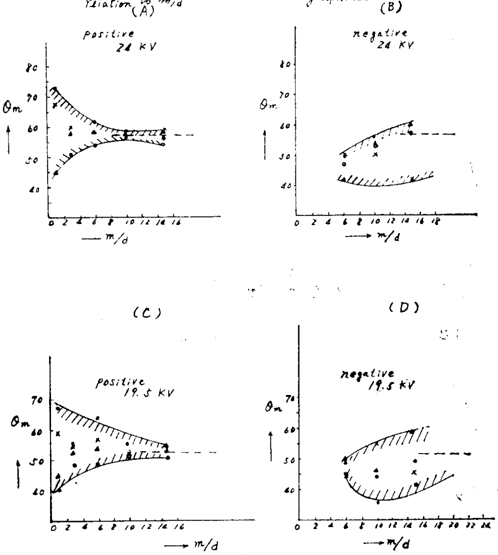


Fig 3

It is very important therefore to know the value of θm. But, if we find the coordinate, that is, the radial angle of the cross point between one of the distribution-curves and the parallel line to abscissa, which shows the mean value of the corona current, the value of θm will be determind.

Fig 4 shows various values of θm which are determind from the results of fig 2 by the above graphical method as a relation to m/d.

Fig 4
Various Value of θ_m by the graphical methode as a relation to m/d



In fig4 are shown the four cases classified by their polarization and the value of applied voltage.

(A) of fig 4 shows the case of the conductor being kept positive at 24 KV, (B) negative at 24KV, (C) positive at 19.5KV and (D) negative at 19.5KV.

3-2 Circular Distribution of Corona Current of Double Conductor, only One of Double Conductor Coated by Poly-Vinyle-Acetate.

If only one of the double conductors is coated by poly-vinyle-acetate, the growth of the corona current on the conductor of coatedside will be suppressed by the coated film of insulastng material.

Consquently, the curves of corona current change their form to dotted curves and lose their symmetry, as shown in fig 5.

In fig 5, one, at the left side of the double conductor(direction of No9 segmentaly electrode)is coated by poly-vinyle-acetate.

The curves of full line in fig 5 show the circular distribution of corona current when the conductor, without being coated, was kept

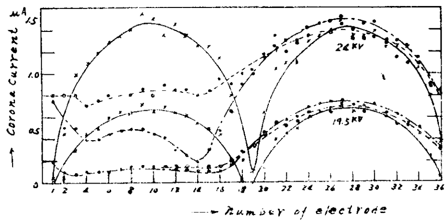


Fig 5 Circular distribution of corona current of double conductor. Left side of double conductor are coated by poly-vinyl-acetate
—x— none coated
—•—— after one-hour from the time of coating
-o- after one-day from the time of coating
Kept m/d = 10 constant, Supplied DC 24 KV, and 19.5 KV, positive

positive at 19.4KV and 24KW.

The dotted curves of fig5 shows the characteristics when only one of double conductors was coated.

From results of fig5, we know the fact that the corona current of the coated conductor is suppressed by thin films of insulator, and that the corona current decreases evidenlty. But in the other conductor which was not coated. the shielding effect by the coated conductor is decreased because the space charge of the conductor is weakened, and the field intensity on the surface of the not coated conductor is heightened. Consequently the corana current at that side shows little increase in fig 5.

we have found some aging effects in these characteristics, following that, the distribution-curves of corona current measured one-hour after the time of coating were considerablly different from those measured one day after the coating.

Fig 6 shows that the same characteristics measured after twelve-days are represented by a full line.

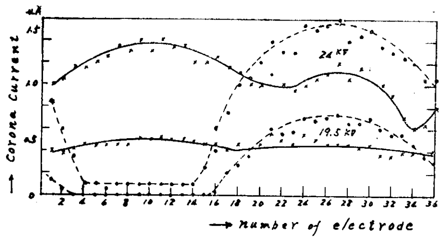


Fig 6 Same Characteristics of fig 5 measured.
—×— after twelve-days from the time of Coating
--•-- re-coating of one of double Conductor by poly-vinyl-acetate
Kept m/d = 10 constant, Supplied DC positive Voltage.

The characteristics become more evfdent than in fig 5.

But, if the applied voftage is heightened to more than 24 KV, and the electrical breakdown occur in the insulating thin-films which coat one of the double-conductors, the characteristics curves of the corona current show the same curves as those of the conductor which is not coated, as shown in fig 5.

Fig 7 shows the circular distribution of negative corona on the same condition as fig5 anp fig 6.

In these case of negative corona, the characteristics curves of corona current are not so sharp and symmetrical as the positive corona, but nearly the same tendency was recognised in both cases.

The circular distribution of carona current of double conductor, when one of double conductor was coated by paint is shown in fig 8.

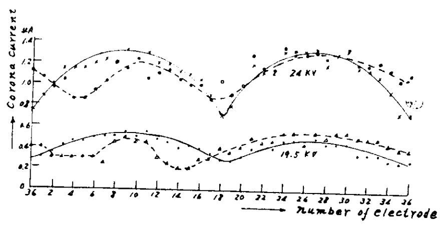


Fig 7 Circular distribution of negative corona on double Conductor
—×— none Coated Conductor. 24 KV
—·— " " " 19.5 KV
-·-×-·- Coated by poly-vinyl-acetate. 24 KV
-×--×- " " " 19.5 KV
Kept m/d = 10 Constant.

In this case also, we obtained nearly the same characteristics as fig5 and fig 6. If one portion of the surface film of the coated conductor is scraped off by knife these characteristic curves shift to those of nearly the same shape as fig 2, in which no coating was made. Fig 8 shows those characteristecs.

4. Discussion and Conclussion.

From the results of our experiments which used a coaxial- cylindrical electrode as the model of multiple-conductor transmission line, we have obtained the following conclussion;

(1) The value of equivalent corona angles of the double conductor, θm, is function of m/d. It is not only different by polarization of applied D.C. voltage but also by the degree of voltage over the critical corona voltage of double conductor.

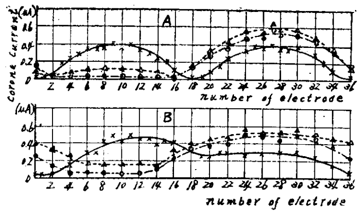


Fig 8 Circular distribution of corona current Only left one of double Conductor Coated With paint
—×— none Coating
—o— one week after Coating
--▲-- one month
A ···· positive corona
B ···· Negative Corona

In the domain of our experiments, the angle of θm was taken as 52°∼58°. In the case of conductor supplied with negative voltage, the value of θm spreads in wider range of angles. But if the mean value of θm is taken, it becomes nearly the same as the case of positive voltage.

From these experimental results, the value of θm at the A.C transmission line of double-conductor seems to became not only function of m/d, but also applied voltage.

(2) To clarify the mechanism of the effect of the coating on the cireular distribution of corona current of double conductor, we classified the process into four-stages.

They are shown as A, B, C, andD in fig9.

In the right side of the first rank of fig 9. A_2 shows typical distribution-curve of corona current in the case of the conductor not coated and supplied with positive voltage.

In the left side, A shows the figure of average distribution of the space charges by the positive corna. In the 2nd rank, B_1shows the distribution-figure of space charge, but in this case, only the conductor at the left side is coated by poly-vinyle-acetate,

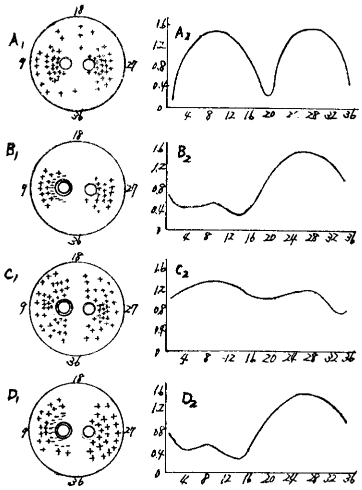


Fig 9 The relation between the figure of ionize Space charge around the surfaces of the double Conducters and the Circular distribution of corona Current, at various Cases, A, B, C, D, respectivoly.

Then, there is an accumulation of negative charges on the coated insulator. Fig B_2 shows the circnlar distribution of corona current corresponding to the space charge of fig B_1 These negative charges of conductor surface decreased the static-shielding effect on the right side of the double conductor. Consquently, the curves of circular distribution of the corona current become to the form shown in fig B_2. The right-half of the curves of figB_2 show little increase of corona current, and the left-half show a decrease due to the coating insulation film.

In the 3rd rank, the distribution-curve recovers nearly the same form as A_2 because over voltage is suppressed and electrical break-down occurs in the coating film.

If one of the double conductors is coated by poly-vinyle acetate once more, the distribution of space charge comes back to the form of fig D_1, which is similar to figB_1. Consequently the distribution-curues show the same form as figD_2.

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