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The Low-Voltage Distribution Area of Theoretical Line Loss is Obtained by Using the Load Power of Cattle Rafah

Dongyue Sun, Haibo Ruan

Anhui Nanrui Jiyuan Power Grid Technology Co., Ltd., Hefei, Anhui Province, China

Keywords: Low-voltage distribution area, Theoretical line loss, Equivalent resistance method, Line loss management

Abstract: as the calculating low-voltage distribution area theoretical line loss and the use of remote automatic meter reading system to raise the level of line loss management, put forward a kind of low pressure is obtained by using the load power.

1. Introduction

Line loss management is a basic work of the power sector. How to take effective measures to reduce the wastage of the distribution network is very important[1]. The low-voltage distribution area of enormous quantity wide, through the comprehensive analysis of line loss management present situation, adopt specific measures to reduce line loss is of great significance.

Line loss is divided into theoretical line loss and line loss management. Because the line loss suggestions are reflected the comprehensive capability in network operation and management level of an important economic and technical index[2], So for low-voltage distribution area in operation, and can look for the unknown by comparing the practical and theoretical line loss suggestions line loss. Suggestions line loss, improve the level of line loss management[3]. This request is based on the analysis of line loss management level theoretical line loss is obtained in advance. Because of the low voltage power distribution area close to the user, the branch line and line loss are affected by various factors[4], So it is difficult to precise theoretical line loss of low-voltage distribution area[5-6]. The existing low-voltage distribution area of the theoretical line loss calculation method can be divided into two categories. One kind is calculated, using the line head-end current or power mainly include bamboo method[7],the average current, load curve characteristic coefficient method[8],based on the actual circuit structure calculation method[9], root mean current square method[10], equivalent resistance method[3,11-13], etc. Although this kind of method can calculate the theoretical line loss, it can not find the problem by using the unknown line loss information contained in the head end of the low-voltage distribution line. Another kind is based on low voltage power distribution line end-users of electricity, power generation method to calculate the theoretical line

loss of the low voltage distribution network[14, 15]. Although gets in the calculation process and the paragraphs on a line load shape factor[14] and takes into account the differences between wire and voltage drop impact on line loss[15].

With smart meters and the application of remote automatic meter reading system[s] [16], collect users of electricity information is more convenient, fast, and accurate. According to the low voltage power distribution network structure, the use of a remote automatic meter reading system and the rational allocation of watt-hour meters can achieve preventing electricity stolen[17]. However, this requires a changing area that is more significant than the total watt-hour meter power in the area when all users watt-hour meter power energy metering center to identify the area. Power to make huge economic losses to the country[18]. Therefore, it is necessary to study can better use the remote automatic meter reading system of user power to raise the level of line loss management methods.

In this paper, based on the low voltage power distribution area of theoretical line loss calculation of the most commonly used method of equivalent resistance[11], Low-voltage distribution area is obtained by using the load power theoretical line loss of Rafa Benitez. This method takes the remote automatic meter reading system to the end-user power as the foundation. By introducing the line load curve shape coefficient and the relationship between the average load current and three-phase load unbalance correction coefficient to establish the mathematical model. Cattle Rafa solves the model was adopted to realize the theoretical line loss calculation. Finally, through calculating examples with the feasibility of the proposed method to identify unknown line loss information.

2. The Basic Principle of the Equivalent Resistance Method

The equivalent resistance method presented by literature[11] calculation in distribution area as a unit of theoretical line loss of low voltage distribution circuit, in accordance with the first wire type, length, conveying the principle of the load is the same person for the same line, from the end of the line to the head end, from the branch line to the order of the trunk dividing line, the theoretical line loss calculation. The specific formulas (1), (2), and (3) are as follows:

$$\Delta A = NI_{av}^2 KR_{dz} t \times 10^{-3} \quad (1)$$

$$I_{av} = A_{p.g} / (\sqrt{3} U_{av} t \cos\varphi) \quad (2)$$

$$R_{dz} = \sum_{j=1}^{n} N_j A_{j\Sigma}^2 R_j / [N(\sum_{i=1}^{m} A_i)^2] \quad (3)$$

Type: ΔA is low voltage line of theoretical line loss; N for the low-voltage distribution transformer export power grid structure constant, Three-phase three-wire preparing N=3, three phase four wire from N =3.5,Single phase two line for making N = 2; I_{av} and $A_{p.g}$ respectively line head end average load current and active power supply; U_{av} for average line voltage, low voltage line desirable U_{av} material 0.38 kV; Time t for distribution transformer to low voltage circuit, the low voltage line running time; $\cos\varphi$ for distribution transformer secondary side average power factor at the main table; K line load curve shape factor; R_{dz} for low voltage circuit equivalent resistance; N_j calculation line circuit structure constant for the first j a, accessor methods same as N; $A_{j\Sigma}$ for the first j a computing segment watt-hour meter copying all the low voltage

power supply users see the sum of power; $R_j = r_j L_j$, R_j and L_j respectively for the first j a computing segment of wire resistance, resistance per unit length and length; A_i is the actual reading power of the I-th 380/220 V user watt-hour meter; N for calculating line number; M watt-hour meter number for the user.

3. Theoretical Line Loss of the Cow Rafa Low-Voltage Distribution Area

3.1 Mathematical Model

By type (1), (2), with the method of equivalent resistance is the basis of theoretical line loss calculation, by the transformer secondary side table always active supply line head end of the average load current. Due to the total measured list to the actual active power supply is low voltage power distribution transformer all power supply station area, so even if the station area has similar unknown to leakage electricity power is lost, total table active power supply for this part contains power still can be used to calculate the theoretical line loss of low-voltage distribution area. But at this time, because the active power supply of the total meter is basically unchanged, the theoretical line loss obtained from this method is almost the same as that in the case of no leakage, so the unknown line loss information is needed for line loss management can not be well-identified.

During normal operation, the user electricity is a major factor in the production of electric energy loss, low voltage power distribution area theoretical line loss should match the real copy electricity users watt-hour meter. When a user's actual electricity consumption is not in the real copy electricity watt-hour meter and at the same time, with these theoretical line loss from real copy power should also be different from the actual user usage of line loss. So can use this information to identify whether there is any unclear power loss.

Based on the theory of low-voltage distribution, area line loss should match the real copy electricity users watt-hour meter the basic physical phenomena, real copy electricity users watt-hour meter used to build a mathematical model to calculate the theoretical line loss. In this case, in formula (1), the formula for calculating the average load current at the head end of the line is (4).

$$I_{av} = (A_{\Sigma} + \Delta A) / (\sqrt{3} U_{av} t \cos\varphi) \quad (4)$$

Type in A_{Σ} for low-voltage distribution area users always electricity.

In the method of equivalent resistance, determine the line load curve shape coefficient K method is, using line active power supply for head-end line head end after the average load current, check with the average load current $K = f(I_{av})$ relation curve line load curve shape factor[3,11]. The curve $K = f(I_{av})$ is based on the active supply line power supply peak valley in, respectively, to determine the corresponding numerical after drawing load curve shape is available[11].In this method, however, by type (4) can be seen, the line head end to average load current in the obtained theoretical line loss ΔA before they can get, so you cannot determine the line load curve shape factor in this way, by the literature[3,11], line load curve shape coefficient K and line head-end active power supply or a linear relationship with the average load current. So the load shape coefficient of the linear equation can be introduced to determine the load shape factor. Based on this, the function relation is (5)

$$K = aI_{av} + b \quad (5)$$

Type of undetermined coefficients a and b, respectively, can, according to the different nature of load pick up corresponding $K = f(I_{av})$to determine the relationship.

Substituting equation (4) into equation (5), we can get equation (6)

$$K = a(A_{\Sigma} + \Delta A) / (\sqrt{3} U_{av} t \cos\varphi) + b \quad (6)$$

By type (6) can be seen, and the equivalent resistance method, this paper adopts low-voltage distribution area users always copy see the power and theoretical line loss calculation circuit load curve shape.

Low-voltage distribution area transformer secondary sideline often USES three phase four wire system because much access to the single-phase load and the power will lead to the randomness of a three-phase unbalanced load. When the three-phase unbalanced load of neutral line loss will increase total line loss[19].In order to gauge and the influence of three-phase unbalanced load, the ratio of theoretical line loss ΔA under unbalanced three-phase load and theoretical line loss ΔA under balanced three-phase load[3] is defined as the correction factor of unbalanced three-phase load line loss (7).

$$K_1 = \Delta A / \Delta A_{ph} \quad (7)$$

From equation (1), equation (5), and equation (7), we can get equation (8).

$$K_1 = I_{av}^2 (aI_{av} + b)^2 N K_1 R_{dz} t \times 10^{-3} \quad (8)$$

3.2 The Determination of Three-Phase Unbalanced Load Line Loss Correction Coefficient

Due to the complexity of low voltage power grid connection, do not practice is difficult to identify the user accurately, so this article still adopts low voltage line side current unbalanced three-phase load line loss correction coefficient calculation.

Three-phase load balance and imbalance of theoretical line loss, respectively.

$$\Delta A_{ph} = 3 I_{av}^2 K^2 R t \quad (9)$$

$$\Delta A = (I_a^2 + I_b^2 + I_c^2) K^2 R t + I_N^2 K^2 (\mu R) t \quad (10)$$

Type: R and μ respectively for three phases four wireline phase line resistance and the neutral wire resistance and the ratio of phase line resistance; I_a^2 and I_b^2 I_c^2 line head-end three-phase average current respectively; I_N^2 to neutral line curren[19].

3.3 The Realization of the Algorithm

By type (13), the method of the mathematical model is a low-voltage distribution area of theoretical line loss for the variable equation of four times a yuan, available cow Rafa Benitez to solve this equation. The calculation steps are as follows.

1)Collect the data. The collected data including low-voltage distribution area of space truss structure and parameters, all clients electric meter measurement to power, table showing the distribution transformer secondary side of three-phase average total power and power factor $\cos\varphi$,and the phase current and power factor, calculation of line loss period of time, the nature of the area load, etc.

2)According to the nature of area load, to determine the line load curve shape coefficient and the relationship between the average current $K = f(I_{av})$, calculate the coefficient of a and b.

3)Calculate the equivalent resistance low-voltage distribution area line. Calculation before, according to the principle of the same as the method of equivalent resistance, from the end to the head end segment will be divided into several low voltage circuit calculations.

4)Calculate the three-phase imbalance degree, unbalanced three-phase line loss correction coefficient K_1 and constants C_1 and C_2, and coefficient of $d_0 \sim d_4$.

5)To determine the initial value of theoretical line loss and the permissible error.

4. The Example Analysis

Using the method of equivalent resistance and the method to calculate two kinds of wiring, figure 1 and figure 2 when in the presence of leakage electricity theoretical line loss[3].

In figure 1 and figure 2, points in front of the Numbers for the line number and the denominator, respectively line type and length (km). The unit length resistances of LJ-16, LJ-25, and LJ-35 are 1.98, 1.28, and 0.92(Ω/km), respectively. Because the lines in the graph contain single-phase load and three-phase power load of life, so in this paper, according to the 0.4 kV mixed load line.

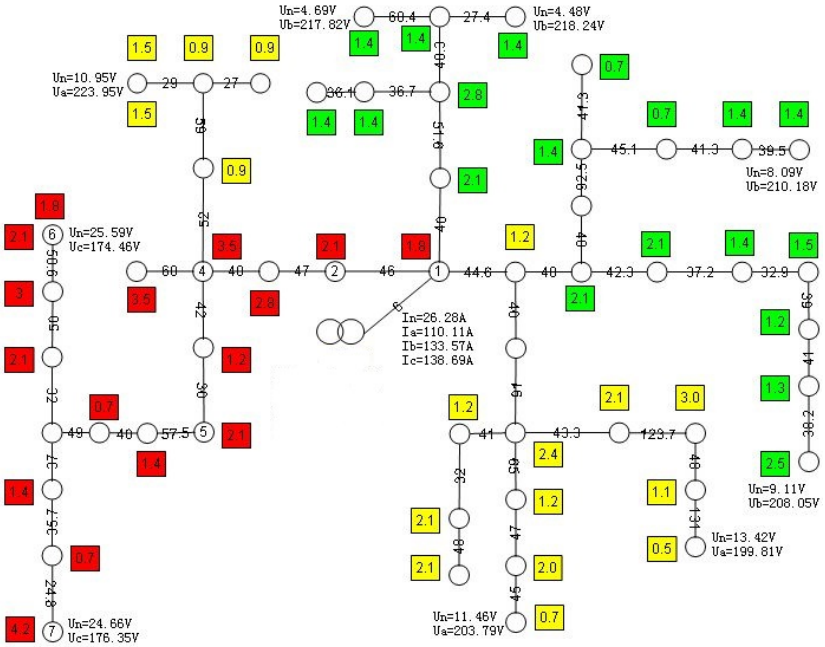

Fig.1 Wiring Diagram 1 of Low-Voltage Distribution Transformer District

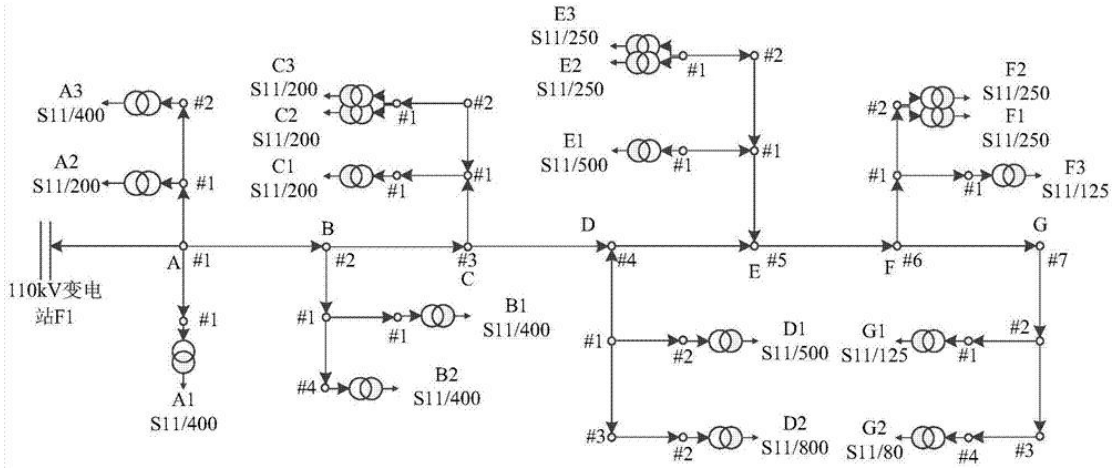

Fig.2 Wiring Diagram 2 of Low-Voltage Distribution Transformer District

This paper points four leakage power situations to calculate. Case 1 and 2 respectively connection 1 line 3 single-phase load and three-phase load without leakage electricity line 1; Case 3 and 4, respectively connection two lines one single-phase load and three-phase load without leakage electricity line 6. Calculation results, the power for the 0 means no cheats, cheats the real copy electricity load is equal to the actual power consumption; Leakage power greater than 0 says more electricity, cheats the real copy electricity load is less than the actual power consumption.

Theory of line loss suggestions calculation results as shown in Figures 3 and 4, respectively; The corresponding part of the theoretical line loss value is shown in table 1 and table 2. By figure 3 shows leakage electricity from 0 to 500kw·h change, equivalent resistance method, and the method of theoretical line loss suggestions fell flat. However, the former theory line loss suggestions changed little; the latter theory line loss suggestions change obviously. According to the theoretical line loss results of case 1 in table 1, the theoretical line loss value of the equivalent resistance method is reduced from 768.6348kW·h to 758.7506kW.h.

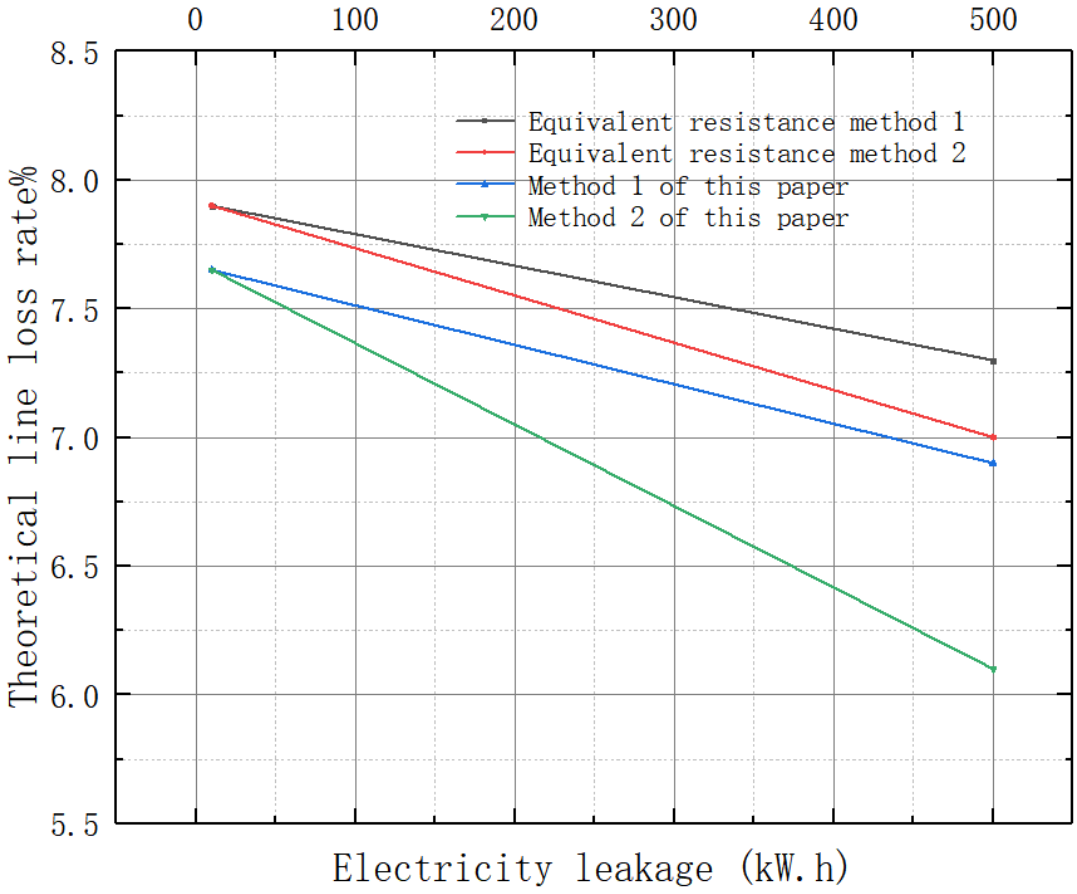

Fig.3 Theoretical Line Loss Rate of Wiring Diagram 1

In fig.4, the theoretical line loss rate obtained by the equivalent resistance method gradually increases slightly when the leakage current changes from 0 to 500kW·h; However, the theoretical line loss rate obtained by this method is still gradually decreasing. It can be seen from Table 2 that the theoretical line loss value of the equivalent resistance method has increased from 308.7343kW·h by 4.3698kW·h and 4.5922kW·h; Respectively; In this paper, the theoretical line loss decreased from 306.6623kW·h by 45.0551kW h and 44.8515kW·h respectively.

Table 1 Theoretical Line Loss of Wiring Diagram 1 Kwh

Leakage power	The theoretical line loss of equivalent resistance method		The method of theoretical line loss	
	Situation 1	Situation 2	Situation 1	Situation 2
0	768.6348	768.6348	746.1251	746.1251
100	766.3142	764.8360	726.8912	725.2581
200	764.1519	761.2399	708.1352	704.9995
300	762.1610	757.8639	689.8556	685.3463
400	760.3555	754.7266	672.0511	666.2958
500	758.7506	751.8483	654.7202	647.8453

Note: the equivalent resistance method of the equivalent resistance of 0.2156 Ω theoretical line loss of value.

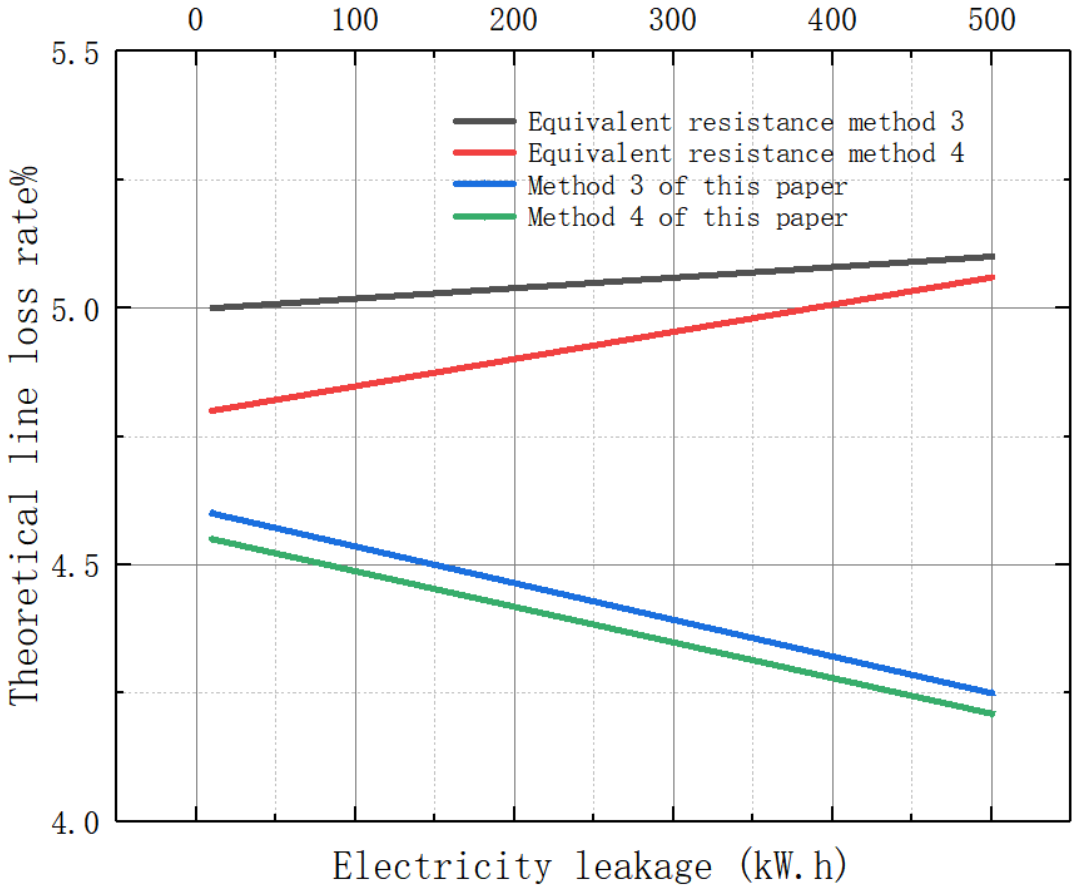

Fig.4 Theoretical Line Loss Rate of Wiring Diagram 2

In fig.4,the theoretical line loss rate obtained by the equivalent resistance method gradually increases slightly when the leakage current changes from 0 to 500kW·h; However, the theoretical line loss rate obtained by this method is still gradually decreasing. It can be seen from table 2 that the theoretical line loss value of equivalent resistance method has increased from 308.7343kW·h by 4.3698kW·h and 4.5922kW·h; Respectively; In this paper, the theoretical line loss decreased from 306.6623kW·h by 45.0551kWh and 44.8515kW·h respectively.

Table 2 Theoretical Line Loss of Wiring Diagram 2 Kwh

Leakage power	The theoretical line loss of equivalent resistance method		The method of theoretical line loss	
	Situation 3	Situation 4	Situation 3	Situation 4
0	308.7343	308.7343	306.6623	306.6623
100	308.8575	309.3394	296.6637	297.1733
200	309.3175	310.0862 287.1584	287.9430	
300	310.1510	310.9889	278.1468	278.9720
400	311.3981	312.0631	269.6294	270.2610
500	313.1041	3133265	261.6072	261.8108

Note: the equivalent resistance method of the equivalent resistance of 0.2156 Ω theoretical line loss of value.

In figure 3 and figure 4, the method of theory than the method of equivalent resistance line loss suggestions line loss suggestions change obvious reason is that, exist for electricity, cheats the equivalent resistance method adopts distribution transformer secondary side of power at the main table is still a total user actual measuring electricity, so in the total table of variations in the theoretical line loss of power to get smaller, not well reflect the effects of leakage power. Methods the users get the theoretical line loss of power in this paper and the presence of leakage electricity user power matching. With the increase of leakage of electricity, the theoretical line loss variation increases, so to give out information is higher than the sensitivity of the method of equivalent resistance.

Figure 5 shows the two connection equivalent resistance. By figure 5 shows the equivalent resistance in the case of terminals 1 and 1 and 2 falls; In 2, 3, and 4 when the wiring but not change at all. Due to the equivalent resistance method adopts a constant line head-end power or current RMS current then theoretical line loss calculation, so the equivalent resistance decrease or increase slightly in figure 5, will lead to the corresponding theory in figures 3 and 4 line loss suggestions slightly decrease or increase, but change is not.

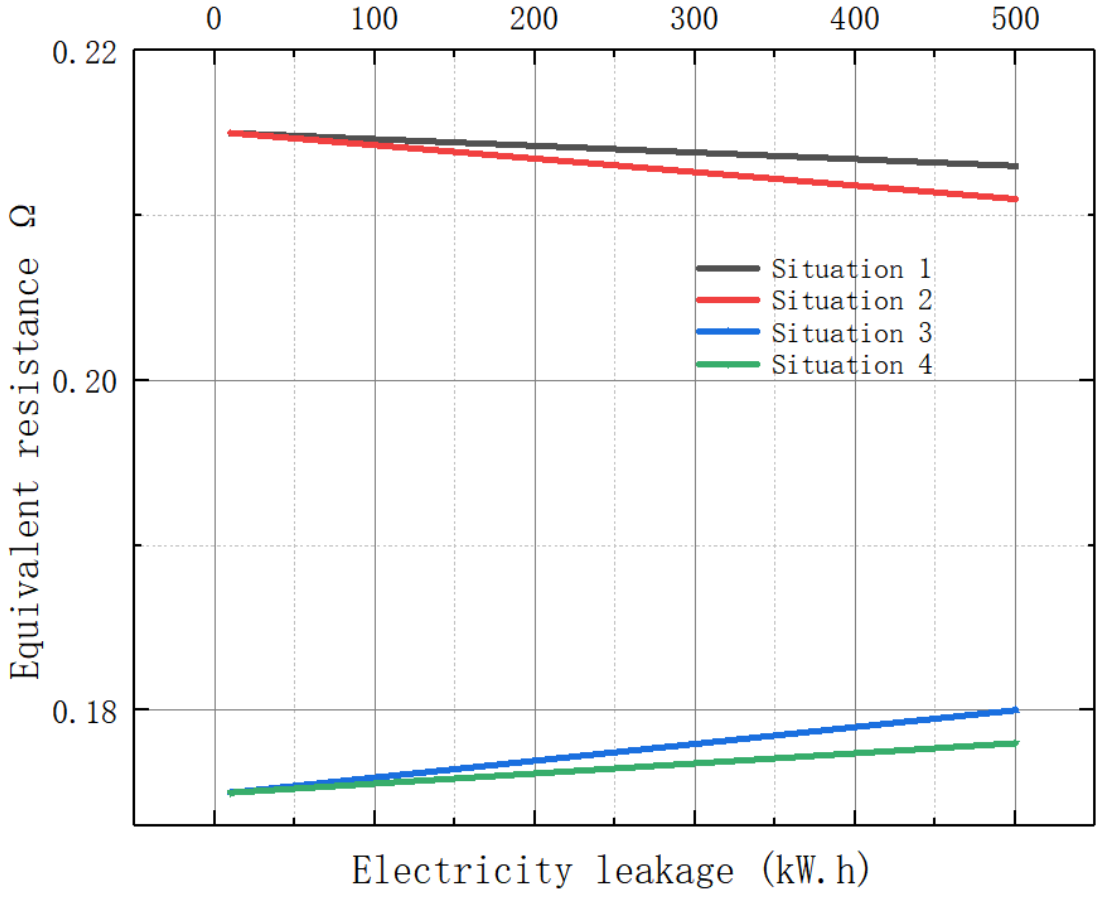

Fig.5 Equivalent Resistances of Both Wiring Diagram

The method by the end-user real copy power calculation of RMS current, two kinds of connection part is presented in table 3 RMS current. From table 3 shows, RMS's current situation 1~4 is diminishing. For cases 1 and 2 of the equivalent resistance and RMS current is reduced, so the line loss suggestions in figure 3, the method of theory also gradually reduced. Although cases 3 and 4 equivalent resistance increases slightly, under

the effect of reducing RMS current corresponding theory is still the line loss suggestions decreases gradually.

Table 3 Root-Mean-Square Currents of Both Wiring Diagram

Leakage power	Wiring 1		Wiring 2	
	Situation 1	Situation 2	Situation 3	Situation 4
0	49.5980	49.5980	34.9812	34.9812
100	49.0286	49.0208	34.3994	34.4021
200	48.4604	48.4454	33.8186	33.8228
300	47.8933	47.8716	33.2390	33.2434
400	47.3273	47.2996	32.6605	32.6639
500	46.7624	46.7293	32.0832	32.0843

To sum up, in electricity, cheats the method USES the load power to calculate the theoretical line loss is reduced. This information can be used to identify unknown line losses. This is because no matter whether there is leakage electricity, distribution transformer secondary side table place always copy see power reflects the low pressure. Under the condition of no electricity cheats, users copy power reduction, distribution transformer secondary side active supply at the main table will be reduced, thus the actual line loss and the theory of line. When there are cheats of electricity for the distribution transformer secondary side active supply at the main table, users copy see power reduction will lead to the actual line loss increases. Then use the method to calculate the theoretical line loss is reduced. Leakage current situation of the actual line loss and reduce the theoretical line loss is not corresponding to the information can be used to identify unknown line loss. The equivalent resistance method in three-phase load is balanced theoretical line loss reduction is small, in unbalanced three-phase load when the theoretical line loss is increasing, so cannot provide adequate information to identify unknown line loss.

5. Conclusion

This paper presents a low voltage power distribution area of theoretical line loss is obtained by using the load power cattle Rafah. In introducing the line load curve shape coefficient and the relationship between the average load current and three-phase load unbalance correction coefficient based on the mathematical model is established. Shows the calculation steps to solve the model cattle Rafah. Numerical example results show that the proposed method can not only help when no cheats electric low-voltage distribution area of theoretical line loss and can use the remote automatic meter reading system to use power is relatively sensitive to provide information to identify unknown line loss, provide a basis for improving the line loss management level.

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