APPRAISAL AND RESEARCH ON THE COMBINATION USE OF NETURAL GROUNDING MEASURES FOR DISTRIBUTION NETWORKS

Li jian-sheng
Henan Kaifeng Power Co. – China
E-mail address：jsh_li@163.com

Song zhi-guo
Henan Kaifeng Power Co. – China
E-mail address :songguo1973@163.com

ABSTRACT

The system neutral grounding relates to the comprehensive problems in the electric power system. In this paper analysis on the neutral grounding on the lines and equipments related to the insulation level, network structure, power supply reliability ,over-voltage, relay protection, personal safely, disturbing on communication as well as economical efficiency was discussed. the choose of using the automatic tracking arc suppression coil with the combination of resistance for system neutral grounding are decided to use according to the present situation of Henan electrical network ,it fully used the characteristics of the two grounding measures ,which can deal with the instantaneous or permanent single-phase grounding and short circuit respectively on their own merits, and appropriate choice the value of resistance to suppress the over-voltage level. the practice proof it is a good way to overcome the obstacles caused by the smallest residual current after compensating by the arc suppression coil which cause the difficult indication of the fault feeder. the practice in the real network proof it is cost effective and safe in operation.

Keyword: Distribution network; neutral grounding; compound mode; evaluation

0 Foreword

At present, there are several representative grounding methods which are the neutral grounding with the quenching of arc coil mand the neutral grounding with small resistance in the distribution network.

Since long periods of time in the distribution network of our country, neutral grounding methods in the system uses to no grounding or neutral grounding with the quenching of arc coil. Because it is not suitable for neutral no grounding when the capacitance currents rather big, the neutral grounding method with the quenching of arc coil is used widely to utilizing. The merits of these two kinds of grounding methods are obvious, which can make schedulings before stopping the faulty lines and can shift the load to reduce to cut-off users. However along with the movement of mode of operation, it needs to adjust the quenching of arc coil unceasingly. Simultaneously what were more serious the recent years, along with enhancement of insulation strength of the line outside station and the electric cable, the insulation strength in the station has relatively lowered. Even in the double generatrix structure transformer station , when the electric cable outside station single-phase earthed fault happens, it can cause breakdown between the breaks of the generatrix disconnecting line , create power cut of the entire station.

Because of the reason above, star point grounding by small and middle resistance is popularized. The system grounding by small and middle resistance takes convenience to dispatching, and it has the advantage of fast accident severing, however, disadvantages come out after a time of operation. It's good for restricting over-voltage to take the star point grounding by small and middle resistance mode, and the earth fault is easy to detect. However, the trips after single-phase grounding are influential to power distribution reliability, and it has high level request for the grid structure of power distribution networks, the ability of providing mutually, the equipments and the level of Automation. The electromagnetism compatible and the personal or equipment safety should also be considered.

Presently, the city power distribution network of Henan is mixing net of overhead network and electric cable, and the status will preserve for a long time. For the reason above, star point grounding by small and middle resistance is not suitable for Henan power distribution network. However, grounding by extinction coil has its localization. Take all kinds of effects in consideration; all the grounding modes present are ineffective for Henan power distribution network. The mixing grounding mode of extinction coil and resistance is much more practicable and effective.

1 The design of grounding mode combined extinction coil with electric resistance

In the premise of solving the problem existed in grounding mode in medium voltage network at present, we should take some factors into account synthetically, drawing merit from this two grounding modes and overcoming the limit. The grounding mode combined extinction coil with electric resistance can meet the Henan distribution net better than neutral arc-suppression grounding mode.

1.1 Composing

The composing of grounding mode combined extinction coil with electric resistance is showed in fig 1.T is Z type grounding transformer supplying system star point; L is extinction coil compensating the capacitance current; Rn is adjustable resistor which can restrain over-voltage and

be used as selector switch in earth fault; PT0is neutral-point potential transformer used to gain the neutral-point displacement voltage; CT0 is neutral-point current transformer used to gain the neutral-point displacement current; PT is bus-bar potential transformer used to gain bus-bar voltage and open-delta voltage; CT1 、CT2、…、CTn are residual current transformers.

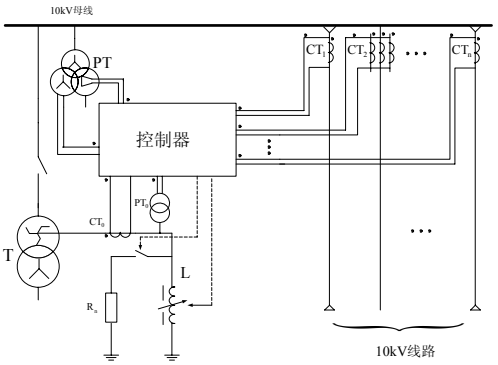
1.2 Operating principle

When single-phase malfunction occurred in the system , the isopleth map can be showed in fig 2.r0 and Co are bleeder resistance and direct-to-ground capacity, L is the tuning induction of extinction coil, Rn is the parallel resistance of star point and extinction coil.

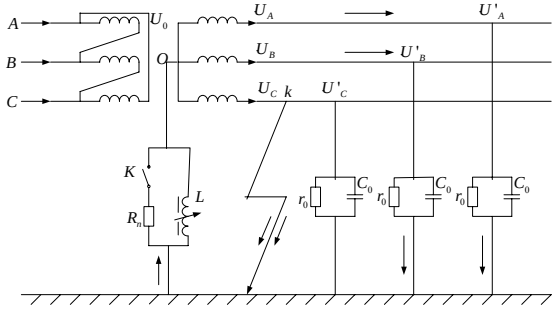
When the power line is in good running ,the parallel resistance of star point and extinction coil is operating .Extinction coil is preset. Circuit controller measure the real-time capacitance current and adjust the position of extinction coil in order to assured it operate near the resonance point.

When the Single-phase earth faults has happened, Arc suppression coil needn't to adjust, the zero time-delay mechanisms compensate it instead. While bringing the effect that Arc suppression coil compensate the capacitive fault currents, slow down the speed of fault-phase recovery voltage, making full use of the parallel connection of middle resistance to restrain over-voltage. After a moment, if single-phase ground still exist, it is necessary to cut parallel connection of middle resistance down and make full of the effect that Arc suppression coil compensate the capacitive Fault currents .it hope that the remained current is less than 10A by compensation to make Electrical arcs go out. If electric arc extinction ground connection disappears, throwing into the parallel connection of middle-resistance and utilizing the Damping effect of the parallel connection of middle-resistance to make the system return to normal work .It is considered that permanency earth fault happened in the electrified wire netting if ground connection does not disappear, throw into parallel connection of middle resistance and minor resistance at the same time , connect in parallel with Arc-extinguishing coil, change the zero circuits parameters , make use of the Zero-sequence protection or choose a line to carry out it.

Extinction coil need operate some time to arrive stable action spot. So in the transient, it may arise arc-grounding over-voltage because of the extinction coil can not compensate the current and delayed input the parallel resistance can abstain the transient. After open the parallel resistance, the system is in neutral arc-suppression grounding mode. Extinction coil is operate stably ,so it can reach the compensation degree . The current in trouble unit is less than 10A and the arc will extinguish easily. The dominance of extinction coil in depressing arc-grounding over-voltage can bring into play.



Graph1 mode of connection's picture



Graph2 picture of equivalent circuit

1.3 Parameters

1.3.1 Extinguishing coil select

First, Based on the actual measurement, we can obtain system total capacitance electric current IC. The total extinguishing coil capacity is

$$S = 1.35EI_C$$

Then according to the system the actual situation, to choose partition compensation or other compensation way, and to confirm the capacitance of one machine .The tap-changing switch and the least regulating current should be determined according to the actual situation. The situation of capacitance and electric current of each outgoing line should be considered. It's necessary to take all circuit situations into consideration and to satisfy the request of residual flow.

1.3.2 Selection of resistance

Neutral point parallel connection with medium resistance can restrict the over voltage under 2.5.p.u.Consideration of the medium resistance may enlarge the residual flow. So the selected resistance should restrict the instant residual flow to avoid two-phase failure. According to internal reality experience, grounding current is between 400A and 600A. When time of duration reach 1s, few cases can develop to two or three-phrase failure. Here grounding current limited by medium resistance should under 100A, durative time should less than 05s. So we should considerate from the restriction of arc grounding over voltage and the restriction of residual flow when we select resistance.

Thermal capacity is another important parameter of resistance; neutral point resistance is designed and made

in short-term operation. The permit current can be calculated as formula (2):

$$I_t = \frac{I_0}{\sqrt{1-e^{-t/T}}}$$

I_0——long-time permit current, A;
I_t——short-time permit current, A;
t——time of current, s
T——characteristic time of fever, s
Select the parameters I_0, T of medium resistance, calculated as formula (2), If I_t larger than I_R, the parameters meet the heat-stable requirement.

1.3.3 Selection of the grounding transformer capacity

The neutral point after the extinguishing coil and the way of resistance combination earthing when single-phase earth fault happens, The neutral point has the three situation, which are extinguishing coil parallel median resistance, extinguishing coil, extinguishing coil parallel low resistance. To suppose the neutral point voltage is Un, the electric current of flowing the extinguishing coil and resistance are IL、IR. When neutral point after extinguishing coil parallel median resistance earthing, the consumed power in extinguishing coil and resistance is

$$S_1 = U_n(I_L + I_R)$$

Likewise, we can get the consumed power S2 when neutral point after extinguishing coil parallel median resistance earthing. Considering a capacitance tolerance, it is can be 1.35, the capacitance S_n of grounding transformer is

$$S_n \geq \max\{1.35S_1, S, 1.35S_2\}$$

To be sure the concrete parameter choice also should unify concrete project example, the Calculates of fault short-circuit current, fault analysis, arc overvoltage, and harmonic oscillation overvoltage.

2 Evaluation of grounding methods

Neutral grounding method is a complicated problem which relates to many respects of the power system. This paper put forward evaluations and research on insulation level of the lines and equipments, network structures, over voltage, relay protection, personal security, communication interference, and economical aspects.

2.1 The insulation level of lines and equipments

The confirmation of the equipment insulation level applying the neural grounding method with the combination of the resistance and arc-suppression coil follows the resonance grounding method. Compared with resonance grounding method, the normal switching of the paralleled neutral point and middle resistance can suppress arc over voltage with in 2.5p.u.. After the switching off of the middle resistance, neutral point is grounded through arc-suppression coil, but the time of the resonance grounding is within T2 , the over voltage won't exceed the level of resonance grounding, and the insulation margin of lines and equipments becomes bigger. Compared with small resistance grounding method, the insulation level of lines and equipments applying combined grounding method is slightly improved. The equipment insulation level which is in domestic distribution networks grounded through small resistance follows the standard of the resonance grounding method, so, the combined grounding method will not increase the cost of equipment insulation.

2.2 Power network structure and power supply reliability

The neutral resonance grounding system can operate for 2 hours with a single-phase grounding fault. To some extent, this improves the power supply reliability. Experimental switching off is the most way to confirm the fault line, and, it will cut the power to many customers (sometimes customers on several lines) in a short time. The power will also be cut off after the confirmation of the fault line, the customers, limited in important customers, will be informed and the flow will be transferred before the power cut.

The signal of switching off will rise and the fault line will be cut off immediately in a neutral small resistance grounding system, when a single-phase grounding fault occurs. This may affect the power supply reliability to some extent. So, this only fits for the distribution networks mainly composed of cables, and has more demand in distribution network structure, mutual supply ability, equipments and automatic level. Else tripping operation lead to frequent power failure, and the reliability of current supply is lower.

To Henan distribution network, the combination of the neutral arc-suppression grounding and neutral resistance grounding method can distinguish instant fault and permanent fault. The avoidance of the most often instant fault makes the supply reliability prior to that of the middle-small resistance grounding method. And this combined method will increase the rapidity and veracity of the fault line selection, and it also can prevent a single-phase fault developing into a 2-phase or 3-phase fault, when the permanent fault occurs. So, the supply reliability of the combined grounding method is prior to that of resonance grounding method and neutral small resistance grounding method.

2.3 Over-voltage level

In neutral arc-suppression grounding mode, the overvoltage of the sound-phase will rise to line voltage. The arc-suppression coil dose not reduce the arc-grounding overvoltage, but improves on blowing out arc and avoiding restrikes in order to reduce restrikes, overvoltage duration and the possibility of high amplitude overvoltage.

The neutral middle-small resistance grounding method, whose overvoltage is lower, could reduce power frequency overvoltage, suppress intermittent arc grounding overvoltage effectively, remove resonant overvoltage, reduce various switching overvoltage, and also do favour to the application of the MOA with excellent volt-second characteristics.
The combination of the neutral arc-suppression coil and resistance grounding method, as an upgrade of the resonance grounding method, improves on confining the arc grounding overvoltage within 2.5p.u. by the normal switching of the paralleled arc-suppression coil and middle resistance, and greatly shorten the grounding duration through the selection of the cooperation time performed with relay protection. Meanwhile, arc-suppression coil and neutral resistance could suppress or remove Ferromagnetic resonance overvoltage.

2.4 Relay protection

The relay protections of the resonance grounding method are much more difficult. They are confirmed mostly by experimental switching presently. In recent years, with the application of the computer and microelectronic technique in the power system relay protection and automation, microcomputer-based relay protective devices and lines selection become applied in middle voltage and small current grounding systems. In a general way, a auto compensating arc-suppression coil of a whole set has a function of rapidly single-phase grounding line selecting. But, the veracity are mostly between 70%-90%, or even lower. The wrong selection rate is bigger, which depresses the advantages of the resonance grounding method. In a neutral small resistance grounding system, the zero-sequence relay protection can act as the grounding line selection, which is simple, rapid, and accurate.
The combination of the neutral arc-suppression coil and resistance grounding method achieves grounding line selection with small resistances, which is the same as the relay protection of neutral small resistance grounding method, and prior to resonance grounding method.

2.5 Personal safety

It is advantageous for personal safety when neutral point grounds by extinction coil, because that the residual flow passing through the fault is small and the contact voltage together with the pace voltage are restricted in the safe range. However, the fault lasts longer, which increases the rate of personal electric shock. It is disadvantageous for personal safety. By using the microcomputer ground protection, instant faulty line tripping off on the condition of not increasing the ground fault current can be actualized, which is good for the personal safety.

The fault current is normally restricted between 800A and 2000A if the star point is grounding by resistance. Bigger grounding fault current can cause contact voltage and pace voltage, which is a menace to the personal safety, but the neutral ground system can trip immediately in order to avoid the electroshock accident.
It is obvious that there are electroshock casualties and instances of escaping from the electroshock accident. The compound mode of neutral ground and neutral point grounding by extinction coil has the equivalent personal safety level with the neutral ground mode. It is because of the effect of parallel resistance, which causes the bigger current in the ground point. In fact, it is obvious from the internal statistical material that there are tiny injuries to personal if the relay protection can trip immediately. Therefore, the personal safety in the system of a compound mode of neutral ground and neutral point grounding by extinction coil can mainly depend on the fast action of residual current protection.

2.6 Communication interference

Neutral resonant grounded system is belonging to small current neutral grounding system, and communication interference can be ignored .The single line grounding current is higher in the system of middle-small resistance grounding mode. The restriction of single-phase grounding current level is various in our country, In Beijing, it's under 2000A, and in Guangzhou, it's under 1000A, IEEE standard is under 1000A.In 22kV-154kV aerial power net, according to the empirical value of Japan, current of neutral grounding resistance is between 100A and 200A; current in cable power net is between 400 and 800A, which has little influence to communication.
Grounding current is less than 100A when neutral arc-suppression-coil grounding combined with resistance, arc-suppression-coil installed in parallel with resistance which value is 64Ω. It will have little influence to communication when the grounding current is limited under 400A.

3 Application

According to the situation of its lines and the load of its 10kV in one substation of the electric network in Henan, the neutral point of its 10kV system adopts the combined neutral grounding mode which uses the suppression arc coil combined by resistance in parallel. In this mode, the capacity of the suppression arc coil is 750kVA, the value of medium resistance selects 64Ω, the value of little resistance is 21Ω. Having been running from October of 2005 to December of 2006, although the system has been suffered by single-phase grounding trouble many times, no over-voltage accident has not taken place and the device has been running well all the

time.

4 Conclusions

The neutral grounding method with the combination of extinction coil and resistance has applied to Henan electric network and the operational aspect is all right. Assessment experience has proved that this neutral grounding method can satisfy city distribution network in Henan. The following are conclusions:

1) Considering about the influence factors to neutral grounding, this method is more superior than resonant grounding and have higher performance-to-price ratio.

2) The neutral grounding method with the combination of extinction coil and resistance can replace the resonant grounding in nowadays power grid, can be suitable well for the distribution network whose primary part is non-cable line.

3) The neutral grounding method with the combination of extinction coil and resistance can make use of the characteristics of the two grounding models, and it can treat the instantaneous and permanent single-phase ground short-circuit faults separately, which raise the power supply reliability.

4) With the correct choose of the grounding resistance's value, we can restrain the over-voltage level and the short-current level effectively, and it will not influence the operation of the current 10kV power system. After the compensation of the automatic following extinction coil, there is less rudimental current in the system, so how to choose the correct circuit to the single-phase grounding is very important. And this method provides an effective method to resolve this problem.

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