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Study on the Methodology Monitoring Transformer Bushing Insulation Defects

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Abstract. Power transformer is the key equipment in power system. In view of the issues of the current bushing monitoring method, a new detection method of bushing insulation defects is proposed in this paper. According to the internal structure of bushing, the internal insulation defects are divided into three categories, including partial moisture, pollution, local insulation defects, the outer insulation of the bushing is equivalent to a resistance chain model. The entire bushing insulation is considered as a parallel between inner insulation and external insulation (inner Insulation is the main). This detection makes uses of the transient voltage measured from transformer bushing and the transient current measured from the end shield down-lead as the signal source. The reference data dynamically generated is used to diagnosis and distinguish Insulation defects of Transformer bushing, according to the monitoring data of the bushing and the maximum of the reference data, the type of the bushing insulation defect and the severity can be sentenced. A large number of simulation results initially confirmed the effectiveness and feasibility of the proposed method.

Introduction

High voltage bushing is indispensable and important electrical equipment in the power system [1]. Transformer bushing has current carrying, insulation, mechanical support and sealing effect [2-3]. The bushing can be divided into pure ceramic bushing, oil-filled bushing and capacitive-type bushings by Insulation structure. The capacitive type bushing is currently the most widely used high voltage bushing, and the internal insulation of the capacitive type bushing is divided into oilpaper capacitive and gluey paper capacitive [4]. In operation, under the influence of the electrical, thermal, mechanical stress and environmental stress, the insulation state of the bushing will be gradually decline. Therefore, researching the bushing insulation monitoring and fault diagnosis method has been the general concern of the power system [5].

The existing bushing insulation defects monitoring methods include dielectric loss method and capacitance increment method [6-7]. In some extent, casing insulation defects can be detected by these methods, such as bushing capacitive screen breakdown and other defects, but there are also some issues such as recognition sensitivity, stability and robustness [8].

High voltage bushing insulation monitoring method

According to the transformer bushing structure, the insulation of the bushing is divided into inner insulation and external insulation in this paper. The inner insulation defects include local damp, filthy and local insulation defects of three categories. The outer insulation is equivalent to a chain structure. In this paper, the transient voltage on the two sets of the bushing and the transient current of the leads of the end of the screen are used as signal source, and the discriminant function of the bushing insulation defect diagnosis reference data can be dynamically generated with that source. According to the correlation between the casing monitoring data and the reference data, the bushing insulation defect type and severity are diagnosed. In this paper, the criterion function is actually a non-linear mapping, the consolidated differences of the bushing insulation defects can be given directly, rather than a tiny feature quantity extracted under strong noise background, so this method has a strong anti-jamming capability.

The casing used in the simulation is oil-paper insulation casing, has a total of 90-layer plate, "the same capacitance, the same level "design scheme is adopted between the respective adjacent capacitor plate. The equivalent circuit of each layer the plate is constant, but the C2 is variable. In order to facilitate the simulation instructions, every 15-layer plate structure is equivalent to a unit in the radial direction in this paper. The unit is shown in Fig1. By analyzing the medium features of the casing and the influence of the size on creeping discharge, the chain equivalent model of the outer insulation is equivalent to Fig.2:

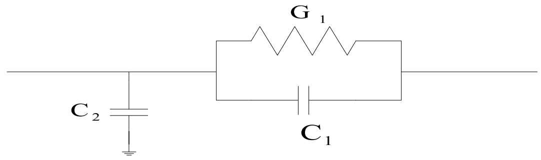

Fig.1. A unit circuit of the internal insulation

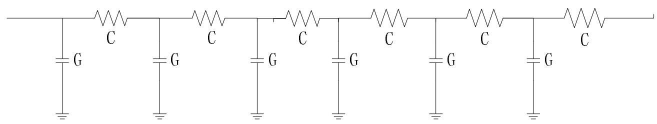

Fig.2. The chain equivalent circuit of the outer insulation

Detection method simulation

Monitoring methods source

In this paper, the source (information source)of the monitoring methods are the transient voltage and the transient current. The Scene Investigation showed that transient voltage waveform is a shock oscillation wave. The shock oscillation wave mainly is generated by the normal operation of the system, lightning, failure and other reasons. The lightning and switching impulse oscillation wave are mainly. The transient voltage waveform on the device of the system as shown in Figure 3, Figure 4.

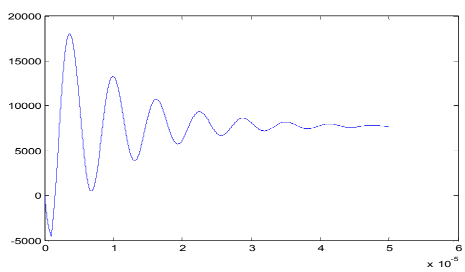

Fig.3. Lightning wave oscillation waveform

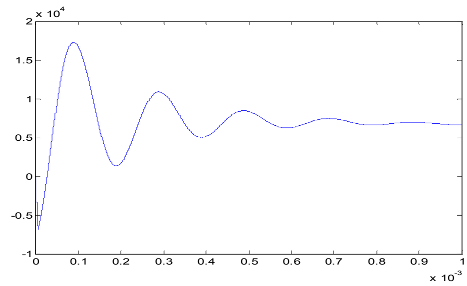

Fig.4. Operating wave oscillation voltage waveform

As can be seen from the Fig 1 and Fig2, the oscillation of the system have the characteristics of a high amplitude and high frequency oscillation. Thus the information of the insulation defects can more effectively be screened. This is the root reason why the transient voltage and current of the system is chosen as the signal source.

Simulation circuits

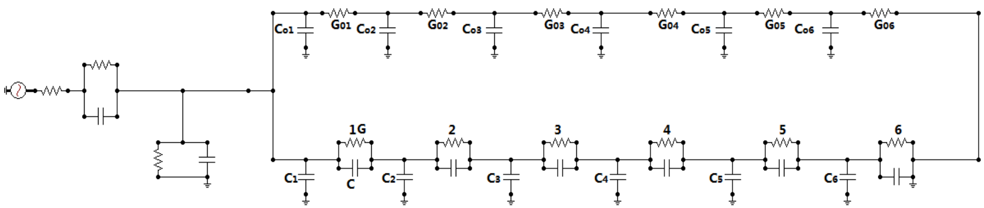

Fig.5. Simulation of operating wave oscillation voltage waveform

In order to obtain the oscillation (supply voltage) shown in the Figure 1, Figure 2, we use the simulation circuit shown in Fig5. According to the structure of the transformer bushing, the insulation of the bushing is seen as a parallel of the inner insulation and the outer insulation, for convenience of explanation, the inner insulation and the outer insulation are respectively equivalent to the cascade of 6 unit circuits.

Through several simulations found that the outer insulation of the bushing insulation has little effect, the internal insulation is dominant. At the same time, the outer insulation problems can easily be found (such as surface discharge, uncleanness, etc.) in the real operation. For the convenience of explanation, so the insulation monitoring of internal insulation defects was chosen as an example in this paper.

In order to facilitate the description of the methodology in paper, the simulation of this paper choose 10 kinds of fault types and 10 different fault locations as the database, which is shown in table 1 and table 2. Should be noted, fault type 1 means the normal operation. And then select the segment 3 of the bushing, C1 changed 10 times (that is corresponding to the fault location 4 and fault type 3) as fault to be identified and do the simulation. Analysis the transient fault voltage and current harmonic, and compare to the fault signal in the database, distribution curve of this criterion function of the monitoring methods can be obtained in paper. The distribution curve is as shown from Fig 6 to in Fig9. For ease of explanation, the correlation coefficient generated is drawn by comparing the signal of the faults to be identified to the signal of the faults in the database with the harmonic N = 10, 20, 30, 50.In the figures, x-axis corresponds to the fault type, y-axis corresponds to the fault location and the z-axis means the correlation coefficient.

Table 1. 10 kinds of insulation fault types

The type of fault	Increased multiples of G	Increased multiples of C	Increased multiples of C1
1	1.0000	1.0000	1.0000
2	1.0000	1.0000	5.0000
3	1.0000	1.0000	10.0000
4	1.0000	1.0000	20.0000
5	1.0000	1.0000	40.0000
6	1.0000	1.0000	80.0000
7	1.0000	1.0000	200.0000
8	1.0000	1.0000	500.0000
9	1.0000	1.0000	1000.0000
10	1.0000	1.0000	2000.0000

Table 2. 10 kinds of fault location

Fault location number	Non-fault segment	Fault segment
1	1-5	6
2	1,3-6	2
3	1,4-6	2，3
4	1，2,4-6	3
5	1，2,5-6	3，4
6	1-3，5-6	4
7	1-4，6	5
8	1-3	4-6
9	1-4，6	5
10	1-4	5，6

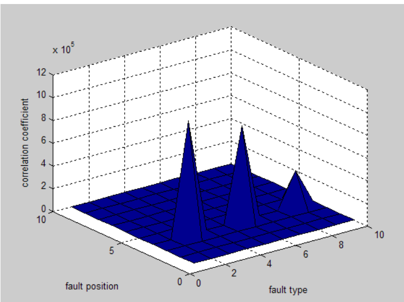

Fig.6 The correlation coefficient in the harmonic N = 10

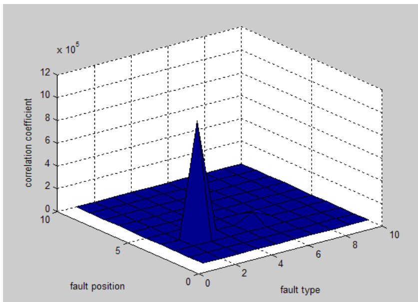

Fig.7 The correlation coefficient in the harmonic N = 20

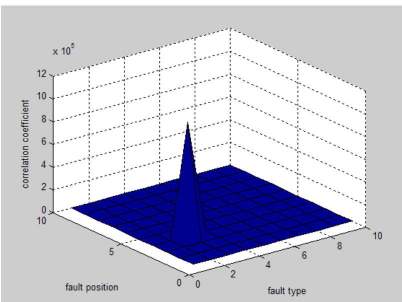

Fig.8 The correlation coefficient in the harmonic N = 30

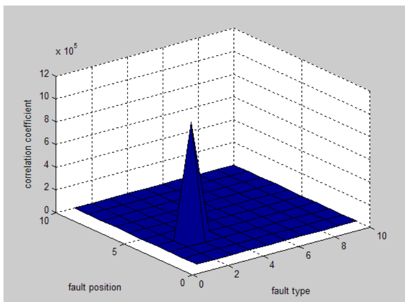

Fig.9.The correlation coefficient in the harmonic N = 50

Simulation results analysis. It can obviously be obtained from the four above figures that when x = 3 and y = 4, the value of z hits the peak, it indicates that the fault to be identified is corresponding to the fault location 4, fault type 3 in the database. So the location and the type of the fault can be judged. The diagnostic results and failure simulation setting are consistent, which proves the feasibility of the method

Further, it can be seen from the four above figures that when x=6, y=4, the value of z is also high, it indicates that the fault to be identified seems to be corresponding to the fault location 6, fault type 4 (C1 increases 100 times) in the database. Therefore, it can be speculated that when the database does not contain the actual fault type of fault, the type of fault also can be identified, but the results are less accurate. Furthermore, it can be seen, if the harmonic number is higher , then the type diagnostics of the fault is more accurate, Therefore, the high-order harmonic the fault type and fault location can be easier and more accurately determined with high-order harmonic.

Conclusions

The high voltage bushing is an important part of the transformer and is also the defective part. According to the transformer bushing structure, the insulation of the bushing is divided into inner insulation and external insulation in this paper, the inner insulation defects include local damp, filthy and local insulation defects of three categories. The outer insulation is equivalent to a chain structure. In this paper, the transient voltage on the two sets of the bushing and the transient current of the leads of the end of the screen are used as signal source, and generate the reference database of insulation defects dynamically. According to the maximum value of the discriminant function (the highest point of the three-surface chart) of the monitoring data and reference data, the location of the fault of the high-voltage bushing and the insulating defect severity can be successful Identified. In this paper, the discriminant functions is actually a non-linear mapping, the consolidated differences of the bushing insulation defects can be given directly, rather than a tiny feature quantity extracted under strong noise background, so this method has a strong anti-jamming capability. The effectiveness and feasibility of this method are confirmed by a large number of simulation results.

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