TEST STUDY ON DC BIAS OF LARGE POWER TRANSFORMER

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Abstract: The experiment study on the large power transformer ability withstands DC bias is few because the requirement of testing instrument is critical. Now, the main study method for the influence of Neutral Point DC Bias to Power Transformer is simulation and simplified model test. To study the ability withstand DC bias, in this paper, the factory testing process and results of two single-phase transformers which type is 334MVA/500kV are analyzed. The instrument configuration, test method and test procedure is proposed. When the rated voltage and the DC bias is both applied to the transformer, the exciting current, the harmonic noise and vibration of the transformer are measured. The DC biasing current of 1, 2, 3 and 4 A is imposed on the transformer respectively. The testing results under different DC biasing currents are compared with these under normal condition. Under the condition of 4 A, content rate of third harmonic for the exiting current reaches 76%, noise value is 91 dB and the vibration displacement is about 4 μm. The results show that the exiting current, harmonic and noise of transformer have very close relationship with the DC bias; and the DC bias has little influence on the vibration relatively. The research results are worth considering in the design and operation of large power transformers, and it provides a verification means for the operation reliability of large power transformers.

1 INTRODUCTION

The power transformers play the important role in the power grid. The running reliability of them has the great means for the safty of power grid. The core of power transformer will be magnetized by the DC current if the DC current flows through the neutral point in the practical operation. In the situaion the core will occur the one-way saturation of magnetic circuit, then the power transformer endures the DC bias. The DC bias applied to the transformer will bring the aggravation of the exciting current, the harmonic noise, vibration, local overheating of the transformer. In the severe case it can lead to the amagment of power transformer and misoperation of protection system. The main cause of DC bias are as follows: sunspot activity, monopole operation of HVDC according to Reference [1-3].

From the last century end, the abnormal sound, damagment of transformer and accident of power system caused by the DC bias is of common occurance. In recent years the HVDC transmission system is increased in the east china power grid. And the influence of HVDC on AC transmission system appears gradually. The biasing current has been detected in some AC transformers of east china power grid. At the same time the harmonic components and noise level measured are enlarged when the biasing current is existed. So the experiment study on the large power transformer ability withstands DC bias is necessary for the safe operation of power transformer.

Now the research work has been carried out by the simulation method in many scientific research institutions and electric power companys in Reference [3]. But there must establish hypothesis in the simulation process. It presents the difference between the actual transformers and the simulation models under the DC bias. So the pertinence of simulation is not strong. The test withstanded DC bias can check the actual withstands ability of transformers under the different DC currents. The paper describes the influence principle of DC bias and the experiment process of two 334MVA/500kV power transformers in the delivery test. The experimental results including the harmonic waves of excitation current, noise values and vibration amplitude are analyzed.

2 THE OBJECT OF TEST AND TEST PROCESS

Test objects presented in Figure 1(a) are two 334MVA/500kV power transformers with the same design. The main design parameters are as follows:

Rated power: 334000/334000/90000 kVA
Rated voltage: 510/230±2×2.5%/36 kV
No-load loss: 75 kW
Load loss: 450 kW

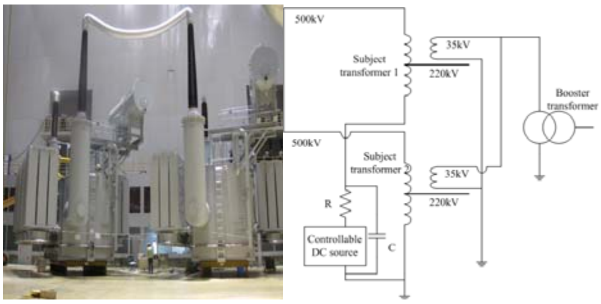


Figure 1□(a) The subject transformer (b) The wiring diagram

Figure 1(b) shows the wiring diagram in the experiment. The rated voltage with power frequency is applied to the low voltage side of 35kV, then the transformer is in the state of the rated excitation. In the state the DC current is imposed on the neutral point. By changing the DC current, the excitation current, noise and vibration tested from the subject transformer are proposed. And the relation are studied between the current and them.

In the test, high voltage side, low voltage side and neutral point of two subject transformers is in parallel connection respectively. The controllable DC source is installed in series in the side of neutral point to simulate the DC influence. The resistance of R in the test circuit is used to adjust the DC current. The capacitance of C in the circuit prevents the damage of DC source and instruments by the circulation. Two power transformers reaches the rated excitation at the same time. The biasing current is 1A, 2A, 3A and 4A apllied in the test.

3 THE ANALYSIS OF TEST RESULTS

The flux density in the core is usually working inside the critical saturation point when the transformer is in normal operation. But the magnetic in core will be supersaturated in the half of primitive period when the biasing current flows into the transformer. The flux density will be greatly increased in the half period which has the same direction with the biasing current, and the other is decreased. The variation of flux density leads the aggravation of hysteresis expansion and noise value. Simultaneously, the loss and temperature rise of core and yoke clamping is greatly increased. In addition, the serious harmonic in excitation current may result in protection misoperation. Besides above influence, the horizontal leakage flux will be strengthen, then the hottest spot temperature of windings and vibration of tank is rosen. Finally, partial high temperature of power transformers is big enough to accelerate the insulation aging due to the biasing current. All these factors can endanger the safe operation of power transformers and transmission lines. According to the analysis, the characteristic parameter including percentage of the harmonic currents, noise value, vibration displacement and the hottest spot temperature are recorded.

3.1 The influence of biasing current on excitation current

If the biasing current is occurred, distortion of excitation current makes the superposition of DC flux and AC flux. The total flux density will present the asymmetry in two half periods of power frequency. Then the excitation current also would be asymmetric in positive and negative half-period. The excitation current includes odd and even harmonics. In actual running of power grid, there is no odd harmonics. The data of excitation current is shown in table 1. It can be found that percentage of the third and fifth harmonic under the biasing current of 4A is much bigger than these under the biasing current of 1A from the Table 1. The percentage of the third harmonic is 4.55% and 76.09% respectively under the DC of 1A and 4A, and the fifith harmonic is 0.055% and 32.454%. The percentage of the second and fourth harmonic is very little. When the DC current is changed from 1A to 4A, the percentage of harmonic is rosen from 4.580% to 83.947%. It can be seen that the DC bias influences the odd harmonic current greatly, and the influence of DC bias on even harmonic current can be neglected.

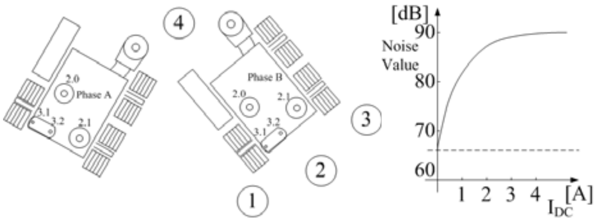
Table 1: The percentage of harmonic in excitation current

Harmonic number	1A	2A	3A	4A
1	100	100	100	100
2	0.498	1.281	1.366	0.108
3	4.550	5.848	9.255	76.090
4	0.100	1.326	2.639	0.272
5	0.055	2.892	2.774	32.454
Total harmonic	4.580	6.883	10.946	83.947

When the harmonic is big enough, the interference of harmonic current will result in maloperation or misstrip of the relay protection and automatic devices, even the transformer can be destroied in the process. So the influence of DC bias on the secondary equipment should be reduced, and the study is urgent to be developed.

3.2 The influence of bias current on noise value

The measuring point of noise is distributed in the Figure 2(a). The total measuring points are four which are in the one-third height of transformer-cabinet. The datas are listed in the Table 2. It is clear that the noise value in the same point becomes big with the DC bias increased. The noise value of the first point under the DC bias of 4A enlarges 36.7% compared with it without the biasing current. And the values of the second, third and fourth point enlarge 32.4%, 38.3% and 30.2% respectively. The curve of average noise intensity is shown in Figure 2(b) described the relation with the biasing current. The saturation tendency of the noise value is occurred with the bias current enhanced. It is close to be saturated under the biasing current of 2A. The change rate of noise is large in the range of 0-2A. It can be said that the excitation winding is saturated even if the DC bias current is little. The saturation is related with excitation force working in the critical saturation status in the design when the transformer is the rated condition.



Figur 2 （a）The distribution of measuring point （b）The curve of average noise

Table 2: The noise value in dB

Measuring point	DC=0A	DC=1A	DC=2A	DC=3A	DC=4A
1	67	81.9	86.8	90.7	91.6
2	66.9	80.4	87.5	88.7	88.6
3	65.8	80.4	85.4	89.1	91.0
4	66.9	79.8	85.6	87.7	87.1
Average value	66.6	80.6	86.3	89.1	89.6

3.3 The influence of bias current on vibration amplitude

The unidirection displacement sensor is used to test the vibration characteristic with different biasing currents. The measuring point of vibration is arranged on the surface of transformer tank, radiator and other accessories. The peak-to-peak value of vibration is recorded in the Table 3. The peak-to-peak value of vibration in the same point tends to be increased with the development of the DC bias current. For all the measuring points, the vibration displacement is increased 33% or 66% under the DC current of 4A compared with it under 1A. And the average vibration displacement is increased 29.2%.

Table 3: The peak value of vibration

DC in A	measuring point of vibration in μm								
	1	2	3	4	5	6	7	8	Mean
1	3	2	3	3	4	3	3	3	3
2	3	2	3	4	3	3	3	3	3
3	4	2	4	4	3	3	4	4	3.5
4	4	3	5	5	3	3	4	4	3.875

4 CONCLUSION

The study on DC bias test of large power transformer is not descripted in the previous lectures. The paper provides the reference on the DC bias test for large power transformers. Based on the test in the paper, it can be concluded that：
1) The DC bias has the bigger influence on the odd harmonic than on the even harmonic of excitation currents. The percentage of the third harmonic is 76.09% with the DC current of 4A.

2) The noise value becomes big with the increasement of DC current, and is trended to be saturated even if the DC bias current is 2A. But the saturation value exceeds 90 dB concluded from the test；

3) The peak-to-peak value of vibration tends to be increased with the advancement of the DC bias. The average of it under 4A is enhanced 30% compared with it under 1A.

Based on the above analysis, the DC bias has the influence of the running of large power transformers. More tests should be done to study the ability withstands of large power transformer on DC bias and verify the design technics.

5 REFERENCES

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