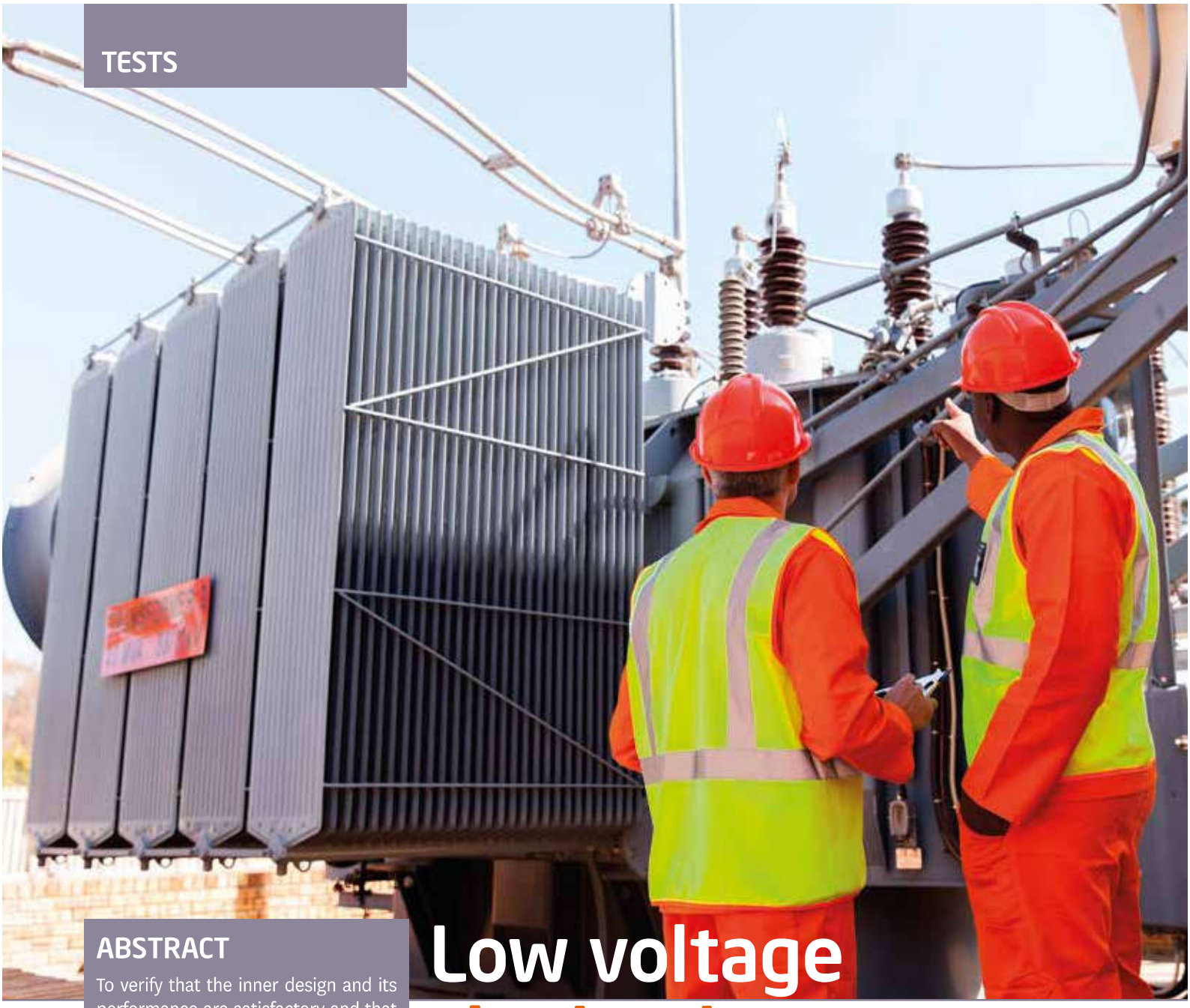

Low voltage single-phase excitation for power transformers

ABSTRACT

To verify that the inner design and its performance are satisfactory and that there are no failures in the winding insulation system and core displacement during long-trip transport, we need to do several tests such as SFRA test or single-phase excitation test. Defect in magnetic core structure, shifting of windings, failures in turns to turns or block to block insulation or problems in tap changers are conditions that change the effective reluctance of the magnetic circuit, thus affecting the current required to establish flux in the core. In order to deal with these problems, we would use low voltage single-phase excitation for power transformers. This is also a kind of auxiliary judgment method to guide us about the condition of transformer.

KEYWORDS

low voltage single-phase excitation, core type transformer, auxiliary judgment, magnetic flux

In the transformer factory, we also use low voltage single-phase excitation during the semi-finished processing of the products, another test to help us confirm the product before the final assembly. This may take several attempts, but if the product is defective, it will reduce labour and financial resources. This test may find that the quality is defective which cannot be found in turns ratio test and winding resistance test. For example, a short-circuit fault between the winding parallel wires will not be obvious in the turns ratio and winding resistance or other test, but it will indeed be evident in the single-phase excitation test because when we do the test, we will see that current change occurs.

We always use 220 V / 380 V single-phase excitation for diagnosis. The test voltage should normally be applied from the low voltage (LV) side for easier connection. This test method can more or less be performed with the Doble test set or another tester designed for this purpose. (Doble test set always supplies 10 kV to the high terminal but has the same

The single-phase excitation test can help to identify the defective quality of a transformer, which cannot be found by turns ratio test and winding resistance test

purpose.) This method is safer and easy to perform because not every client has the Doble unit but a usual contact voltage regulator. One should be aware of voltage appearing at other terminals and to ensure safe limits are not exceeded when performing the test. A note should be taken with regards to safety considerations when performing these measurements.

Also, just to note on terminal designations, it is probably best to keep it simple, e.g. A-B-C-N for HV and a-b-c-n for LV etc., mainly to keep it easy and consistent for the reader. Before you perform the test, it is important to review the factory test report to determine if the tap position and test voltage are in the same condition as when the test was performed in the factory, otherwise you will get the wrong guidance.

For single-phase unit as well as three-phase transformer bank, when we perform the single-phase excitation test, we could

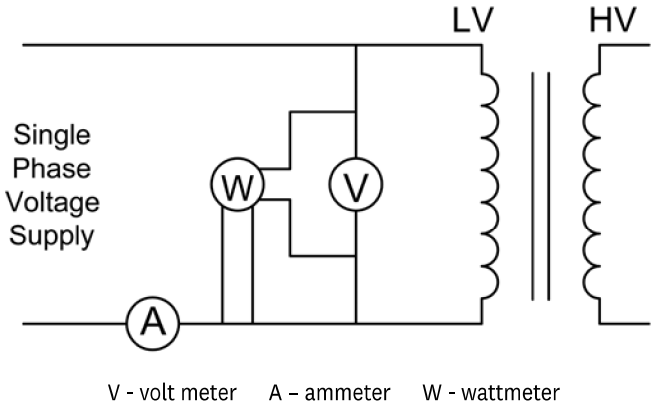

Figure 1: Standard requirement for single-phase excitation

Before performing the test, it is important to review the factory test report to determine if the tap position and test voltage are in the same condition as when the test was performed in the factory, otherwise a wrong guidance could appear

compare the results with the factory report. At the same voltage, the result compared with single-phase units will differ less than 5 % for the loss and current.
For three-phase transformer, the following should be performed: the entire test method phase by phase, for a three leg or five leg core structures. When we test the middle phase, we will get high readings for current and loss because the magnetic flux has a long way to flow.

For transformers with wye-connected LV windings, measure the following:

- supply l1-l0, short circuit l2-l0
- supply l2-l0, short circuit, l3-l0
- supply l3-l0, short circuit l1-l0

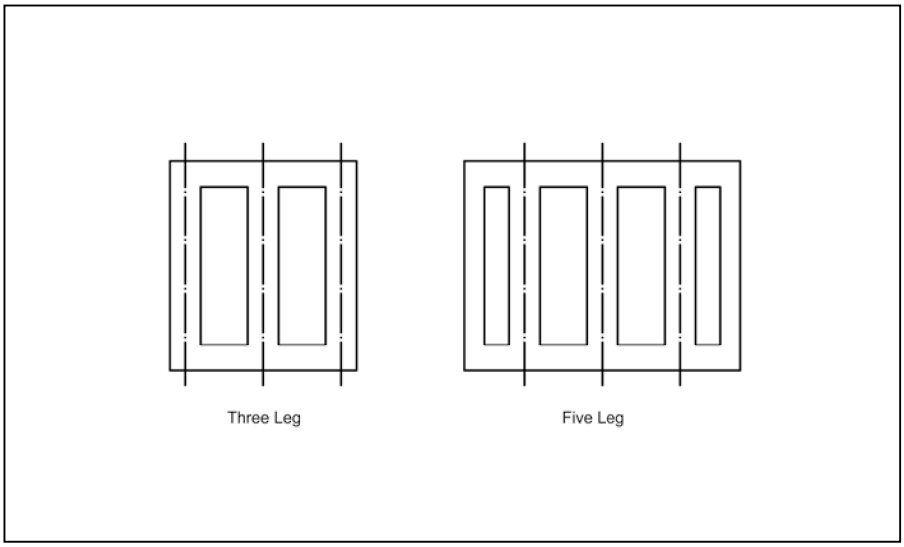

Figure 2: Three-phase core types

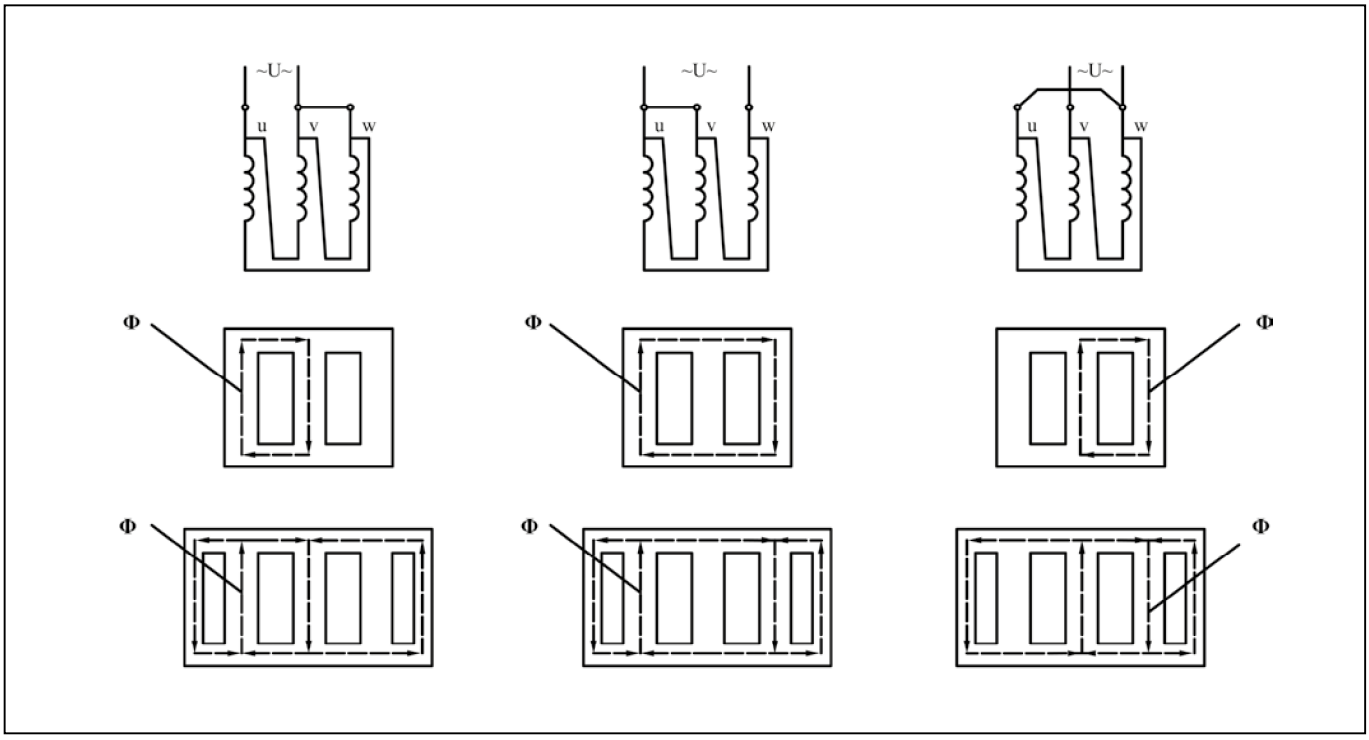

Figure 3: Single-phase excitation for three phase transformer, d11

Table 1: Single-phase excitation for three-phase transformer 220 kV, 180 MVA, five leg ,YNd11

	Supplied	Shorted	Voltage (V)	Current (A)	Loss (W)
Before DC resistance	uv	vw	220.0	0.3167	42.2
	uw	uv	63.1	0.5273	64.2
	vw	uw	220.2	0.3102	41.5
After DC resistance	uv	vw	220.0	0.4658	66.1
	uw	uv	220.4	0.9077	96.1
	vw	uw	220.4	0.4597	

		Supplied	Shorted	Voltage (V)	Current (A)	Loss (W)
Factory report		uv	vw		0.4518	49.2
		uw	uv	220.2	0.8123	84.2
		vw	uw		0.4502	48.8
Test result on site	Before demagnetised	uv	vw		0.7658	85.1
		uw	uv	220.4	1.177	126.1
		vw	uw		0.7707	83.1
	After demagnetised	uv	vw		0.4523	50.8
		uw	uv	220.0	0.8317	87.2
		vw	uw		0.4499	50.0

Table 2: Single-phase excitation for three-phase transformer 110 kV, 200 MVA, five leg ,YNd11

For transformers with delta-connected LV windings, measure the following:

For d11
- supply L1-L3, short circuit L1-L2
- supply L2-L1, short circuit L2-L3
- supply L3-L2, short circuit L3-L1

Excitation tests must be performed before any DC tests because the application of DC voltage may alter the test results. The results from single-phase and three-phase excitation will not always correlate. If the voltage applied in the field is not properly selected, we should also notice that in waveshape of the supply, it is really better if the reading of root mean square (r.m.s.) voltage and root mean (r.m.) voltage is within 3 %. Then the data may be influenced by the magnetising reactance. If there is suspected residual magnetism in the transformer, transformer being tested may be demagnetised before the commencement of magnetising current test.

Here is the comparison of the same three-phase unit before and after the DC resistance, where we can see very high readings for current and loss.

Comparing several types of transformers and structures, either in factory or on site, when we perform the test after the DC resistance test, we will always measure erroneous results, but generally after demagnetising, the measurement data is in a good agreement.

But we should note, although we get a high reading, the highest one is still when we short the middle leg. That does not change.

Low voltage single-phase excitation test should only be considered as a diagnostic tool, not a pass/fail acceptance test. But if the measured exciting current value is many times higher than the value measured during pre-commissioning checks, then there is likelihood of a fault in the winding, which needs further analysis.

The identical test results help us confirm no damage occurred due to transportation. The availability of test data for both normal and faulty condition results help us analyse the problem in the future.

Compared with several types of transformers and structures, either in factory or on site, when we perform the test after the DC resistance test, we will always get an erroneous results, but generally after demagnetising, the measurement data is normal

Author

Zhan Yangang holds Bachelor's degree in Electric Engineering which he obtained in 2003 and is currently working in Baoding Tianwei Baobian Electric Co., ltd. in China. He has been a test engineer for more than 10 years and has experience in testing of power transformer and shunt reactors up to 1000 kV, phase-shifting transformers up to 600 MVA, 260 kV and HVDC convertor transformers up to 800 kV. Zhan is also experienced in handling and solving the problem of power transformer and reactor assembly work and commissioning test onsite. He has been responsible for South America market since 2012.