

Case study on pre commissioning of power transformer engineering essay



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After new power transformer has been set up on site and before it connects with power supply and loading the load, it is must to have to go through numbers of testing procedures for confirming the specifications and performances of a power transformer. The purpose of commissioning tests on transformer is to satisfy, to pre-determined standards, that all the equipment erection is correct and that all the equipment connections or cables have been installed in accordance with the approved erection drawings and diagrams. This paper describes about some testing before commissioning of power transformer at site (Penang Port Sdn. Bhd., Pulau Pinang).

Nowadays, power transformer is most important equipment in electrical power transmission and power distribution system. Commissioning test for power transformer should to be done to verify the technical suitability for the application and check the healthiness or condition of power transformer before energizing by connecting to the power supply system and loading the load[1]. For confirming that power transformer is follow the specification and performances according customer needs based on the specification set by manufacturer of power transformer, some of testing procedures should to be done. . The pre commissioning test result should to compare with manufacture test result (basically on transformer name plate or manual guideline) and international standard (IEEE STANDARD or INTERPLANT STANDARD-STEEL INDUSTRY, Code Of Practice For Testing And Commissioning Of Power Transformer And Related Switchgears, IPSS: 1-04-035-08). The INTERPLANT STANDARD covers guidance on testing and commissioning of power and distribution transformer [12]. The power

transformer testing performed before actual commissioning test of the transformer at site is called pre commissioning of the power transformer at site like insulation resistance test, transformer turns ratio test, dc winding resistance test, temperature test and oil test[2]. The objective of this paper is

To assess the condition of power transformer after installation

To compare the test results of all the low voltage tests with the manufacturer of transformer test reports.

To affect the safe and orderly handover of the power transformer from manufacturer to costumer, guaranteeing its operation in term of performance, reliability, and safe.

pre comissioning test

Insulation Resistance Test

The insulation resistance, IR test (brand name DC Megger) is an insulation test which uses an applied DC voltage (5KV) for electrical part to measure insulation resistance in $k\Omega$, $M\Omega$, or $G\Omega$. The measured insulation resistance is intended to indicate the condition of dielectric or insulation between two parts of conductive, where the higher resistance is the better condition of the resistance [2]. Generally, IR would be infinite, but as no insulators are perfect where leakage currents through the dielectric will ensure that a finite resistance value is measured. The table 1 showed the acceptable resistance in IR test.

Table 1: transformer IR acceptance testing

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Winding Insulation class, kV

Insulation Resistance, M Ω

1. 2

600

2. 5

1000

5. 0

1500

8. 7

2000

15

3000

Transformer Turn Ratio Test

Transformer turns ratio test is very important to find out that the power transformers have a ratio corresponding on its rated voltage at primary and secondary follow the specification [1]. In an ideal transformer, the induced voltage in the secondary winding (V_s) is proportional to the primary voltage (U_p) and it given by ratio of the number of turns in primary to the number of

turn in the secondary [5]. This figure showed the ideal transformer and equation of the proportion;

Figure 1: Schematic diagram of ideal transformer

Being transformer ratio test, tester have injected AC voltage (415V) at primary (HV side) measure voltage phase to phase and phase to natural at secondary (LV side).

DC Winding Resistance Test

Measuring the resistance of the winding in transformer is to ensure that the connections winding are correct and good condition and resistance measurements indicates that there are no mismatches or broken. Winding resistance measurements in power transformers are of fundamental importance for the following purpose [10];

Calculations of the conductor losses

Measurement of winding temperature at the end of the temperature test cycle

As a base for assessing posible damage in the field

The resistance in the winding should below then 0. 5%, follow the standard from IEEE specification. The tap changes of transformer allow ratio to be increase or decrease by fractions of a percent and that is involve a mechanical movement of a contact from 1 position to other position [10].

Temperature Rise Test (Oil And Winding)

Temperature rise test of power transformer is including the pre commissioning test of transformer. The test is shows the tester check whether the temperature rising limit of power transformer winding and oil as per specification or not. If the temperature of transformer is very high, its can cause accelerated aging and their inaccurate measurement limits transformer loading. Oil temperature can be measured and displayed, but it is more difficult to assess the winding temperature. One method of gauging the temperature of the hottest part is by the use of resistance in the form of thermal models by being immersed in it, and on the other of transformer load current, by caring a current proportional to the load. Using the temperature indicator meter, the tester can get the temperature for oil and primary winding by the setting of thermometer temperature where the thermometer has be immersed in the oil.

METHODOLOGY

Before do the testing, the testers must be following the guideline to avoid the most accident because testing work on transformer need to be done carefully and cautiously. Figure 2 showed the flow chart when doing the testing on pre-commissioning of power transformer.

Start

Literature review (studied about previous project of pre-commissioning)

Required equipments and materials

No

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Testing work

Data acquire and data collect

Expected result

Z No

Yes

Data analysis

End

Figure 2: Methodology for testing

Insulation Resistance Test

This test is carried out to ensure the healthiness of over insulation system of an electrical part of power transformer. Before measure the IR, ensure that all connection in the test circuit are tight. The IR testing instrument is called " megger". To ensure that megger is in good condition, the finger megger must show INFINITY value when not connected, and ZERO when the two terminals are connected together and the handle is rotated. During testing, connect one terminal in to earth, and the other terminal must connect to electrical part [3]. The tester should inject the DC voltage using megger (5KV) on electrical part such as primary side to earth, secondary side to earth, primary to secondary. Duration of the test voltage shall be one minute minimum.

Transformer Turn Ratio Test

Ratio between all the three corresponding primary and secondary phases is to be measured on all each taps. The simple testing of measuring voltages and current using multimeter can also serve the propose. Disconnect all the line and neutral terminal on transformer. The tap changer of transformer is kept in the lowest position and secondary terminals are kept open. Injected AC voltage (415V) supply on primary terminal and measure the voltages applied on each phase (phase to phase) on primary side and induced voltage at secondary side simultaneously. After measuring the voltages at primary side and secondary side, the tap changer of transformer should be raised by one position. Repeat testing for each tap position separately until 16 taps.

DC Winding Resistance Test

By the configuration transformer delta-wye, the measurement are made phase to phase and comparisons are made to determine for each tap, if readings are comparable [8]. The tester has to apply dc current through the winding and internal standard current shunt. The resistance on winding have measure by the calculation on[8],

$$R + (L di/dt) = V_{dc}/I \quad (1)$$

Where;

V_{dc} = voltage across transformer winding

I = DC current through transformer winding

R = resistance of the tranformer winding

L = inductance of the transformer winding

di/dt = changing value of current - ripple

Where voltage and current is measure on primary side by phase to phase on transformer for each tap using multimeter. From that, we can calculate the winding resistance on primary side using equation (1). Inject for example 5V on dc voltage on primary side before get the actual data (voltage and current) in the winding. The acceptable of windings resistance usually between 0. 1ohm until 0. 5ohm. For the secondary side, dc winding resistance test must to do but if the winding resistance at high-voltage side is acceptable, the tester just measure on one tap only.

Temperature Rise Test (Oil And Winding)

A temperature indicator calibration system including a well including a well for receiving a temperature sensor such as thermometer and thermocouple, and a heater for heating the well to desired and adjustable temperature[4]. Setting temperature at range 40celcius to 120celcius and data will be temperature for oil and winding have been recorded.

RESULT AND DISCUSSION

Transformer name plate details

The minimum information to be shown on transformer nameplate depends on the KVA rating of the transformer as specified in the standard like figure 3.

Table 2: transformer Nameplate detail.

Make

SGB

Year Of Manufactured

2009

Rated Power

30000KVA

S/Number

716471

Type

DOTW 30000/30

Total Weight

48500kgs

Vector Group

DYN 11

Total Mass

-

Rated Impedance at 75°C Tap 7 = 13. 12

Min. Tap = 1

Centre Tap = 7

Max. Tap = 16

Tap

HV

LV

Oil Raise Temp.

50°C

Volts

Amp

Volts

Amps

Ratio

1

36300

477. 2

11000

1575

3. 3

Winding. Temp. Raise

55°C

2

35750

482. 5

3. 25

3

35200

492. 5

3. 2

Rated Freq.

50Hz

4

34650

500

3. 15

5

34100

507. 2

3. 1

HV Winding. CT

(CT1)

Ratio: 1575/1. 5

10VA

Class: 5

6

33550

516. 4

3. 05

7

33000

525

3

8a

LV Winding. CT

(CT2)

Ratio: 1575/1

10VA

Class: 5

8b

32450

533. 8

2. 95

8c

9

31900

543. 0

2. 9

10

31350

552. 6

2. 85

11

30800

562. 4

2. 8

12

30250

572. 6

2. 85

13

29700

583. 2

2. 7

14

29150

594. 2

2. 65

15

28050

605. 8

2. 6

16

28050

617. 6

2. 55

Insulation resistance test

Table 3: insulation Resistance Test Result.

Between

Insulation Resistance Measured (M Ω ,!)

1 minutes

10 minutes

HV - E

6000

10000

LV - E

6500

11500

HV - LV

6000

11000

The results shown in Figure 4 shows the experiment conducted in 1 minute and 10 minutes using insulation tester. Therefore, the result is up to the standard of IEEE. So the testing is successful.

Tranformer turn ratio test

Ratio check by injected AC voltage (415V) at HV side and measure voltage at LV site has showed by graph.

Figure 5. 1: Graph voltage measurement at phase A-B for HV side and phase a-b for LV side vs tap changing

Figure 5. 2: Graph voltage measurement at phase B-C for HV side and phase b-c for LV side vs tap changing

Figure 5. 3: Graph voltage measurement at phase C-A for HV side and phase c-a for LV side vs tap changing

Based on figure 5. 1 to figure 5. 3, we can see that voltage on HV side is proportional with LV side (at phase to phase) for each tap changer. That means the calculation ratio based on voltage and current measurement at HV side and LV side depending on phase shown almost the same for each taps.

Figure 5. 4: Graph calculation ratio and rated ratio vs tap changing

Based on figure 5. 4, the graph shown that the rated ratio is almost the similar with calculation ratio for each taps.

DC winding resistance test

Figure 6. 1: Graph voltage at HV side vs tap changing

Figure 6. 2: Graph current at HV side vs tap changing

Figure 6. 3: Graph winding resistance at HV side vs tap changing

Based on figure 6. 1 to figure 6. 3, the graph shown the relationship between primary and secondary to find the winding resistance. All the result have displayed follow IEEE standard where the winding resistance is must below than 0.5Ω .

Temperature rise test (Oil and Winding)

TABLE 4: temperature Indication Meter (Oil And Winding)

Temperature

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Setting (°C)

Temperature Indication Meter (°C)

Oil

HV - Winding.

120

122

120

110

110

117

100

102

105

90

90

90

80

80

80

70

70

70

60

60

60

50

50

50

40

40

40

30

-
-

Based on the result in Table I, the temperature for oil have increase 2°C when the tester increase the temperature setting up 120°C while temperature of winding maintain 120°C. For the setting temperature 110°C, temperature indication meter for oil shown constant but for HV winding increase up to 117°C. The difference between temperature indication meter and temperature setting maybe caused by condition of transformer have not stable, but eventually it will good soon.

CONCLUSION

To ensure that power transformer is in good condition when operation and according of customer needs, and follow the specification from manufacturer test, most of testing need to be done. Based on the all result, it can be concluded that all of the tests done on the transformer power is follow the specification of manufacturer and able to meet the needs of the industry in Penang Port.

RECOMMENDATION

The present research studies for the assessment on power transformer by considering the most advance testing such as;

Using SCADA for monitoring the condition of transformer

Applying micro-controlled system of digital measurement system for oil and winding temperature.

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