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Power Transformer: Explained Practically

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Abstract: Transformers, either power or distribution type, cater the needs of electrical power consumers by acting as a bridge between a Generator and Consumer. There are enormous volumes of text books on their theory like basic working principle, construction, classification, tests and their operation. However there is little information available on their practical aspects, unless one has to work on them practically. This paper explains the practical aspects of power transformers with reference to their name plate data and industry trends. Suitable examples are given as appropriate places for their understanding and ease to work at field.

Keywords: Power transformer, MVA rating, vector group, impedance, voltage, oil, maintenance.

I. INTRODUCTION

Transformers are the very vital components in almost all the parts of electrical power systems like generation, transmission, distribution and essential utilisation area. It can be either step-up or step- down the voltage at these areas, but it is needed in all the parts of human life, right from home to industry whatever the industrial revolution. Transformers are known to be more reliable and higher energy efficient of the order of around 98% as on date. There is so much of literature on transformers theory like it's working principle, construction, operation and maintenance in the form of text books [1-2] and hand books [3]. Also the continuous research is going on globally on transformers design [4-6], construction, efficiency, smart transformers [7], maintenance and modelling is being disseminated through various forms like journals and conferences/seminars. But little information is available as place about the practical aspects with reference to its name plate specifications. This has a major significant thrust on fresh electrical engineers joins any industry who generally knows most of the theory only. Hence it is proposed to explain about a transformer practically by taking the name plate example one Distribution Transformer (DTR) of an Engineering College.

II. NAME PLATE DATA

Fig. 1 shows the image of a 500 KVA DTR :

Fig. 1 500 KVA Transformer

Fig. 2 shows the image name plate or rating plate or technical specifications of one DTR which is explained as follows:

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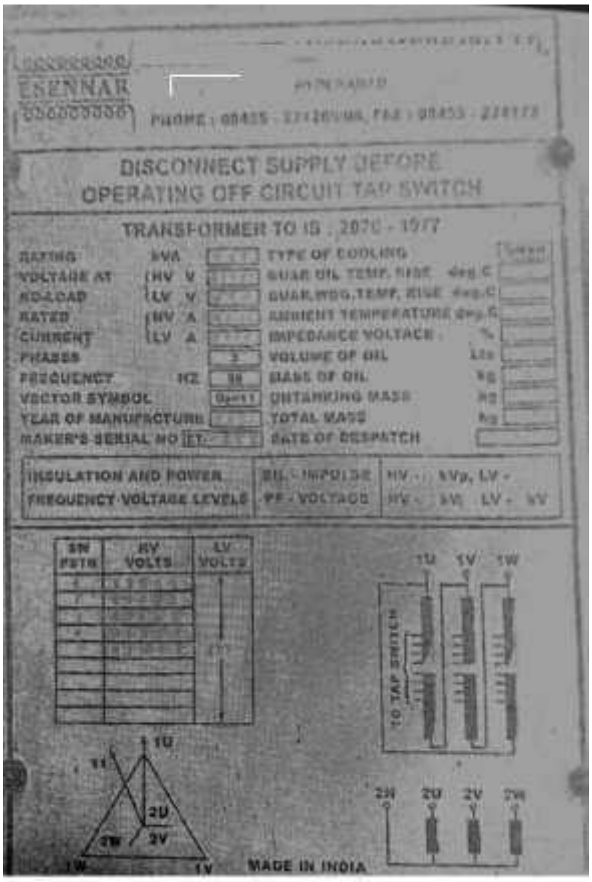

Fig. 2 Name plate of DTR

1. Power rating of 500 KVA: Generally it will be given as MVA (large rated) or KVA (smaller). Even though motors are rated in HP (horse power) or KW (kilo watt), transformers being a source for different types of loads are rated in VA since it's voltage rating and ampacity are only known. Being a source, the power factor of loads which are fed from time to time is changing based on type of load. Hence rating is either in MVA or KVA.

   This can be obtained as $KVA = \sqrt{3}\, VI \times 10^{-3}$ (1)

   Where V= Rated voltage of primary winding, if primary is considered and
   I= Rated current of primary winding, if primary is considered.
   It is same either from primary side or secondary side.

2. Standard reference: The standard followed for design, construction and testing is mentioned. It can be either Indian Standard like IS 2026-1: 2011[8] by Bureau of Indian Standards or IEC [International Electro-technical Commission standard] like IEC-60076-1[9]. IS-2026 is having 10 parts with different years in which part 1 is of 2011 version for general specification.

3. Year of manufacturing: This is required to know the age of Transformer at any time and also helpful in attending regular preventive maintenance and overhauling systematically [10].

4. Type (Core): It is required to know whether it is core type (of CRGO i.e. Cold Rolled Grain Oriented or Amorphous) or shell type. CRGO core type is used for normal power and distribution purpose where as shell is type is used for larger power transformers. Amorphous material is latest in which core losses are very low and is presently used for distribution purpose.

5. Voltage at No-load: Here the line to line voltages of both HV (11000 Volts) and LV (433 Volts) windings are given at rated tap. Higher voltages cannot be given to primary side since it may be leads to winding instantaneous failure.

6. Current: The rated current of both HV (13.1 Amps) and LV (333.33 Amps) windings are given. This is the maximum value to which Transformer can be loaded beyond which the temperature will go high and damages windings, wires and insulations.

7. Phases and frequency: The number of phases of HV and LV windings (3 in present example) and supply frequency (50 Hz) are given. Transformers are to be charged with voltage of rated frequency only otherwise it may lead to over fluxing or higher core losses.

8. Number of windings: Generally two windings i.e., primary (to which supply is given) and secondary (from which the supply is taken out). There are some three winding Transformers having Primary, secondary and tertiary. The tertiary winding is either for other voltage or for harmonic compensating delta winding in case of both primary and secondary in star connected mode.

9. Temperature (in °C): The value of ambient temperature (generally 50° C) and permissible temperature rise of oil (in case of immersed windings) and winding. These are the values for monitoring and setting of oil and winding temperature gauges for alarm and trip.

10. Mass: The weight of total Transformer, oil (in case of oil filled Transformer),untangling and a core windings are given for foundation and transformation purpose. If the oil is in different form like mineral oil, synthetics or the latest trend of using vegetable oils [11] will be given.

11. Impedance volts (4.3% in example):

    % Impedance (Z) = (I1×Z×100) ÷ V1=

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$$(I2 \times Z \times 100) \div V2 \quad (2)$$

This value will be ranging from 4% (250 KVA Transformers onwards) to 12.5%(7.5 MVA and above). The suggested values are given in below table I [12].

TABLE I
% IMPEDANCE VALUES

S. No.	KVA Rating	% Z
1	Up to 630	4
2	631-1250	5
3	1251 - 2500	6
4	2501-6300	7
5	6301-25000	8
6	25001-40000	10
7	40001-63000	11
8	63001-100000	12.5
9	Above 100000	>12.5

This value used to know

i. The voltage drop when it is loaded fully which is useful in selecting taps.

$$\text{Voltage drop} = \%Z \times V1 = \%Z \times V2 \quad (3)$$

ii. To know the fault current (short circuit) which is useful in selecting equipment and relay settings.

$$Isc = Irated \div \%Z \quad (4)$$

iii. To know %load shared by a transformer when parallel connected.

Loading on the transformer-1 =

$$\text{Total Load KVA}(Z2/Z1+Z2) \quad (5)$$

Loading on the transformer-2 =

$$\text{Total Load KVA}(Z1/Z1+Z2) \quad (6)$$

Where Z1, Z2= % impedances of T1 and T2.

Generally transformers with lower %Z shares more load that that of higher %z impedance rating.

12. Vector Group (Dyn11): This is an connection symbol used to inform about type of connection of 3 phase windings and angle [8].

e.g. : Dyn11

The type of connection of high voltage (HV) winding is denoted by a capital letter; D=delta, Y=Star Z= Zig- Zag connection and A=Auto Transformer.

Similarly the type of connection of low voltage (LV) winding is denoted by a small letter; d=delta, y=Star nd z= Zig-Zag connection and a=Auto Transformer.

The phase angle between HV and LV induced EMF's is given by a clock number and to be specified in anti-clockwise direction.

e.g : 11 =11° clock i.e. LV leads HV by 30°.
Others like; 1= 1° clock i.e. LV lags HV by 30°,
0 = 12° clock i.e. LV and HV are in phase,
6= 6° clock i.e. LV and HV opposite by 180°.
The information is required in parallel operation.
Since same vector grouped Transformers only to be connected in parallel.

13. Tap switch: It used for voltage regulation purpose by maintaining EMF per turns as constant. The tap changes is used to add or remove some turns from winding (generally HV) to maintain constant voltage at other side (generally LV). These of either One load tap changes (OLTC) or Off-circuit tap changes (OCTC). The taps and their switch position with voltages will be diagrammatically shown on name plate [8].

14. Type of cooling: In case of liquid filled transformers, the type of cooling is indicated by alphabetic letters.

ONAN= Oil Natural Air Natural
ONAF= Oil Natural Air Forced
OFAF= Oil Forced Air Forced

It is known that each forced cooling will increase the capacity by 15 to 25% due to better heat dissipation.

e.g. A 16 MVA transformer with ONAN cooling can cater the loads up to 20 MVA without exceeding its temperature limits if oil forced cooling (i.e. ONAF) is provided.

Note: Other than the details mentioned above, it may contain additionally the name of the manufacturer, Current transformer (For winding temperature and neutral CT for earth fault protection).

III. Internal Parts

Fig. 3 shows the internal parts of an oil immersed transformer on lifting its core from tank.

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Fig. 3 Internal parts of a Transformer

Fig. 4 shows the image of Off-circuit tap switch.

Fig. 4 Off-Circuit Tap switch

IV. CONCLUSION

The practical aspects of a transformer are discussed in detail with an example. The details are given in brief with explanations useful at field. This information is very essential for any electrical person right from electrician to engineer. With this data, an electrical person can understand the transformer in depth along with parallel operation suitability, fault currents relay settings, voltage drop etc.

REFERENCES

[1]. Rajput, "A Text Book of Electrical Machines", Firewall Media, 2006.

[2]. V. K. Mehta, R. Mehta, "Principles of Electrical Machines", S. Chand Limited, 2008

[3]. BHEL, "Transformers", Tata McGraw-Hill Education, Jan-2003.

[4]. Indrajit Dasgupta, "Design of Transformers", Tata McGraw-Hill Education, 2002.

[5]. M. G. Say, "The performance and design of alternating current machines", CBS Publishers, 3rd edition, 2002.

[6]. B. K. Reddy,"Design Changes to Improve Transformer performance" *International Research Journal of Engineering and Technology,* vol. 6, issue 6, pp 2621-2624. June 2019.

[7]. M. Liserre, et al. "The Smart Transformer, its impact on the electric grid and its technology challenges" *IEEE Industrial Electronics*, July 2016.

[8]. IS 2026-1: 2011, Power transformers- General, *Bureau of Indian Standards*, 2011.

[9]. IEC 60075-1, Power transformers- General, *International Electro-technical Commission, 2009*.

[10]. B. K. Reddy, "Systematic Steps in Overhauling of a Transformer", *International Research Journal of Engineering and Technology*, vol. 6, issue 7, pp 1453-1456, July 2019.

[11]. B. K. Reddy, "Latest Trends in Use of Transformer Oils", International Journal of Engineering Trends and Technology, vol. 67, issue 7, pp 37-39, July 2019.

[12]. IS 2026-2: 2011, "Power transformers-Ability to withstand short Circuits", *Bureau of Indian Standards*, 2011.

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