A Review of Tank Type for Bus Reactor [Bell Vs Conventional(T-Type)]

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Abstract - *In this study, a comprehensive review on selection of tank type for Bus reactor and its possible aspects which influence the design criticality.*

Key Words: Bus reactor, Transformer, tank,Bell

1.INTRODUCTION

The purpose of this paper is to provide a general guideline for selection of tank type for EHV oil type shunt reactor (Bus rector or line reactor) which reduce the design criticality and Operation & maintenance problem. At present, there are two types of tank design is popular, i.e., Conventional (T tank - top cover welded) or Bell type (bottom plate flange bolted), in the industry for design Power transformer or reactors. However, Bus reactor are generally manufactured with conventional tank in which complete enclosure of tank is welded at bottom plate.

Bus Reactors are typically used in EHV substations for compensating capacitive VARs to avoid TOV (Temporary Overvoltage) phenomenon due to Ferranti effect during light load or no-load conditions. On the other hand, line reactors are normally used to limit switching overvoltage during charging of long EHV transmission line and compensate leading VAR along with Bus reactor.

Reactors are single winding element contrary to multi winding power transformer. Also, B-H characteristics of reactors are much linear (typically up to 1.4PU of rated voltage) compared to Power transformer to order to ensure proper operation of reactor during TOV condition. Air gaps are created inside reactor core to have linear characterizes up to high excitation voltage.

Due to this air gap in the core reactors vibrations in reactors are much more compared to transformers. We can say vibration is inherent characteristics of reactor and that discriminate physical behaviour of reactor than transformer.

2. Tank type

The transformer tank provides the containment for the core and windings and for the dielectric fluid. Based on the adopted practices, there are Bell tank and conventional top cover welded construction.

2.1 Conventional tank

This type tank design has top cover tank cover as shown in the below figure. There is no joint at bottom level of tank only at the top portion jointing done for opening tank cover.

Fig:1 Shows the typical Conventional tank.

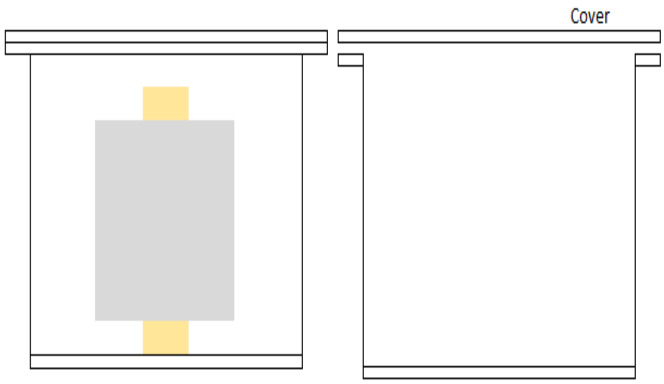

Fig -1: Convention Tank

Advantages

Eddy-current losses in tank is result of leakage flux which link with tank. This will be more predominant at bottom portion of tank at flange bolt region rather than top part of tank. In this situation a reduction in the magnitude of the losses can be obtained by the provision of flux shunts, or shields, to prevent their flowing in the tank, will also prevent an excessive temperature rise in the tank.

Fig:4 Shows the placement of shunt/shield in conventional tank.

This type of tank design generally preferred by OEM as magnetic shielding design become simpler and chances of oil leakage reduces due to lower hydraulic pressure at top tank joint.

Further, Oil pressure imposed at bottom where tank is welded in this arraignment and hence, chance of oil leakage during operation is nil.

Being a no flange bolted connection at bottom part, Bolt heating will never arise during the temperature rise as well as no requirement of copper links.

Disadvantage

Major difficulty of this type design is to carry crane repair at the field. Larger carne boom height is required to remove core coil assembly at field.

2.2 Bell Tank

In this type of tank construction, joint between two parts is done at the bottom yoke level to facilitate inspection of core - winding assembly at site after bell cover is removed. Pictorial representation of bell type tank design is shown in Fig-2. Thus, it consists of a shallow bottom tank and a bell-shaped top tank.

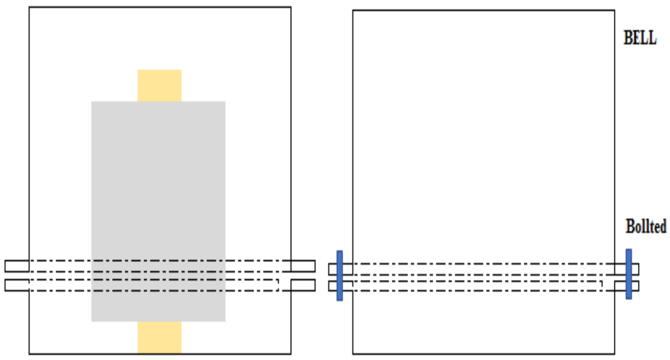

Fig -2: Bell Tank

Advantage

The purpose of bell type design is to make it possible to access the active part for maintenance/repair without lifting the active part out of the conventional tank

Height of the tank along with the tank set up in the lower part is generally varies between 300 mm to 500mm based OEM design. So, at site level inspection of core coil assembly become very convenient. Crane boom height requirement is also less in this type of design.

Disadvantage

Majority of stray loss takes place in the transformer tank. Hot spots generated in the flange–bolt region, are produced by the induced stray currents. To eliminate or reduce the effect, Transformer manufacturer provides the shunts.

The bell tank construction may not be convenient for a proper placement of magnetic shunts if the joint is at such a height from the bottom that it comes in the path of leakage field. This may lead to tank bot overheating problem if not designed properly. This may cause numerous problems like the induced currents may concentrate in the larger cross-sectional area of flanges causing local overheating, which leads to deterioration of gaskets over a period of time. Second, due to the bad electromagnetic contact between the tank and cover, there is an increase in magnetic voltage drop (magnetomotive force), leading to a greater magnetic field strength on the bolt surface, which may give rise to excessive local eddy current losses in the magnetic steel bolts. The local eddy currents in these bolts may cause dangerous hot spots, damaging the gaskets/sealing between the flanges.

Further, As stated above, the reactor by its nature produces vibration during its service and these vibrations in long run will also impact on the gasket and bolts at the bottom curb Joint.

Since the tank curb joint located at bottom of tank, due to greater hydraulic pressure at tank joint increases chances of oil leakages in the long run during operations.

The reactor with bell shape is also susceptible to significantly higher measured noise level than conventional tank.

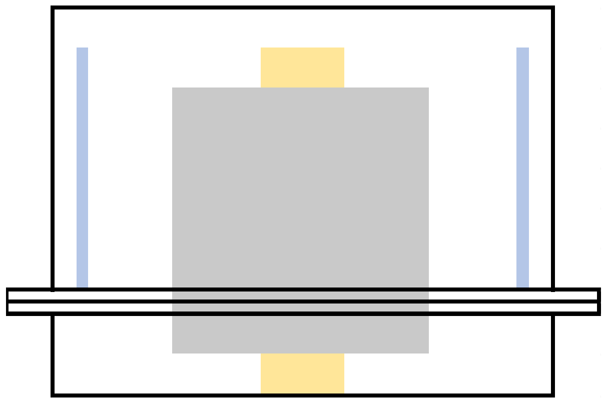

Fig -3: Shunt Placement in Bell tank

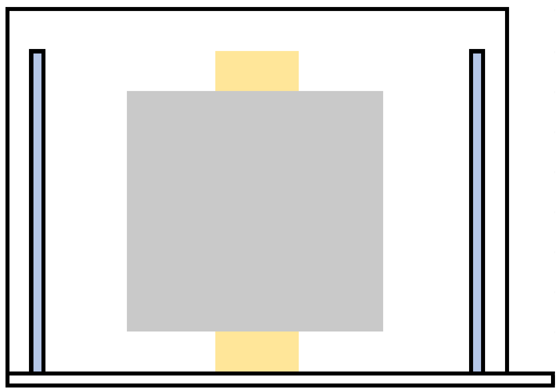

Fig -4: Shunt Placement in Conventional tank

3. CONCLUSIONS

In this paper an attempt is made to review tank type, may be used for reactor. In this we studied on which tank type is suitable reactor application.

After studied on above tank type advantages and disadvantages, we concluded that conventional (T type) tank is more preferably and there are two major issues concerning the bell type tank :

A. The location of the bell stays at nearly the level same as the bottom of the coil. The radial components of leakage magnetic flux is maximum at the coil ends. Higher the percentage impedance higher is the leakage flux density. The flux density is not uniform at the top and the bottom of the bell. The eddy currents produced at top and bottom induce a voltage which are different. The differential induced voltage flows a current through the connected bolts and heats up.

To reduce the contingency both the parts of the bell are tied by low resistance copper connectors at various locations of the flange but heating can not be avoided.

B. The radial flux penetrates into the gap of the flange and produces circulating current between consecutive bolts and localised hot spots are developed.

To overcome this insulated moulded hats are fitted over the bolt surface so that they are isolated and current does not have a path to circulate.

C. The bolts connecting both the parts of the tank are magnetic in nature. The leakage flux interacting with the bolts produce eddy current on the surface and the bolts are heated up.

Use of non magnetic stainless steel bolts prevents the occurrence but is expensive and needs tightening at regular intervals because of different coefficient of expansion for the mild steel flange and the SS bolts.

D. Unlike a conventional tank design the gasket flange connecting the top and the bottom of a bell type design experiences higher head of oil because of its location at a lower level. This leads to high pressure differential between the inner and outer surface of the gasket and they become prone to oil leakage. The leakage becomes predominant at higher temperature as the viscosity of oil is lowered.

The use of nitrile rubber gasket in lieu of rubber bonded cork and provision of stoppers to prevent over tightening and damage to the gasket have been the improvements made in the gasketting system and have minimised the oil leaks.

Leak prevention can be achieved by removing the bolts and welding the flange.

Though it provides the advantage of easy active part inspective at site. However, site level repair does not make sense for any major fault in core coil assembly, as always it is advisable to reactor/transformer to OEM shop for major repair work. Hence, in the view of above it is suggested to prefer oil type shunt conventional tank rather than conventional tank type.

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REFERENCES

[1] Martin. J. healthcote "The J&P- The Transformer book – A Practical Technology of Power Transformer", Twelfth Edition.

[2] Juan Carlos Olivares, Rafael Escarela and Pavlos S. Georgilakis "Reduction of Stray Losses in Flange–Bolt Regions of Large Power Transformer Tanks" IEEE Trans. Ind. Electron., vol. 61, no. 8, Aug. 2014.

[3] Transformer Engineering : Design, Technology and Diagnostics , Second Edition by S.V Kulkarni and S.A.Khaparde.

BIOGRAPHIES

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