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Exceptional High Rise of Temperature in LV Turret Bolt in Generator Transformer

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Abstract: ***Generator transformers are among the most critical and high-value assets in a power plant. Any abnormal behaviour during commissioning or operation poses serious operational and safety risks.***
This study presents a detailed investigation into an abnormal temperature rise observed in the LV turret bolts of a generator transformer. The root cause analysis identified induced eddy currents and uneven current distribution as the primary contributors. Corrective actions focused on restoring proper electrical continuity and enabling uniform current sharing among turret bolts.
Keywords: Transformer, Turret, Eddy Current, Heating, Earthing.

I. INTRODUCTION

At Hindalco Mahan Plant, six (06) Generating Transformers (GTs) of 200 MVA capacity are installed. On 27th April at approximately 16:30 hours, operational personnel observed smoke-like emissions near the LV turret of Generating Transformer #2. Considering the criticality of the asset, the condition was treated as an emergency.
All related Personnel immediately rushed to the site to assess the condition. Upon closer inspection, it was identified that the observed “smoke” was actually oil vapour emanating from the turret.
The visual effect was further intensified due to sunset conditions, where inclined sun rays enhanced the visibility of the vapour, making it appear like dense smoke.

A. Problem Statement

The key concerns identified during initial assessment were:

- Why was the oil vaporizing rapidly?
- What was the source of the oil leakage?

Subsequent thermographic inspection of the LV turret revealed that the temperature of the turret bolts in the affected area was approximately 200°C, which is significantly higher than normal operating limits.

It was concluded that:

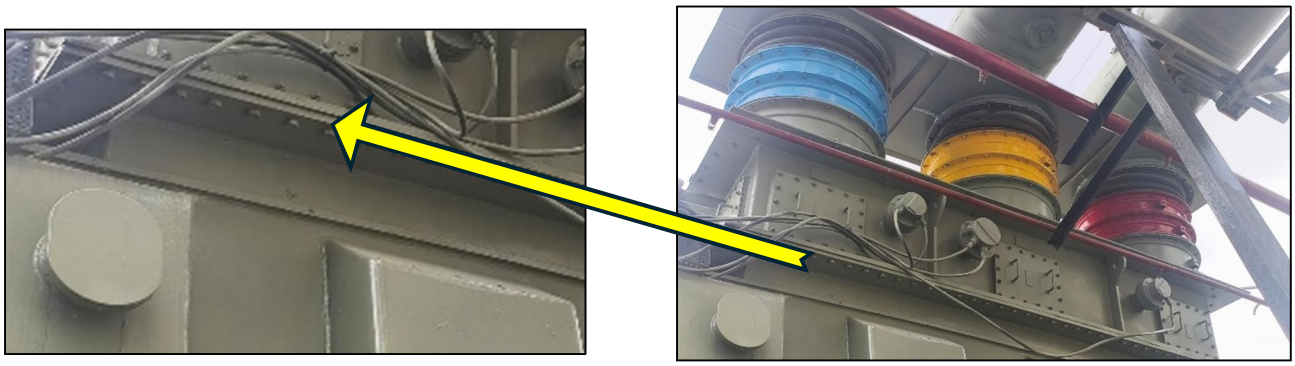
- There was oil seepage from the turret gasket.
- The leaked oil, upon coming into contact with high-temperature turret bolts, rapidly vaporized, resulting in the observed oil vapour.

The turret bolt temperature reached 200°C, which is a serious concern since the flash point of transformer oil is approximately 140°C.

We perform the why-why analysis:-

1) Why was the turret bolt temperature high?
Because heat was being generated in the turret bolt due to the flow of electrical current, as there was no other external heat source was present.
2) Why was current flowing through the turret bolt?
Because the turret bolt was providing a low-resistance path for the current.
3) Why was the turret bolt providing a low-resistance path?
Because unintended current is finding a path through the bolt.

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4) Why was current present in the turret structure?
   Because eddy currents are being induced in the turret body.
5) Why were eddy currents being induced in the turret body?
   Due to the high current (≈6000 A) flowing on the LV side, which produces a strong magnetic field.
   The proximity of the turret structure to this high current path results in electromagnetic induction, causing eddy currents to circulate in the turret body and associated metallic components, including the turret bolts.

Hence it was concluded that the excessive temperature rise in the turret bolt is primarily caused by passage of eddy current, induced by the high LV current in turret structure. The closeness of the turret structure to the current-carrying conductors and the availability of a conductive loop allow circulating currents to develop, which was leading to tank body, through these bolts finally to ground.

The excessive heating was caused by:
Localized concentration of eddy current in a single turret bolt due to unequal current distribution.
A detailed brainstorming exercise was carried out to identify and implement corrective actions for the high temperature in the turret bolt. The following actions were attempted sequentially:

1) Replacement of Bolt: Initially, the turret bolt was replaced with a new one. However, no improvement was observed, and the temperature again started rising after some time.
2) Change in Material of Construction (MOC): The bolt material was changed from MS to GI and Stainless Steel (SS) to reduce heating effects. Despite this, no significant reduction in temperature was achieved.
3) Providing Copper Braid Jumper: A copper braid jumper was installed to bypass the bolt current. Even after proper surface cleaning, the temperature did not reduce. Additionally, the temperature of adjacent bolts increased, indicating redistribution of current.
4) Direct Grounding of Bolt: The bolt was directly connected to ground using a 16 sq.mm copper conductor. Measurement indicated a current of 14.6 A flowing through the bolt, confirming that it was part of an unintended current path. This was not considered a viable solution.
5) Surface Cleaning and Equal Current Distribution: On studying the turret design, it was observed that multiple bolts (total 96 nos.) are provided, intended to collectively share any induced current. However, it was found that only one bolt was carrying a major portion of the current, as it was offering the lowest resistance path.

Subsequently, bolts were removed in pairs, and the contact surfaces of the turret were cleaned. It was discovered that paint on the turret surface was acting as an insulating layer, preventing uniform current distribution. After proper cleaning and ensuring good electrical contact, all bolts started participating in current sharing, thereby eliminating localized current concentration.

II. CONCLUSION

The root cause of excessive heating (up to 200°C) in the turret bolt was uneven distribution of induced eddy current, where

1) Other bolts had higher contact resistance
2) Presence of paint layer acted as insulation
3) Only one bolt carried significant induced current

After removing the insulating effect and ensuring proper metallic contact across all bolts, the induced current was evenly distributed, thereby eliminating localized overheating.

A. Lessons Learned

1) Design Intent Must Be Understood Before Modifications: The turret design with multiple bolts was intended for uniform current distribution. Any deviation (due to poor contact) defeats the design purpose.

2) Paint/Coating Can Act as Electrical Insulation: Surface coatings such as paint can unintentionally restrict current sharing by increasing contact resistance. Proper surface preparation is essential where electrical continuity is required.

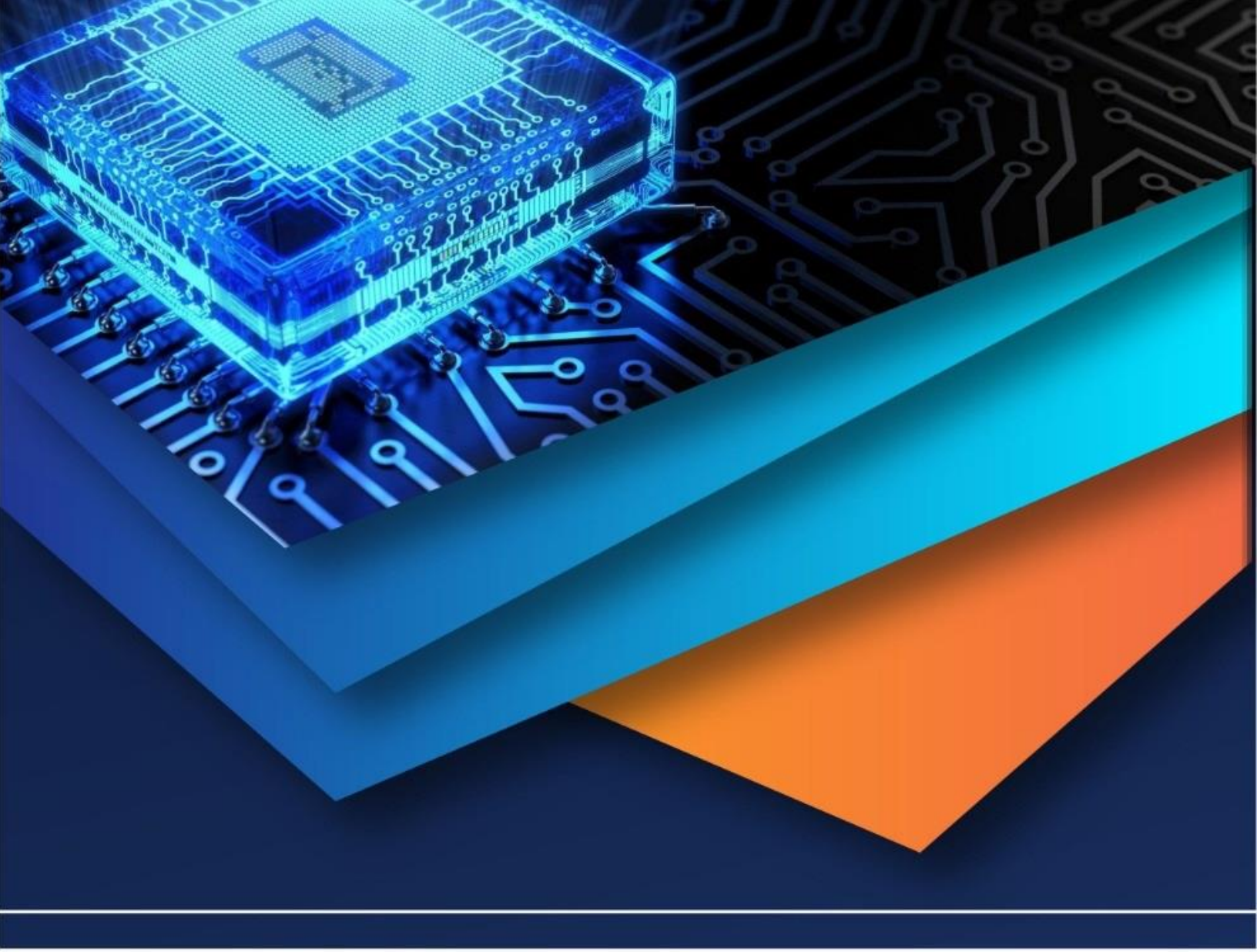
3) Material Change Alone May Not Solve Induction Heating Issues: Changing bolt material (MS, GI, SS) does not address the root cause when heating is due to induced currents, not resistive losses of the bolt material.

4) Uniform Electrical Contact is Critical: Uneven contact resistance across multiple parallel paths (bolts) can result in current concentration in a single path, causing severe localized overheating.

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[1] IEEE/ANSI Standards C57.12.00 “IEEE Standard General Requirements for Liquid Immersed Distribution, Power, Regulating Transformers “, 2000. IS 2026: Power Transformers

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