Alstom Grid provides smart, efficient and environmentally-friendly solutions to deliver electricity reliably across the world.
“Maintenance & Onsite Repair of Transformers”

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Content

- Transformer Operation & Maintenance Cycle
- Transformer Condition Monitoring
- On Site Repair of Transformer: 70MVA, 400KV GSU
  - Dismantling of transformer active part
  - Re-assembly of core laminations
  - Assembly of Transformer
  - Dryout and testing of transformer
  - Transformer Commissioning
- Conclusion
Transformer O&M Cycle

Maintenance cycle of transformers used:

- Commissioning
- Transformer Operation
- Time Based Maintenance (TBM)
- Time Based Condition Monitoring (TBCM)
- Condition Based Maintenance (CBM)
- Online Condition Monitoring (OLCM)
- Continuous On-line Monitoring (COLCM)

Condition Monitoring:

- The condition begins to deteriorate
- The condition change begins to be detectable
- The condition is so deteriorated that failure occurs
EHS Requirements

• To ensure employee health & safety and proper handling of equipment, the team was introduced with OUR ZERO DEVIATION (EHS) plan and necessary guidelines were shared.

Success of any activity is also measured on scale of safety of employee & equipment; ensuring the completion of work on time without any injury or severe accidents.
Identification of Fault and Action Plan

The transformer was in service since years and started giving repeated alarms on buchholz relay and transformer oil DGA result was indicating presence of C2H2 more than permissible limits and customer decided to take the transformer out of service for inspection & repair of transformer. The planning was done to zero in the actual cause for presence of C2H2 and remedy action to restore it back in operation & service.

In inspection, problem was predicted in magnetic circuit.

<table>
<thead>
<tr>
<th>Action Plan</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage I</td>
<td>SFRA, winding resistance test &amp; other low voltage testing &amp; comparison with commissioning results</td>
</tr>
<tr>
<td></td>
<td>Inspection of all joints and take out points</td>
</tr>
<tr>
<td></td>
<td>Removal of HV lead Shield Pipe and Inspection</td>
</tr>
<tr>
<td></td>
<td>Cutting &amp; Removal of Winding outer cylinders</td>
</tr>
<tr>
<td>Stage II</td>
<td>Dismantling of core coil assembly and inspection at site/workshop</td>
</tr>
<tr>
<td>Stage III</td>
<td>Fault Rectification at site/ shop floor</td>
</tr>
<tr>
<td>Stage IV</td>
<td>Re-assembly of core coil assembly and associated work at site</td>
</tr>
<tr>
<td>Stage V</td>
<td>Placing the transformer back on plinth and Commissioning</td>
</tr>
</tbody>
</table>
Freezing of Scope of work and brainstorming

- The situation became critical when the problem could not be located by external inspection of core coil assembly.
- The scope was again discussed and it was clearly confirmed by the customer that the transformer could not be taken to workshop due to transport constraints and hence only option was to take this challenging work under on site repair on priority, ensuring the completion of work on time.
- Finally, it was agreed to bring the facilities from workshop to site and take the work as mentioned in action plan.

**Receiving & storage of core bed & rockers at site**

**Core Pallets, Beams and Supports at stored at site**
Dismantling of Active Part

• Once the JFTs, T&Ps and consumables were received at site, dismantling was started step by step
• The winding and core laminations, insulation & tank bottom surface were checked for any abnormality, flashover, melting of contacts & joints, burns and/or carbonization.
• While dismantling of top yoke laminations, each lamination was checked and was stacked over core pallets and covered properly to avoid any moisture ingress.
During the dismantling activities, the defect points were checked and main defect / damages noted were as following:

- Core lamination sheets (CRGO) were found electrically shorted and its carlite coating was badly damaged
- Core laminations were found overheated at few points in few steps of core assembly
- The press board insulation wrapping over the central core limb was found overheated, carbonized and partly burnt at inner surface and vertically outer surfaces of HV & LV side
- Main tank bottom insulation was seen blackened and over heated
- Water marks/moisture was seen on pressboard insulations and CRGO laminations
Re-Assembly: Core building & DCA

- Looking at the condition and findings, the defect was clear in magnetic circuit
- Each lamination of the core assembly was checked for its insulation & any defects
- While segregating the core laminations, it was observed that the carlite coating of laminations were not healthy enough to reuse

* Thus the old CRGO laminations were discarded and new CRGO laminations were required along with core insulations, winding and core limb pressboards etc

- The core insulations, pressboards, creep paper, craft paper, TG assembly supports, permali studs etc were received at site, packed in MS contained pressurized with dry air of dew point better than -60 deg C.
- The CRGO laminations were assembled on its bed and it was checked for step size, insulation placement, burrs etc.
- Parallelly, DCA was repaired for damages in lead joints, inner and outer press boards were replaced with new ones.
All other parts of winding were found healthy and no major repair was taken. During & after repair the winding was in housed in a polythene wrap/cover to avoid direct ingress of moisture in its paper & insulation.

- The tank bottom tank insulation was replaced with new papers.
- CRGO assembly was lifted with Overhead crane and was placed back in tank with proper care of insulations & bottom, side wooden packing.
- The DCA was ready for lowering and it was lowered after wrapping new pressboards over the core limbs and top yoke filling was done after placing back the top channel.
- TG assembly, OCTC connection, paper wrapping at damaged points were completed and tanking was completed.
- The turrets, CTs and bushings were erected and tank was pressurized with dry air for pressure test and it withstood the test successfully.
Dry out: Process & Method

The effectiveness of dryout of active part by hot oil circulation (HOC), vacuuming and dry air purging was critically controlled by stable temperature of active part throughout the process and hence;

• Temporary enclosure of GI sheet was constructed. Over the GI sheet, cotton Tarpaulin was spread to avoid heat loss and better maintenance of temperature around the transformer

• Hot air blowers were placed on four corners of enclosure

• Halogen bulbs were placed in front of tank surface inside the enclosure, maintaining the safety distance to avoid any local overheating

• Filter machine inlet temperature was maintained at 65-70 deg C and filter machine heater settings were done accordingly.

• DOF (Directed Oil Flow) pipes were used for HOC in transformers rather than filter valves

• Dry air to be used for purging was checked for Dew Point between -50 to -60 deg C or better

• The oil to be filled for hot oil circulation (HOC) was maintained for BDV>80KV & PPM <10

• Vacuum was maintained for better than 0.5 torr for specified hours in quality plan
Dry out : Results

- Dew Point Achieved after Final dryout Cycle; Dew Point: -27.99 deg C against permissible value of -23.33 deg C (CBIP manual publication no. 295) at temp. of 27.87 deg C
- Insulation dryness also compared with acceptance limits as per moisture equilibrium chart and found within permissible limits
The PPM value of transformer oil after 48 hours filtration dropped from 31 to 5 from 1\textsuperscript{st} dryout cycle to 11\textsuperscript{th} dryout cycles, respectively.

*(each processing cycle was consist for vacuuming for 48 hours, oil filling, hot oil circulation for 48 hours, oil draining, vacuuming & dry air purging)*
PI and Tan Delta Measurement also confirmed the dryness of insulation system:

- Pre-commissioning PI > 1.3 for all combinations at 64 deg C
- Tan Delta of windings < 0.5
The repair was done in core (new CRGO assembly) and no major repair was done in individual windings or DCA and also this transformer was provided with HVCB which resulted into non availability of HV terminal for any HV tests; Hence it was not opined to go for dielectric test (High Voltage Testing) at site.

The following tests were carried out and found satisfactory:

• Winding Resistance Measurement
• Voltage Ration Measurement
• No Load Magnetizing Current Measurement
• Low Voltage Short Circuit Current Measurement
• Winding Insulation Resistance Measurement
• Core-Clamp-Tank Insulation Resistance Measurement
• HV bushing Tan Delta & Capacitance Test
• Winding Tan Delta & Capacitance Test
• Sweep Frequency Response Analysis

The test results were compared with FAT (Factory Acceptance Test) report and original commissioning reports and found satisfactory.
Charging & Behaviour observation

• The transformer was finally checked for general external clearances, oil level in conservator, external connections, Oil BDV & PPM of main tank and HVCB, IR values and earthing.

• The transformer was charged from LV side with 30% of Rated Voltage from Generator and the voltage slowly increased up to rated voltage in approx 2 hours time. The voltage was applied in below steps:
  • 30% of rated voltage at starting
  • 50% of rated voltage held for 10 Min
  • Voltage increased by 5% in 5 min approx

The GSU transformer withstood the voltage successfully and no abnormality was recorded.

Transformer was charged successfully and loaded after 24 hours on no load
Conclusion

• High Voltage Class Transformers can be repaired at site under strict quality control and supervision
• If no major repair is done in winding parts, the high voltage testing of transformer after such site repair may not be a necessary condition
• Vacuuming followed by dry air purging can be used an effective process for dryout of active part at site
• DOF pipes can also be used during dry out cycles, if the moisture content in insulation is high or if the transformer is opened for long duration for repair/rectification activities
• A major challenge for on site repair is dry out of insulation which may take months to bring dryness level within permissible limits but needs extra care while such long filtration is being done at site.
Thank you!