Two-day interactive workshop on

"Distribution Transformers – Latest Technology in Manufacturing and Best Practices in Maintenance"

Central Board of Irrigation and Power, New Delhi, on 24. & 25. June, 2010

CBIP has always strived to bring together the Engineering Community in the fields of Water Resources, Power & Renewable Sources of Energy. Toward this, CBIP periodically organizes Conferences, Seminars, Workshops, etc., on relevant topics. Continuing this trend, CBIP organized an Interactive Workshop on one of the hot topics of the day, namely, Distribution Transformers – Latest Technology in Manufacturing and Best Practices in Maintenance. That the choice of the topic was timely and relevant was underscored by the large number of registrations for the workshop, as well as, the rather lively and informative interaction between the presenters and the participants on both the days.

Many of the presenters expressed appreciation for the format of the workshop, allowing the audience and the participants to take active part in the deliberations, thereby enhancing the effectiveness of the bidirectional information flow.

The workshop was divided in to six sessions, whereby the first session was the inaugural session, with well known dignitaries, Mr Mata Prasad, Mr S N Dhiman – Member (Grid Operation & Distribution), CEA, Mr N N Misra – Executive Diretcor -HR, NTPC, Mr M Vijayakumaran – Senior Expert, Areva & Mr V K Kanjlia, Secretary, CBIP. The session, and indeed the workshop, was ably conducted by Mr P P Wahi, Director, CBIP.

The dignitaries expressed happiness that the workshop aimed to discuss both manufacturing and maintenance issues. Among the major issues touched upon were:

- Concerns about the use of recycled CRGO
- Manufacturers are significantly dependent on the import of CRGO
- Efforts at replacing/ supplementing the transformer oil with vegetable oils
- Non-applicability of international standards
- Failure of Distribution Transformer (DT) on account of lightning induced voltages
- Low efficiency of the DTs in use
- Relatively high failure rate and lower life expectancy of local DTs
- The very large requirement of DTs in view of the planned expansion in line with the 'power to all households by 2012' programme
- Need to align DT manufacture and procurement in the country, with which aim CEA has recently issued specific guidelines

The remaining five sessions saw In-depth presentations by eminent persons, along with a high degree of interaction between the presenters and the participants. The presentations were:

1. **Overview of Distribution System**, by *Ms Anjuli Chandra, Director, CEA*
   Ms Chandra presented a series of relevant statistics and other information regarding the Distribution sector in the country. One interesting fact that came out was that around 36% of DT failures in the country are attributed to poor design. Among the other causes are poor quality material, poor maintenance, improper operation and bad installation practices. CEA has brought out a comprehensive set of guidelines on DTs. It is available on the CEA website.
   - The country has close to 4 million DTs, with a growth rate of about 9.5% per annum. These DTs distribute about 3 lakh MVA power. In view of the large numbers, even a small improvement in efficiency is highly desirable. BEE has a 'Star-rating' programme. Utilities should procure only the 3-star or above rated DTs.
   - About 3% of the total power is lost on account of poor efficiency of the installed DTs.
   - The DT failure rate is very high at about 20-25%. Some utilities have achieved a figure of under 1%.
   - The presence of harmonics leads to increased losses in the DTs.
   - The local purchasers tend to routinely specify the relevant IS, without appreciating that the losses specified therein are only the maximum losses acceptable under the standard, and that lowering of losses should be attempted.
   - Rather than the initial purchase price, more relevant would be to consider the 'Total Owning Cost' (TOC), which includes the cost of the losses over the life o the unit.
   - The optimum loading of a DT is at around 70% of its rated capacity.

2. **Experience of Tata Power in Distribution Transformers**, by *Mr Girish Jawale, Tata Power Company*
   Mr Jawale informed that most of the DTs under their control (about 400 no.) are of 1250 kVA, with some of 2000 kVA and a few of 1000 kVA. He shared many of his experiences. A few among these were:
   - High level of harmonics leads to rise in core and winding temperatures.
   - Oil-filled transformers have the advantage of lower cost.
   - Dry type transformers are best for indoor application, in view of the lesser fire hazard.
   - Fully sealed DTs should be preferred for outdoor applications.

- The various specified tests must be conducted as recommended, at site and after a tripping. Thermal Vision Scanning may be resorted to, where needed.
- After the Mumbai floods in July 2005, the DTs were only subjected to external cleaning.
- After a fire in an HT cable, the DT was found to be in order.
- Use of Fire-resistant cable or Fire-proof coating for the cable is recommended.
- Bakelite separators were found to absorb moisture after a lightning strike incident, leading to failure of the DT.

3. **Best Practices in Maintenance (Case Studies) of Distribution Transformer**, by *Mr Harshal Joshi, ABB Ltd.*
   Mr Joshi presented a number of recommendations, supported by photographs. A few samples:
   - The DTs received from the vendor must be loaded/ unloaded properly and stored in an orderly manner to avoid damage.
   - Any DT must be kept, stored, moved or used in vertical state only.
   - Bypassing of the MCB on the DT can lead to stress on the windings.
   - Oil theft is one major problem area.
   - A 3-phase DT can be used for 1-phase, provided the single phase load is under one-third of the DT rating.
   - Maintenance should be undertaken as recommended.

4. **A Case Study**, by *Mr K K Tiwari, BSES Yamuna Power Ltd.*
   The case was about Oil contamination and water ingress in a lot of 25 kVA DTs. Every DT was found with signs of rusting just below the Oil filling cap. The vendor maintained that the packing material provided on the cap was missing, leading to water ingress. After analysis and some experimentation, it was deduced that with changing temperature, air enters the DT through the capillary space along the cap threading (non-standard size). On exiting the capillary, moisture condenses and gets deposited on the core laminations. Mr Tiwari recommends:
   - Follow good storage practice
   - DT must only be handled by trained persons
   - All the joints and the accessories on the DT must be correctly tightened
   - Every DT must be subjected to the pre-installation tests, prior to its removal from the store

5. **Technology in Manufacturing of Distribution Transformer**, by *Mr Harshal Joshi, ABB Ltd.*

Mr Joshi gave a brief look at some emerging technologies affecting manufacturing of DTs. Some of these are:

- The use of Ester as Insulation fluid. It is bio-degradable and has a high flash-point. But it is costlier.
- To reduce copper losses, liquid Nitrogen cooled Super Conductors may be used.
- Amorphous Metal Core may be used in place o CRGO. Easy availability is an issue.
- Grade II Super Enamel could be used. It has better breakdown strength.
- The gaskets used may be made from Type-C Cork.
- Hot Dip Galvanisation and use of Brass fittings is recommended.
- Also recommended is proper drying of the core and Oil filling under vacuum.

6. **Engineering Design for efficient distribution transformers and its installation aspects**, by *Mr G Venkatraman, DGM, NTPC Electric Supply Company*

   Mr Venkatraman lamented the general shortage of Power Engineers, in the light of the power expansion plans of the nation. He observed that many purchasers may not have the requisite QA and testing facility/ ability. The lowest capacity DT in the country is of 5 kVA (for HVDS use). He appreciated that the probable payment period for DT purchase orders could be one year or more, and with the volatile CRGO prices, the vender finds it difficult to maintain cash-flow and may resort to cost cutting. One significant issue raised by him was for the utilities to exercise due caution and prevent use of recycled material in the DTs. He felt that conducting type tests should be mandatory. Among other issues noted by him were:

   - Re-cycled CRGO is a major problem. It could lead to high Technical losses, going up to 22%.
   - While AMT (Amorphous Metal Transformer) has higher initial price at present, it would contribute to lowering of losses. AMT shows lesser temperature rise when subjected to harmonics. Also, it does not show deterioration after faults.
   - A Wound Core has lesser leakage flux, and hence has higher efficiency.
   - Dry type DT may be used in a ‘fit-&-forget’ situation. In the case of varying load and high value of harmonics, Oil-filled type DT is to be preferred.
   - While some users maintain that internally mounted (immersed in oil) LT breaker leads to oil contamination, the other side is that it would have higher capacity for overload.

- It is highly recommended that DT primary connection should be Phase to Phase, rather than Phase to Earth/ Neutral. This is to avoid accidental full voltage exposure in case of earth line breakage.

7. **Significance and importance of fittings, accessories of transformer and maintenance aspects in modern power system**, by *Mr K Bheema Prakash, Senior Expert, Areva T&D India Ltd.*
   The presentation covered a lot of ground, touching multiple products and different aspects. Mr Bheema Prakash pointed out that the transformer oil has many issues linked to it, contamination being one of these. He also gave an extended list of accessories. When it was pointed out to him that his presentation referred mainly to HT Transformers, his stand was that most of the accessories & fittings were same or similar to that for DT. He also briefed the gathering on Smart Grid. Among the information provided by him was:
   - Tap-changing control constitutes about 40% of the failures.
   - Frequency analysis is very helpful in identifying transport related problems/ issues.
   - The use of Breather & Conservator reduces the exposure of the Oil to Air.
   - Test for explosion vent pipe is recommended. Also recommended for it is double diaphragm with oil gauge.

8. **Improved Single Phase Power Supply System**, by *M/s P P Patel, GM & Mr N D Bidarkar, Manager, Madhya Gujarat Vij Co. Ltd.*
   M/s Patel/ Bidarkar informed of the fact that in Gujarat every household has 24 hr power availability. However, agriculture load is supplied 3-phase power for only a limited period. There are some areas where a common feeder supplies both the households and the agriculture load. To prevent the farmers from diverting the domestic power for agriculture loads, MGVCL has designed and patented a Special Design non-symmetric Transformer (SDT), with full normal voltage on one phase only. The other two phases have differing and much lower voltages, sufficient only to sustain magnetisation current in DTs. Current limiters are used on the other two phases to prevent connection of higher loads. During the allowed period of the Agriculture load, this transformer is not put in the circuit, hence normal 3-phase power reaches the loads. At all other periods the use of the special transformer ensures that the households get one phase properly. The lower voltages on the other two phases ensure that 3-phase loads can not be supplied, even with the application of phase splitter. It was informed that the SDTs are all created from existing old and discarded Transformers.

9. **Preventive Maintenance and Condition Monitoring of distribution transformer**, by *Mr Amit Gupta, Manager, NDPL*
   The DT failure rate at the time of the creation of NDPL was arount 11%. Today it stands at less than 2%. T&C losses have come down from about 53% to around 15%. NDPL has over 25000 DTs of different capacities, from 10 kVA up to 1000 kVA. Generally preventive maintenance is undertaken twice a year on every DT. The high-/ medium-risk DTs are candidates for Thermography, to identify 'hotspots'. He recommends this procedure to al the utilities. The operating temperature has been brought down from around 50-55° C to around 35-40° C, lengthening the life of the DT and the insulation. Another very important recommendation is 'Post-failure' analysis for all the higher rating DTs, indeed any transformer.

10. **Amorphous Metal Transformers & Test Facilities at CPRI,** *by Soumitra Pathak, Engineering Oficer, Central Power Research Institute*
    Mr Pathak emphesised that AMT may lead to up to 70% reduction in losses. Amorphous Metal refers to the phenomena of absence of crystal lattice. Smaller atoms of material, e.g., Boron or Phosphorous, fill the space between the regular atoms. The result is lesser number of free electrons, hence the magnitude of eddy currents is low. Also, due to lesser space being available for vibration, the temperature rise is also low. Hysterisis losses are lower. One interesting point shared by Mr Pathak was the use of a large volume of Araldite in some DTs to fix the coils in position to pass the CPRI test. The same DTs are more likely to fail in use. There is no clear answer to the possible reaction of the Araldite with the Oil. Some other observations were:
    - Quality of Off Load Tap Changer needs to be improved, as a number of transformers failed during Short-circuit test due to poor quality of tap switch.
    - Random selection the sample is absolutely necessary to select a unit or type-testing.
    - The utility representative should witness the type-test.

Overall, the workshop succeeded in its aim of bringing together the DT community and being a forum for exchange of knowledge and experience. The interactive format encouraged a lively exchange of views. Even the speakers ware benefited by the interchange, leading to the uncovering of a few more relevant points of interest. The time allowed, namely two days, was also appreciated by those present.

The workshop ended with recommendation by the participants to CBIP to hold more such workshops on topics of contemporary interest.

This paper contains only a reference to the proceedings of the workshop. CBIP or the presenters may be contacted for further details.