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POWER T&D OUTLOOK 2021

Industry's leading experts rightly address the challenges aroused from the increased transmission and distribution requirement. They also talk about impacts of the same across infrastructures.

Futuristic transformers for sustainable power distribution

This article talks about technical know-how of a distribution transfrmer. It also talks about the maintenance aspects towards reducing the stress and enhancing the performance of a distribution transformer.

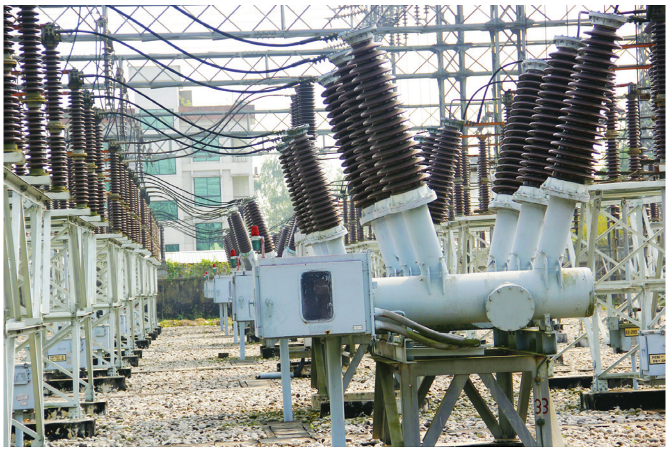
Distribution Transformer (DT) is one of the most important and high value capital asset for an electrical utility. And, their number is very large, with more than 12 million DTs only in India. DTs are an essential part of power distribution infrastructure in providing 120-240V-415V to distribute electricity to customers. As a critical component of electrical infrastructure and since their number is very large, strategic change to DT design, manufacturing, and maintenance practices, can bring down the electricity losses and reduce its environmental impact. Being a stable machine, the life of DTs is long - from 20 to 40 years. Extensive protection of DTs is not economical; hence, DT's intrinsic strength must be sufficient enough to take care of thermal, mechanical and electrical stresses. The Failure Rate of DTs varies widely - from 1 percent to 20 percent depending upon maintenance, type of material used in manufacturing, manufacturing processes, design, and quality assurance plan.

No doubt, there are continuous efforts to reduce losses with labeling of DTs, by various countries including India. Further, these DTs use mineral oil as insulating oil, which is not eco-friendly. Eco-efficiency in DTs can take different forms, such as reducing losses, increasing life cycle and using biodegradable ester oil as insulating liquid.

Energy Conservation and reduction of CO2 emission are in spotlight for environmental sustainability. Thus, finding ways to increase the efficiency of our electrical Infrastructure, especially the power distribution network, is an important factor towards reducing emissions and the cost. Higher efficiency of DTs at the last-mile delivery point can help avoid the cost of generating additional electricity while lowering total running cost of the power distribution network. Considering these aspects, energy planners are adapting efficiency standards, based on consideration of Techno-Economics of DTs during its life, called Minimum Energy Performance Standards (MEPS). Some energy planners also suggest capitalisation of losses. The Bureau of Energy Efficiency (BEE), India, specified five levels (Star label) of maximum losses at 50 percent and 100 percent of rated load. Thus, it takes into consideration the load factor of DTs. Similarly, USA, EU and other countries also promulgated MEPS for DTs. The MEPS influence the whole Techno-Economics of DTs, such as:

- Reduction in losses (up to 40 percent) and thereby increase in efficiency of system
- Higher capital cost, call for better design and manufacturing for creating visibility in better service in addition to efficiency
- Environmental impact towards greener earth.

While the MEPS stipulate maximum losses, they are invariably silent on the rate of failure of DTs. The international norm of rate of failure of DTs is in the range 1-2 percent, which provides for life expectancy above an estimated life of 25 years. However, underdeveloped and developing countries experience failure rate of DTs that are much higher than the international norms, which usually is in the range of 5-7 percent. It must be mentioned that some utilities in India also have a failure rate of DTs at 1-2 percent only. Thus, there is need for



a cautious approach and proper analysis while adapting MEPS; otherwise the whole exercise would just end up as a drain of resources without accomplishing return on investment.

Material selection for manufacturing DTs is equally important for sustainability of DTs. DTs mainlyuse CRGO/ amorphous, copper/aluminum, solid insulation, liquid insulation and cooling media (mineral oil), steel for making tanks, radiators and core &coil assembly. Mineral oil is normally used as liquid insulation and cooling media. It is not eco-friendly and may be replacedby ester oil in future. Ester oil is bio-degradable, high fire point bio-temp fluid. CRGO is available in various grades having specific loss of0.75Wper Kg at 1.7T and higher, saturation flux densityof 1.9T, stacking factor of about 0.97 and it is not brittle. CRGO is good for manufacturing DTs having good inherent strength. Amorphous metal is available having very less specific loss - about 0.18W at 1.3T. Its saturation flux density is low,at 1.59T; highly brittle stacking factor is low 0.84. Core cross section of amorphous metal based core section is rectangular and the coils for making DT are rectangular in construction. Rectangular coil assembly possesses poor short circuit strength in comparison to circular coils used in CRGO based DTs. Further, it is difficult to maintain quality of amorphous based transformer during repair mainly due to loss of some core material during repair as amorphous is brittle and care has to be taken regarding broken material being left in the core and coil assembly. Regarding conductor for coils and termination, copper is better from the reliability point of view due to its higherconductivity, very good creep and fatigue behavior, good conductivity and higher tensile strength. But it is costly in comparison to aluminum/ aluminum alloy. Creep temperature of copper is about 135°C, whereas, it is only 7°C for aluminum. Elongation in aluminum conductors is more, requiring care during coil making. Therefore, with aluminum, special care has to be taken in making coils, joints and terminations. Frequent tightening of termination, a rare possibility in the current utility O&M environment, is a must for aluminum wound transformers, else contact resistance at terminations and joints will increase with time due to poor creep behavior of aluminum and it may cause failure of the DT. There are greater chances to leave seed defect in aluminum wound transformers. Normally mild steel is used for making tank, and core and coil assembly; as such there is no problem and it is cheap. Class A insulation is used in making DTs, which is eco-friendly.

Proper design of DTs is also important for achieving good inherent strength of DTs, for long life and lower losses within economical limits. Ampere turn along the axis of core of coil assembly must be matched to minimise axial forces during short circuit and proper insulation coordination for achieving good dielectric strength. At the same time to reduce thermal stresses, lower hot spot temperature is desired. Clear instructions for manufacturing DTs must always be provided by the designer and be followed during manufacturing. In case of any deviation, the designer must be consulted. This procedure must not be compromised to produce quality DTs. For this purpose, a good quality assurance Programme must be in place.

For sustainability and achieving low failure rate of DTs, proper loading pattern and maintenance must be in place. History cards of each DT must be maintained and a database created. Historical data may be continuously analyzed to update maintenance/replacement procedure to reduce failure and inconvenience to customers, not to mention the cost of reduced revenue. With effective maintenance and proper loading profile, failure rate of DTs can be reduced and it has been achieved by some utilities to below 1 percent.

Balancing the economic needs of society with sustainability, DT procurement policies with dynamic MEPS may be evolved. Any system of MEPS and energy efficient DTs can be sustained if it yields payback within 2 to 5 years, and a DT serves its estimated life. Parameters that go into formation of MEPS are both technical and commercial in nature. Mere specifying maximum losses for certain loading conditions in the beginning serves the purpose of creating awareness amongst stake holders. But considering the dynamic pattern of economic parameters, availability of new materials, and technology upgradation, periodic validation of parameters becomes essential. The population of DTs is huge and increasing with time; a small improvement towards sustainability will have its impact.

Authored by:

Dr. Hari Om Gupta, Director, Jaypee Institute of Information Technology Noida, Former Professor IIT Roorkee, India