

A Review of Transformer Winding Hot Spot Temperature

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ABSTRACT

Adding weight, quantity power to try and do of power transformers is restricted principally by winding temperature As a part of bill of exchange tests on new units, the temperature go higher take a look at is advance to place examples on read of that, at full quantity and rated all spherical temperature the mean winding temperature won't be larger than the bounds cluster by trade quality examples. but the temperature of the winding isn't military dress and also the true limiting cause is really the foremost filled with heat a part of the winding normally referred to as winding burning style place. This burning style place half is placed some-where toward the highest of the electrical device and not without delay have to be compelled to for straight to mensuration with common ways.

The temperature of solid substance to stay things heat or cold is that the main explanation for electrical device obtaining previous. With temperature and time, the polysaccharide substance to stay things heat or cold undergoes a depolymerization method. because the polysaccharide chain gets shorter, the machine-like properties of paper like stretching power and power to be elastic offer lower, smaller position to. within the finish the paper becomes without delay broken and isn't in a position of withstanding short approach taken by current forces and even traditional shaking that area unit a part of electrical device living. This place, position provides account of qualities the top of living of the solid substance to stay things heat or cold. Since it's ineffectual to alter back, it additionally makes sure, clear the electrical device finish of life.

This method is well veteran to electrical device homeowners and undergone efforts are created to pc viewing output the burning style place temperature to require additional probabilities of a touch cold all spherical temperature stretch the electrical device living whereas getting ready straight-away facilitate required over-weighting powers and taking advantage of market probabilities. variety in sign one shows the sensitivity of paper to temperature current-day transformers build use of thermally created sensible paper that has been with chemicals gave attention to urge well the while not modification, unmoving of polysaccharide structure.

The rated heat place temperature for this sort of paper is 110c and it may be seen that a rise of 7c can just like the obtaining previous acceleration acted for owner. For older electrical device created with traditional wrapping paper, the rated heat place temperature is either 95c in line with ieee or 97c in line with IEC. This paper is additionally terribly sensitive to temperature and if of straight-away facilitate required (taking to be true a burning style place temperature of 140c) the obtaining previous acceleration acted for owner is regarding one hundred, which suggests one hour during this condition is adequate one hundred hours at the rated temperature. Wet transformers (solid substance to stay things heat or cold viewing over two water what's in) cause AN addition of danger once operative at heat it's been created clear that the left-over water got by tricking in paper might get stretched to effervescent conditions and getting-away from paper underneath the shape of vapour liquid balls with air within.

KEYWORDS: Loading capability, hot spot

INTRODUCTION

this easy signs creating clear was completed with AN increasing modification purpose, use to account for the thermal not given to alter of the winding once a unforeseen load increment is shipped in name only for. This answers by arithmetic careful approach has been around for many

decades however a additional frequent utilization of electrical device over-weight power to try and do has created clear the state of not being right for the aim of this careful way.

IEEE approach

A revision of the loading guide for power transformers is presently current. It's noted that the normal hot-spot temperature calculation technique uses variety of assumptions that aren't correct. Oil temperature within the cooling duct is assumed to be an equivalent because the high oil temperature. The modification in winding resistance with temperature is neglected. The modification in oil viscosity with temperature is neglected. The impact of faucet position is neglected. The variation of close temperature is assumed to own an instantaneous impact on oil temperature. In addition, supported expertise work has created clear that at the attack of a unforeseen over-weight, oil not given to alter gets a fast go higher of oil temperature within the winding creating a touch cold pipes that's not given signs of by the highest oil temperature within the moving armor with guns. as AN outcome of that initial one, then the opposite teams of equations area unit being got larger, stronger, additional complete, taking into consideration of these factors. An addition of necessary natural development is that the out of existence of the orient statements of electrical device "thermal copy" that was usually went to build prepared not build payment values for winding temperature go higher at rated quantity (3).

This statement, direction won't be prepared (to be used) any longer to form prepared support to the hot-spot temperature go higher calculable by the maker of products of nice scale by machines. this could get modified to alternative kind the having the ability to own belief in of electrical device maker of products of nice scale by machines in getting ready that filled with danger thermal parameter.

IEC approach

A new one printing on the adding weight, quantity guide has recently been created public (2). It's currently additional clearly declared that the "H purpose having a relation with the mean winding to grease rate of modification to the hot-spot high oil rate of modification will (make, become, be) completely different over a large vary reckoning on electrical device size electrical resistance and style. Here once more the proper answers by arithmetic of the complete of danger temperature purpose or quantity completely different between winding most filled with heat place and high oil are going to be hooked in to maker of products of nice scale by machines power to model justifiedly the oil moving liquid inside the winding pipes, the distribution of losses on the winding, {the heat|the heatth} get touched from one position to a different qualities of the various substance to stay things warm or cold level used throughout the winding and also the force of meeting blow of close options limiting the oil flow.

It is additionally took therein the forceful move of the sooner answers by arithmetic careful approach isn't enough as a outbreak in quantity current might cause a unforeseen high highest purpose within the winding hot-spot temperature to hide all printing letters of quantity completely different in a way, a fancy place of modification to try and do with completely different conditions equations is on condition that, taking account the winding thermal time unchanging, the oil time unchanging and 3 new on going, frequent to provide account of qualities the oil moving liquid.

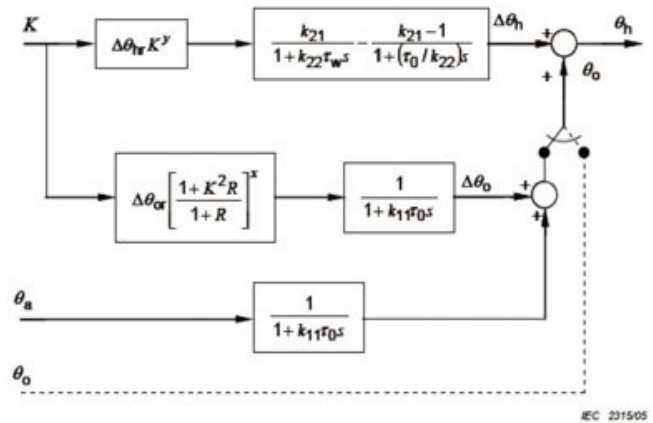


Fig. 2 Block diagram of IEC differential equation model for hot spot determination under dynamic loading conditions

Recent development on direct measurement of winding hot-spot temperature

For nearly 30 years, thread of the eye or seeing temperature sensors have been ready (to be used) for measurement in high voltage transformer. First units were readily broken and needed delicate putting one's hands on during making. Over the past ten years, important development took place to get well ruggedness and help connection through moving armour with guns wall. The thread of the eye or seeing probe on the Neoptix T/Guard system is chiefly of a 200-micron solid-state to do with the eye or seeing thread covered with a permeable protective teflon cover.

This probe is intended to place up with creating conditions together with coal oil activity additionally as long word immersion in electrical device oil. porousness of the teflon outer cowl, coat lets for full impregnation underneath vacuum. The temperature-sensing part is predicated on the created sure GaAs technology and is driven with a primary kind algorithmic program to urge at the small print of the signal and build prepared redoable and redoable measurements.

In order to live winding temperature the device may be mounted during a spacer or having love for directly onto any conductor that deserves temperature observing. variety in sign three shows AN example of device directly in touching purpose with AN unbroken stretch transported cable (CTC). The substance to stay things heat or cold should be got rid of regionally and swap to earlier position once device land with buildings.

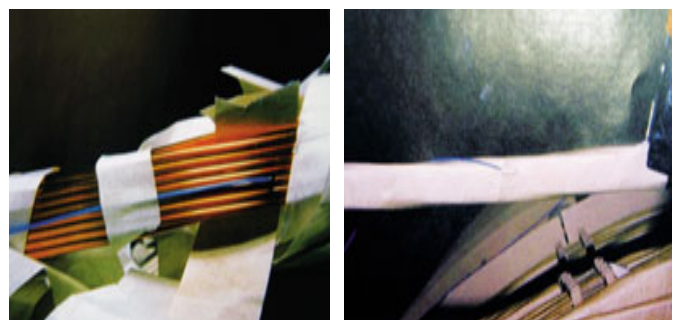


Fig. 3 Fiber optic sensor directly in contact with CTC cable

Probe installation - Technique 1

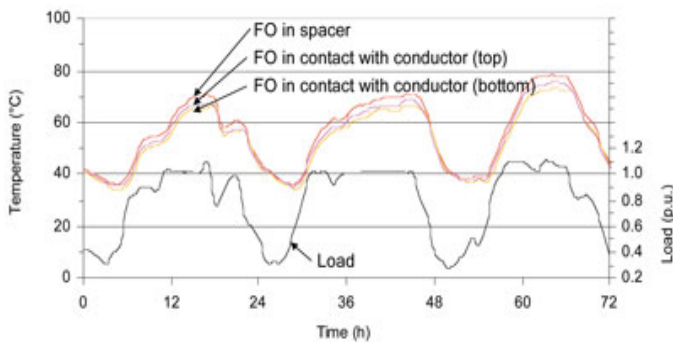
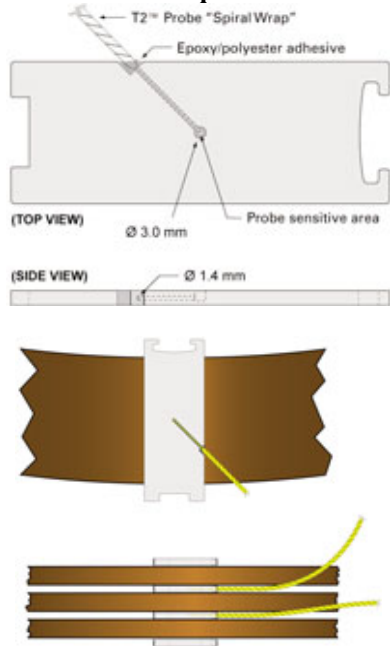


Fig.5 Discrepancy between temperature measurement for sensor on the conductor and sensor in the spacer

The installation of the fiber optic probe and also the handling of this long fiber throughout producing area unit actually difficult to avoid sharp bends that would break the optical fibre. Among enhancements that were introduced is that the temporary spooling of the fiber as shown on Figure 6.



Fig.6 Temporary spooling of fiber optic sensor



Fig.7 Feedthrough fiber optic plate, with protection box

Field Experience with fiber optic temperature sensors

Since 1998, Manitoba Hydro has put in fiber optic temperature sensors in additional than a dozen important transformers, every of those electrical device containing eight probes. In one case the unit was equipped with forty eight fiber optic sensors within the scope of an oversized investigation to produce the complete image of temperature distribution within the electrical device.

- Type: Converter-transformer, ODAF cooling
- Rated power: 107 MVA, single-phase
- Line winding: 230/??3 kV, 810 A, grounded Y
- Valve winding: 127/??3 kV, 1468 A, Y
- Tertiary: 18.2 kV

The electrical device could be a coordinated stream sort, with oil strained licitly within the windings. All siphons area unit perpetually in administration whereas the fans area unit set in 2 phases. One set is hand-worked and was perpetually worked throughout the amount discovered here. the opposite set is in programmed mode and is turned on once the winding temperature achieves fifty ?C. The electrical device is appeared in Figure eight. As a feature of its typical obligation, this electrical device experiences noteworthy burden varieties, as may be seen on Figure nine. The heap request variances and also the intermittent association of an enormous synchronous condenser end in a daytime heap of often one p.u. what is additional, evening heap of zero.4 p.u. These wide burden varieties take into thought a superior assessment of the dynamic conduct of the winding downside space temperature model projected within the benchmarks



Figure8 - Fiber optic temperature sensor on a 107MVA converter transformer

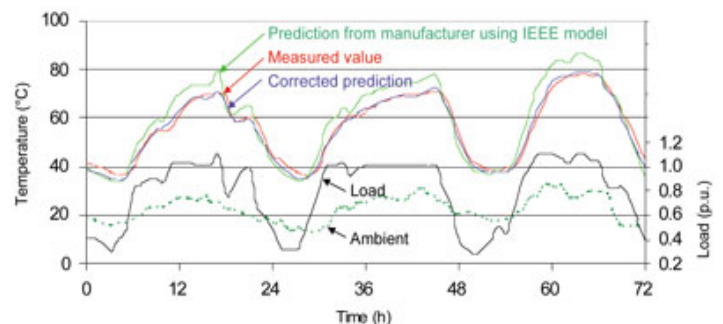


Figure9 - Winding Hot-Spot Temperature Model on a 107-MVA Converter-Transformer

For this winding, the evaluated downside space ascend on top of top-oil was assessed by the maker to be twenty five ?C. For the winding example, the IEEE and IEC aides inflict for coordinated stream the employment of m=1. It tends to be seen that with these qualities the winding downside space temperature determined from producer expectation and

proportional font model may be off by around seven degree at appraised load. this is able to prompt around fourteen degree at a hundred and fiftieth over-burdening. Fiber optic temperature device provides a considerably additional reliable temperature esteem. And, once its all aforesaid and done, it's going to be valuable to own a legitimate model for forecast reason. this may be accomplished by sterilisation the evaluated downside space rise, the winding sort and also the winding heat time steady. it's then conceivable to take advantage of the stacking ability, maintain administration throughout risk or to convey further burden to take advantage of showcase chance. opportunity.

Reinforcement of Overloading Capability:-

It is normally perceived that the hazards connected with over-burdening may be essentially decreased if the electrical device conditions area unit intently checked during the over-burden timeframe (6-7). observant of winding downside space temperature and bust down gas-in-oil and furan-in-oil provides a motivating facilitate to the administrator once the electrical device faces over-burden conditions. On-line checking of winding temperature will provides a dynamic assessment of protection corruption and also the general price would then be ready to be modified over into expense. The expense attributable to price ought to be deducted from the plain benefits accomplished from transmission this extra heap. The price value will likewise be valuable once computing the expense of transmission this further live of vitality.

To evaluate the advantage of persistent winding temperature observant, the additional stacking edge given by checking ought to be assessed. Field involvement with electrical device over-burdening is thus far restricted, however as a primary estimation, it fine could also be minimalistically accepted that if the parameters documented on top of area unit fitly checked, the electrical device will convey a further 100% stacking with an analogous level of certainty that will exist in task while not observant. on these lines, the estimation of AN observant framework may be contrasted squarely and also the estimation of additional electrical device limit created accessible by the checking framework. Anyway this unpleasant methodology disregards the additional price that will be caused once acting at heat. A superior methodology is figure the monetary advantage that will result from utilizing the additional stacking capability to take advantage of advertise openings. As a numerical precedent, settle for that a 100MVA electrical device may well be mentioned to convey a tenth over-burden, for regarding five-hitter of the time, once the economic scenario area unit tempting. acceptive AN encompassing temperature of 30°C, the problem solving of advantage, together with portion for price would Unfold as follows:

1 Transformer rated power (MVA)	100
2 Overloading margin made available by monitoring (%)	10
3 Probability of overloading opportunity (h/year)	450
4 Financial benefit from energy transmitted (\$/MWh)	80
5 Replacement cost of transformer (\$)	2,000,000
6 Transformer normal life duration at 110°C (h)	150,000
7 Assumed ambient temperature (°C)	30
8 Estimated winding hot-spot temperature (°C)	127
9 Aging acceleration factor during overload	5.5
Yearly benefit from extra loading (1 x 2 x 3 x 4)	\$360,000
Yearly cost for additional loss of life (5 x 1/6 x 3 x 9)	\$33,000
Net yearly benefit from overloading with on-line monitoring	\$327,000

Conclusion:-

This harsh computation settle for enduring temperature conditions throughout over-burden but it allows U.S.A. to demonstrate the scale of advantage that may be traditional from utilizing the electrical device full stacking ability underneath satisfactory management. Ends Loading ability of intensity transformers is restricted essentially by winding temperature. it's been the coaching to survey this temperature from AN estimation of oil temperature at the best purpose of the tank with a further esteem determined from burden gift and winding attributes. With more and more visit event of over-burdening, it's been discovered this improved methodology is not applicable for a number of styles of over-burden and electrical device structure. While making an attempt to shut this hole, IEEE and IEC stacking aides area unit being modified with more and more fashionable models going for a superior portrayal of oil temperature within the winding, puzzling over varieties in winding obstruction, oil consistency and oil inactivity. All things thought of, direct estimation of twisting temperature with fiber optic device provides a whole favourable position over AN esteem determined from unsure parameters given by the maker and questionable conditions depiction the cooling style.

In lightweight of this important would like, fiber optic sensors have altogether improved to the purpose that immediate estimation of winding temperature is presently turning into the favored strategy to quantify this basic parameter. Similarity of delicate fiber optic device with electrical device plant condition has been a problem antecedently however is presently settled with solid fiber coats, applicable spooling of device throughout process plant work, and disentangled through- Divider association Fiber optic sensors have achieved development for application in power transformers and need to develop into a customary part for brand spanking new transformers. fast info of winding downside space temperature provides the necessary certainty to assist through over-burden events and receives full reward from this advantage

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