

Transformer Condition Determination Methods

M. Muhr, C. Sumereder

Poster ISEIM 2008, Yokkaichi, Japan

ABSTRACT

Power transformers represent very important equipment in production and distribution of electric power. Since the liberalization of the electric energy market the cost pressure to the utilities raised and enforced to change the management strategy in several business segments. Taking a look to the technical and economical aspects of operating a distribution grid the length of life in correspondence to the drop out risk of electric power equipment is coherence.

Aging of Cellulose

Degradation of the paper can cause the fail of the transformer by several mechanisms: the brittle paper can break away from the transformer windings and block ducts; water is a product of degradation and builds up in the paper, reducing its resistivity; in the extreme, local carbonizing of the paper increases the conductivity to cause overheating and conductor faults.

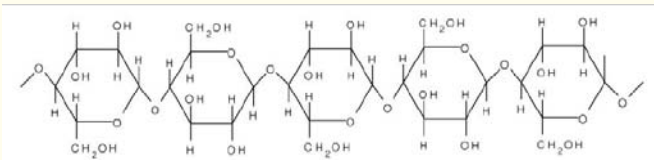


Figure 1: Structure of cellulose molecule [1]

Furan Analysis

By the means of furan analysis the DP is determined in a chemical analysis of the transformer oil. New paper has a DP of more than 1000, after factory drying this value will drop to 800 to 1000. Paper under normal operating condition has a DP of more than 400, aged paper more than 200 and paper with a DP lower than 200 is aged extremely.

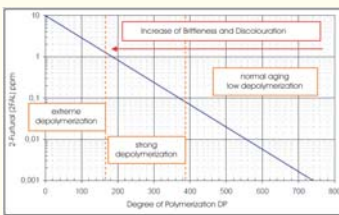


Figure 2: Determination of DP from 2FAL [2]



Figure 3: Viscosimeter [1]

DP Determination with viscosimeter

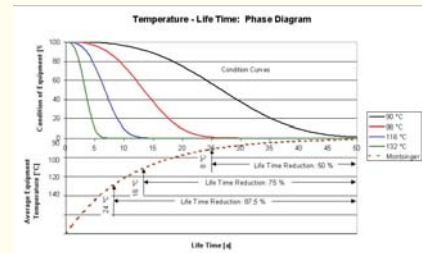
Paper test specimens have to be taken out of the transformer and to be prepared according to this standard by crushing and drying the cellulose fibers and resolving in the CUEN solvent. Then the average viscosity is measured with a viscosimeter and from this result the DP can be determined by the relation of intrinsic viscosity and limiting viscosity number.

References

- [1] Kuen C., "Determination of the moisture sorption curves of cellulose for transformers depending on the degree of polymerization", Diploma Thesis, TU Graz 2008
- [2] Wesselnk H., "Papier in Transformatoren", Energietechnik (74), 7/8 (1996), page 480-483
- [3] Sumereder C., Muhr M., Körbler B., "Life Time Management of Power Transformers", CIRED 2003

Thermal Degradation

High load of a transformer means high ohmic losses and a rise of the temperature in the windings and the insulation system. With the rise of the operating temperature the degradation processes of the paper-oil insulation system is accelerated according to the law for thermal aging, the parameters for aging of paper-oil systems were determined a long time ago



$$\text{Thermal Aging} = 2^{\frac{=90-C}{8-C}}$$

Figure 4: Transformer lifetime in dependence of thermal load [3]

Influence of Moisture

Water molecules in oil and paper accelerate the depolymerization of paper on the one hand and minors the quality of mineral oil concerning the electric strength parameters (breakdown voltage etc.) on the other hand.

Determination of Humidity Sorption in Paper

A test series with different paper qualities was done. The test samples were weighed under dry condition than stored in a climate chamber with defined climatic condition (temperature and air humidity) and then weighed again. For the determination of the weigh a chemical balance with high accuracy was used, so that the weighing resulted in a traceability calibration process.

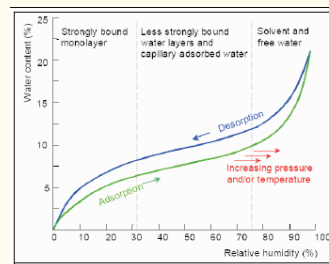


Figure 5: Sorption Hysteresis [1]



Figure 6: Determination of water content with PDC analysis

Summary

Beside the classical oil analysis there were new methods to determine the condition of the electric insulation system of transformers. The aging of the insulation system is influenced dominant by the water content of mineral oil.

The mechanical paper condition is linked directly with the electrical breakdown strength. For this reason the structure of the paper gives useful information about the transformer condition. The appearance of the paper molecule can be determined by analysis of the furanic compounds or by measurement of the degree of depolarization (DP). The DP measurement with a viscosimeter requires an extraction of paper test samples out of the transformer. For this reason the furanic analysis is applied more often and the expressiveness of both methods equals.