VAISALA / APPLICATION NOTE

TRANSFORMER MONITORING SEPTEMBER 2011

Monitoring Transformer's Oil Moisture Levels

Transformer windings are insulated with cellulose and surrounded by oil to ensure proper insulation and cooling. Poor oil quality can lead to a low dielectric strength and even to a system failure. High water content together with dissolved gases in oil may cause bubbling in case the total pressure of gases exceeds the ambient pressure of the transformer.

Knowledge of the transformer's insulation cellulose dryness is needed to avoid a breakdown situation and to optimise the transformer maintenance. As the dryness of the oil correlates well with the dryness of the cellulose, it is a practical and traditional way to monitor the oil moisture level in a transformer. A sudden increase in moisture level indicates e.g. a leak. By keeping the transformer as dry as possible its lifetime will be extended.

Moisture Dynamics

The insulation cellulose absorbs water from the transformer oil, which can absorb it from the atmosphere via the free breathing conservator or through degraded sealing. The moisture level increases also with water formed as the cellulose insulation slowly degrades i.e. the DP value decreases. With higher water content, the degradation rate is faster, forming more water resulting to an accelerated ageing process. The life span of a transformer is generally defined by the quality of the cellulose insulation.

It is common practice to monitor the transformer moisture level by a scheduled oil sampling and analysis in a laboratory. The oil sample for moisture analysis should be taken when the system is quite stable i.e. the load and oil temperatures have been relatively constant for a longer period. As this procedure is quite demanding and time consuming several problems might occur, causing a change in the moisture level of the sample and as a result producing misleading information. Moisture in oil levels also vary considerably depending on the operational conditions, which means that a moisture reading from an oil sample at a single point in time may not be typical. Therefore, an on-line moisture monitoring system would be a right solution to overcome possible problems encountered during a traditional oil sampling procedure.

Reverse Water Absorption Behaviour

The cellulose-oil system in a transformer is very complex in regard to moisture distribution, because of the reverse water absorption behavior of oil and cellulose. With increasing temperature, solid cellulose releases water that is absorbed by oil and vice versa when temperature decreases. As there is continuous water transfer between oil and cellulose, equilibrium is difficult to reach. Most water in solid insulation is located in the coolest part, i.e. the bottom. It is important that the relative saturation of oil does not approach high levels at the lowest temperature that the transformer may be exposed to. Due to the load variation of an operating transformer, moisture levels in cellulose and oil change 24/7.

Benefits of On-Line Monitoring

On-line monitoring gives a true and real-time picture on the moisture levels in a transformer oil at all conditions the transformer is exposed.

On-line moisture monitoring can provide valuable information on transformers which have previously being identified having moisture problems, and also transformers which may have moisture issues that have not been detected by routine oil sampling. A common observation is that a single heavy overload-over temperature event can rapidly increase moisture in oil levels as moisture is driven from the cellulose.

The return of moisture to earlier levels may take a remarkably longer period of time.

Installation of the on-line moisture sensor is also beneficial with rather low moisture levels in transformers that have a higher increase rate of the carbons and a low DP value of the cellulose insulation, as these values indicate further possible degradation of the cellulose and therefore a further increase in the water concentration.

The moisture sensor will provide the transformer with enough operational safety margins. Moreover, based on the sensor's moisture readings (calculated as ppm) and the equilibrium moisture charts available, it is possible to estimate the water content in the cellulose insulation during the transformer operation. This would often demand an intelligent cooling system in order to maintain the temperature as constant as possible for the time period long enough to reach the moisture equilibrium state. There has been recently some literature published to evaluate the cellulose moisture also directly from the measured relative moisture saturation and temperature of oil.

Monitoring alone will not fix anything. It is the action taken based on monitoring which can result to condition improvement in the long run.

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