Maintenance of wet power transformers

Comparison of standard methods

and

Altmann´s method

Any standard maintenance of a wet power transformer is primarily focused on the decrease of the water content in the solid insulants and simultaneously at the the best possible improvement of its dielectric.

There are two basic maintenance methods:

- **the off-line** dehydration, degassing and , filtration of the oil filling of transformers
- **the on-line** dehydration, degassing and filtration

By the standard **off-line process,** the transfomer (Tx) is always shutted-down. The maintenance process can be performed by:

- **big vacuum units** (ABB-Micafil, Hering, Filtervac, Fluidex…) with the hydraulical power over 3000 l/hour, the oil is heated over 80 C and the vacuum is kept under 0.1 kPa, to accelerate the whole process and shorten the procedure as much as possible.

  Advantages : short procedure, good degassing of the oil filling, oil inventory of a Tx is not discharged.

  Disadvantages : very poor dehydration efficiency - only the water from the oil filling of a Tx can be removed, due very low diffusion flow of the water from cellulose materials where more as 95% water is deponed, the water content in the cellulose remains therefore basically the same as before.

- **Oil Spray method** : cellulose materials of a transformer are heated by jets of the hot oil (from internaly installed sprinklers), under high vacuum.

  Advantages : paper and other cellulose materials can be effectively dehydrated

  Disadvantages: the oil inventory of a transformer has to be discharged - high logistic costs (special high volume tank is necessary)

  for the installation of oil sprinklers must be the Tx be partially disassembled (the crane is necessary)

  high probability of an irreversible damage of aged insulants due high temperatures, high vaccum and dynamical stress caused by jets of the hot oil

  high danger of overdrying of cellulose and subsequently the loss of clamping forces

  high costs

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- **LFH method** (**L**ow **F**requency **H**eating) method – slow diffusion of the water from the cellulose is accelerated by the heating of the paper on HV and LV wires. The LFH process is performed under relatively high vacuum.

  Advantages : the paper on HV and LV wires can be very effectively dehydrated

  Disadvantages : the oil inventory of a transformer has to be discharged - special tank is always necessary

  only the paper on wires can be effectively dried

  another cellulose materials of a Tx as boards,. etc. cannot be effectively dehydrated (these materials represents usually more than 40% of cellulose materials in any Tx)

  high probability of an irreversible damage of aged insulants due high temperatures and high vaccum

  dangerous overdrying of cellulose and subsequently the loss of clamping forces

  high costs

The standard **on-line maintenance procedure** (dehydration, degassing, filtration) is performed by a small vacuum or absorbtion unit, permanently or long-term hydraulicaly connected with the oil filling) under normal operational conditions of a transformer.

- **Small vaccum units** : the oil is permanently removed from the oil inventory of a wet transformer, the humidity and gases are removed under high vacuum and high temperature and then is oil forced back in a transformer.

  Advantages : low purchase price

  easy installation and low operational costs

  celullose materials of a transformer are effectively dried without any additional stress

  the oil filling is not discharged

  Disadvantages : slow process

  continuous, undesirable and not-allowed removal of light fractions of the oil from the oil filling due to the long-term application of the high vacuum

  slow but undavoidable deterioration of the oil inventory due high vacuum and high temperature

  effectivity of the dehydration process cannot be effectively monitored and controlled

  overdying of cellulose insulants is not excluded

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- **absorption unit** the oil is permanently drained from the oil inventory of a wet transformer, the humidity is reduced by the absorption of the water at suitable absortion insert and the oil forced back in the transformer.

  Advantages: **low purchase price**

  easy installation

  all celullose materials of a transformer are effectively dried without any additional stress

  the oil filling is not discharged

  the oil can be partially reclaimed

  Disadvantages: slow dehydration process

  no degasing of the oil inventory

  high operational costs – *the capacity of the absorption insert is relatively small, the insert alone is relatively expensive and has to be routinely changed*

  effectivity of the dehydration process has to be effectively monitored and controlled, *precise measuring of the amount of removed water always means reading of input and output of water sensors + precise reading of throughflow of the oil*

  overdying of cellulose insulants and a subsequent lost of clamping forces is therefore not effectively excluded

  when the oil is partially reclaimed must be immediately re-inhibited due lost of natural inhibitors - *otherwise the very rapid ageing of the oil inventory is unavoidable*

  no effective remote control and corresponding feed-back to the client

Altmann´s Method of the Maintenance of wet transformers

- **Precise Diagnostics** - before beginning of any dehydration procedure the new a more precise diagnostics is performed and subsequently an exact scheduling of all maintenance steps and targets is adopted:

1) the on-line measuring of the relative humidity of the oil, temperatures of the Tx , inclusive the evaluation of the Tx equlibrium conditions is performed - SIMMS
2) potential measuring errors are evaluated (TRACONAL)
3) to avoid the overdying (TRACONAL), the maximal amount of the water which should be removed is roughly predicted
4) with regard to required minimal Ud-value at required operational temperature (TRACONAL) is predicted a minimal amount of the water which must be removed
5) with regard to maximal allowed water content in the oil at expected max. temp. of Tx the minimal amount of the removed water is predicted (TRACONAL).
6) the effect of particles in the oil is evaluated (TRACONAL)

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For the active part of the maintenantce of a wet transformer - it means for its dehydration, degassing and filtration, the vacuum separator VS-06 Climabox is used.

- **Vacuum separator VS- 06 Climabox -** the oil is permanently drained off the oil inventory of a wet transformer, the humidity, gases and particles are removed under a moderate vacuum and temperature and the oil is forced back in the transformer.

Advantages: easy installation

complex on-line maintenance of a transformer due simultaneous dehydration, degasing and filtration of the oil

low operational costs – no routine change of special cartidges

all celullose materials of a transformer are effectively dried without any additional stress

the oil filling is not discharged

no removal of light fractions from the oil filling

re-inhibition of the oil inventory is not necessary

no deterioration of the oil inventory due high vacuum and high temperature (only moderate vacuum and temperature is used)

effectivity of the dehydration process is (daily) monitored and controlled from remote by manufacturer and/or by client in situ

amount of the removed water is continuously measured and removed water is deponed in the external tank of dehydrator

precision of the measurement can be easy controlled and volumetrically verified

overdying of cellulose insulants is excluded by proper diagnostics, subsequent parametrical setting of dehydrator and continuous remote control

dehydration process can be easy optimized due permanent feed-back to the client

Disadvantage: slow dehydration process

higher purchase price

After the active maintenance is necessary the long-preservation of achieved parameters of a transformer . The corresponding, preventative maintenance is performed due TRAFOSEAL.

- **TRAFOSEAL** - the new, patented hermetization technology uses the transformer oil alone as a very effective sealing element. The cold – gas saturated contaminated oil in the conservator is separated from the hot oil in the main tank by a naturally created thermal stratification layer, which is created naturally in the TRAFOSEAL tank by the temperature difference between a cold and hot oil.

  This thermal stratification layer forms as a very thin horizontal, virtually undestructible natural membrane which seperates the hot oil in the upper half of the TRAFOSEAL tank,

and the cold oil in bottom part . This natural membrane is extremely effective at stopping the mixing of cold gas and water contaminated oil from the conservator, with the hot oil from the main tank.

Advantages : low purchase price

easy conversion of any free breathing transformer to a sealed one

no substantial modification of the main tank or the conservator is necessary.

elimination of oxygen and water vapour ingress

substantial decreasing of the oxidation and related ageing intensity of the cellulose (and oil)

significant prolongation the life of the transformer

no maintenance necessary.

no on-line check of the tightness necessary

Disadvanteges: none

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