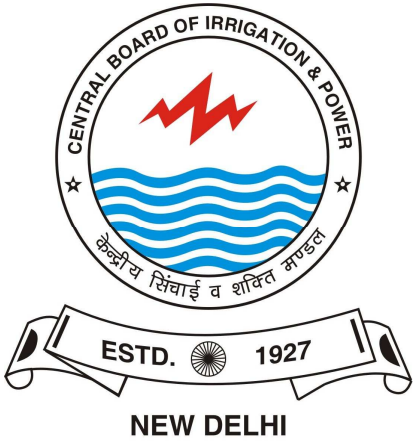


Conference on

Modern Technology trends in Power Transformers including OLTC, Bushings etc .

27-28 February 2019

CBIP Conference Hall, New Delhi

(Under the aegis of CIGRE NSC A2 on Transformers & A3 on HV Equipments)

Modern Trends in Upper End of Windings and Lead Exit Insulation Technology of HV Power Transformers , a Case study

Selim Yurekten, CIGRE Distinguished Member, TR Member IEEE
ENPAY Transformer Components

1-Insulation Quality

The hope, Life time of transformer > 50 years ? OK, but reality?!

This is limited to the life of its solid insulation, if all others are OK ?

According to statistic of CIGRE , about 50 % of major failures occur in the windings.

This reality will be understood better day by day.

Challenges and solutions ?

There are different opportunities to achieve limited aging of paper and insulating fluids.

All the first, insulation materials must be clean, without metal contamination.

But, in reality the chemical or X-Ray tests from pressboards showed on the contrary of it. Many samples collected from market were contaminated with iron dust. The dusts contaminate the oil in transformer.

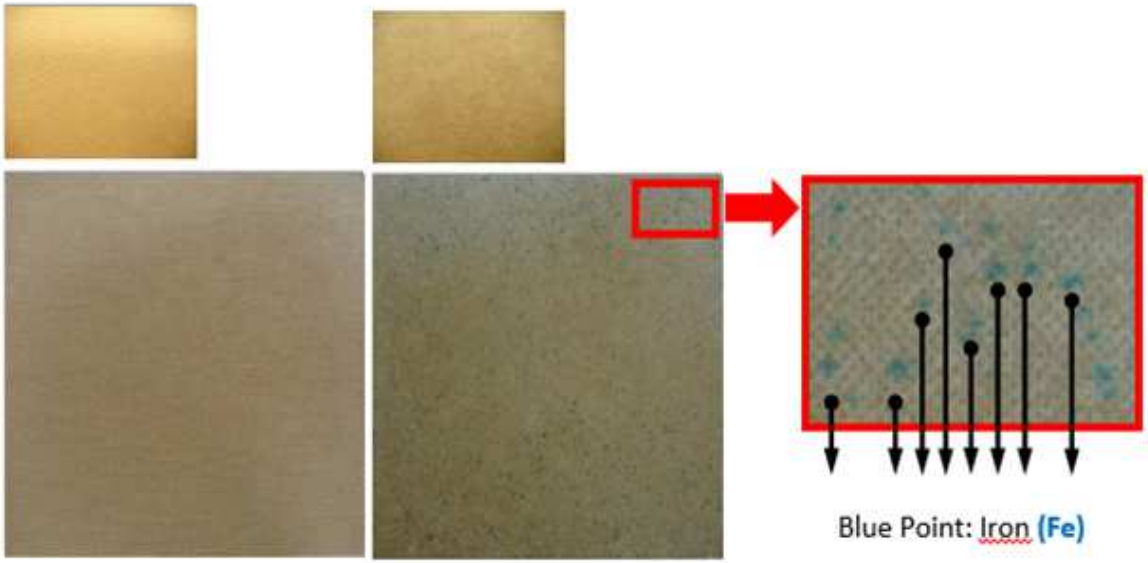
RESULT ?

Please don't forget that, The Major quantity of solid insulation in transformer are pressboards.

It will be not sure of the insulation quality in the transformer, if the following dark color of pressboard is used.

We are testing periodically, and have the detailed statistic from different producers.

Pressboard impurities CHEAP IS EXPENSIVE



Pure Pressboard Impure Pressboard Blue Points are Iron Particles

2- Application of pressboard in power transformers

Oil paper insulation in HV power transformers play a big role.

This insulation system is under regular loading from electrically, thermally and mechanically . So it is under increased ageing process.

The measurement result of the DP (degree of polymerization) value can show the ageing of the insulation. The places of the main insulation parts are :

between HV windings and LV windings, tank

between upper and under sides of windings and yoke

between windings and core

In the solid insulation system of the ends of windings are: angle ring/caps, snouts, clamping rings, spacers, strips, shield rings, lead exits.

Field strength analyzing is a precision work, that need an experience

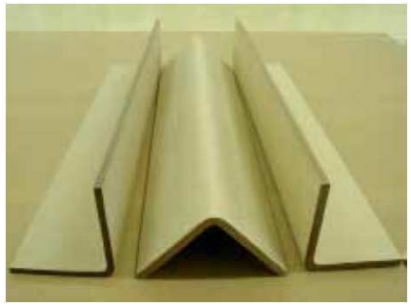
Different field strength, different geometry and thickness.

As temperature increases,. dielectric strength of most of solid insulation reduces.

Short circuits tend to compress the windings. The forces should distribute on clamping rings equally. Clamping rings used to clamp the windings







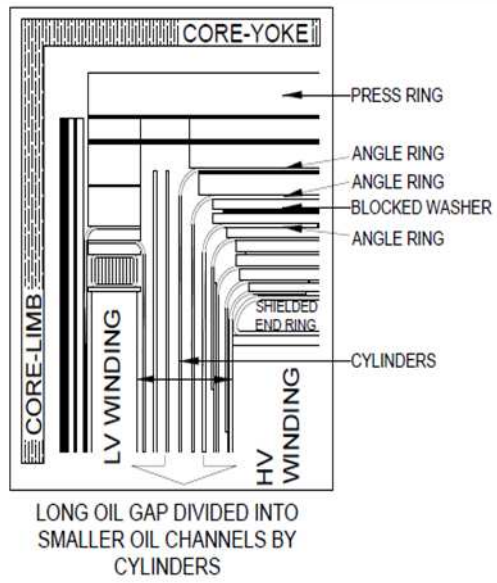

3- The End Insulation and Barrier Systems

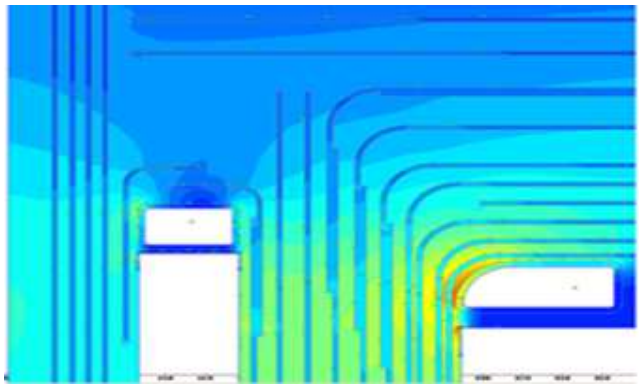
Insulation system is subject to Temperature and moisture, which affect to aging.

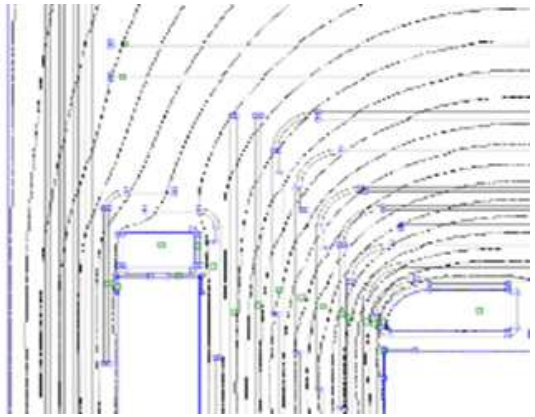
Most important and sensitive parts are the ends of HV windings (upper end especially), lead exit and bushings.

Dielectric design must be on the basis of the lightening impulse and switching impulse values.

The stress analysis of the oil gaps in modified design with safety margins is receivable from FEM program.







The geometries of the structures should be arranged to optimize the field stress distribution. Use FEM 2D-3D.

For subdividing large oil gaps in to smaller oil gaps are used molded pressboard insulation barriers. The barriers can obtain field conform structure.

In state of barrier system to use thick wrapped crepe paper has big disadvantages.

The pictures below shows some parts of upper insulation system

The end insulations are that of the winding ends from each other and winding to yoke.

The electric field at the winding edges and in lead area zone is quite non homogenous.

For optimal of the oil circulation in the windings and to have a high electric strength in the both end of windings the barriers must have effective design.

The barriers increase especially dielectric strength of the oil gaps by subdividing the gaps in to narrower sub-gaps.
The edge to edge distance of the windings plays a major role in the dielectric field distribution in these areas.
Unexpected change of dimensions affects the electrical stresses in this zone and might result in to higher partial discharge levels or even full break down in the life span of the transformer.

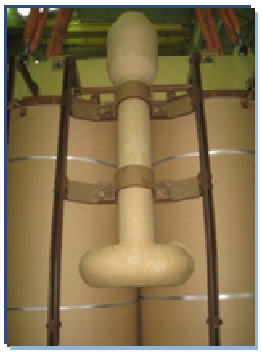
4-Lead Exits

Lead exits connect HV winding end in middle or upper end with the bottom of the bushing in an shield (electrode) .

The design of lead exit is little bit complicated.
There are different designs depend on winding ends.

The best technology for that is, to use a metal tube covered with wet molded cellulose and multiple pressboard barrier tubes, with vertical and horizontal supports.

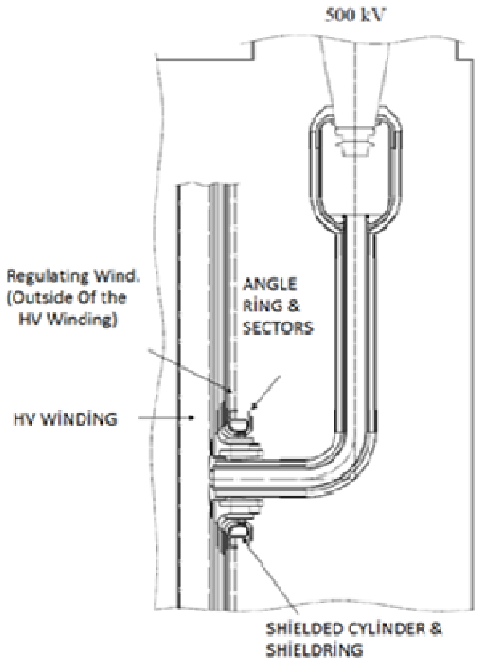
This is electrically better, safer solution using less amount of insulating oil and steel. Turret diameter will be smaller.



In lead exit units also instate of barriers, wrapping fully paper is unsafe, can age faster, because to much paper. Some body look for the easiest way.

But don't forget, In this way Cheap is expensive !
Lead exit assembly is a precision work.

Typical design of the Lead Exit which is going from mid of the winding.



It is not so easy to produce the electrodes (shields), because their surface must be very precis, and shine. Any roughness and burr in surface can disturb the electrical field.

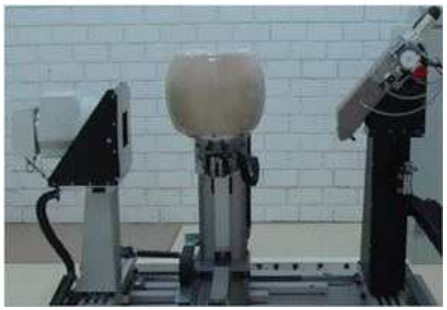
If not !

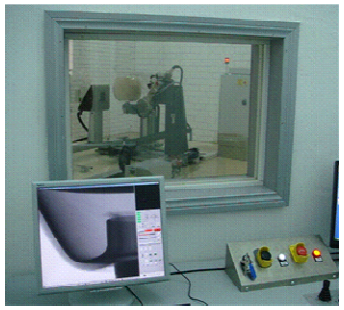
Even at the beginning you can have problem in HV lab, shortage , during impulse and HV testing .

In the following pictures are the X-RAY testing procedure after insulating with wet mold insulation .

Metal particles or air bubbles can be checked in computer screen , which disturb electrical field.

X-RAY lab is expensive investment, using mostly for development of proto-type products.





5-Case Study

General Information

Successful operation and life management (TLM) are depended on consequent surveillance and regular condition assessment (CA).

Main purpose of TLM and CA are:

Identify the withstand strength reductions by

- normal ageing,
- under destructive processes,
- under influence of air, moisture, contamination etc.
- under transient stresses

Operational stresses are

- Thermal conditions
- Dielectric
- Chemical changes
- Dynamic changes

On-line monitoring will become a essential warning system

Furthermore , **Maintenance** is a result of qualified functional diagnostic controls of windings, bushings, core and other components

The main ageing factors are (which affecting life of transformers)

- Moisture
- Temperature
- Air/oxygen
- Electrical stress
- Mechanical stress
- Insulation contamination

Most powerful ageing detection procedures

- Dissolved gas in oil analysis (DGA), acdg. to IEC/IEEE
- Oil parameter analysis
- Furane analysis

The short circuit in the network and due to leakage humidity entrance in the transformer is one of important cause of trouble for transformer.

Knowledge of transformer condition is essential for lowering the total cost of ownership.

Water content in transformers tends to increase with time.

Excessive moisture in the main insulation of transformer can also lead to significant reductions of dielectric strength and reduction of partial discharge inception voltage, (CIGRE).

The most powerful diagnostics are DGA, Oil value Analysis and Furans.

The main Data of defected transformer:

3 Ph/ 10,5 kV/400 kV/125 MVA, Gen-Transformer was operation for 30 years.

This is second fault of this transformer.

The upper insulation of HV windings, lead exit and bushing faulted completely.

Lead exit system was special bellows type with drip proof seal.

Major reason of insulation breakdown was (PD) partial discharge.

Due to leakage from drip proof seal and bellows comes moisture from outside.

Particularly the connecting and sealing part need high attention and experience.

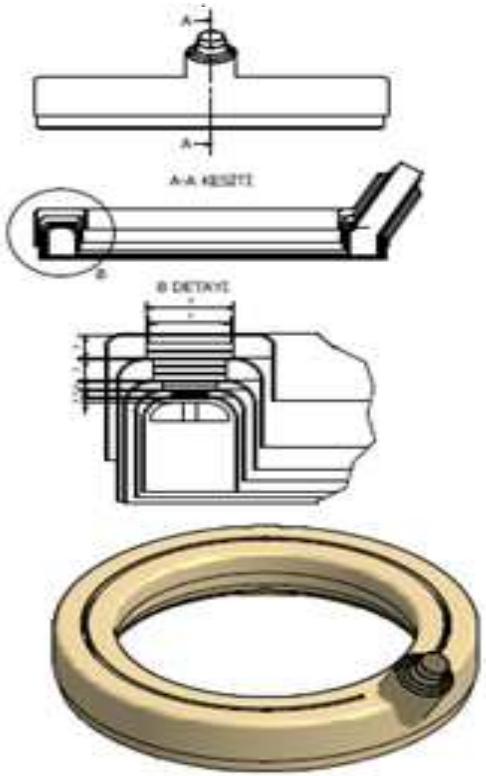
In the new version the type of lead exit is changed, economical solution.

The detailed Inspection Findings ,Designing and Refurbishment Activity

The pictures below shows the defected parts, some of them were burned completely.

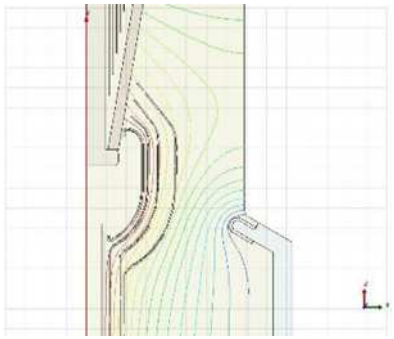
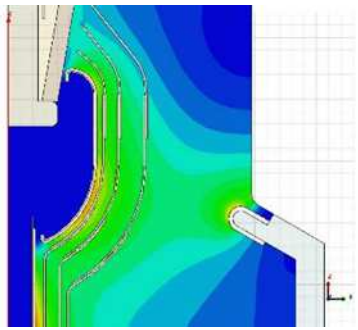
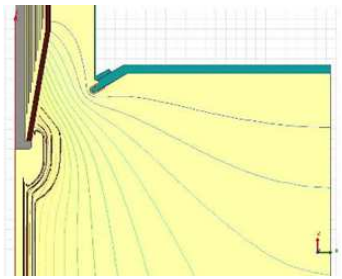
The bushings were also faulted and changed with new units.

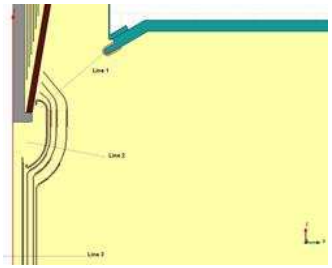
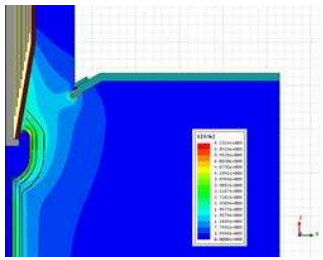
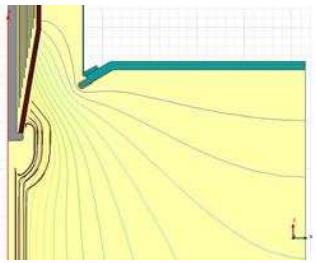


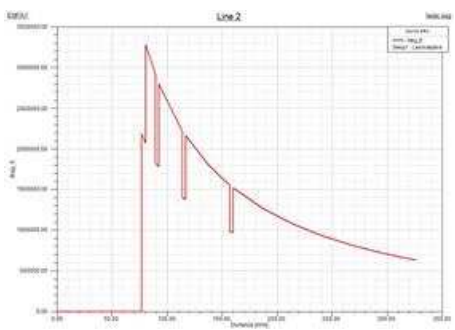


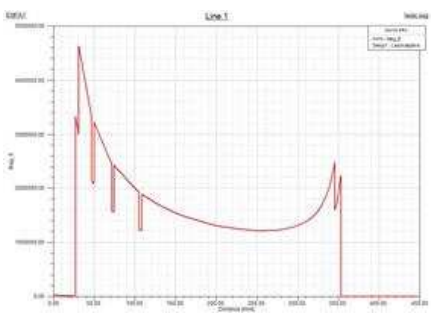
The new design of lead exit started to analyze the dielectric fields.
It is used the FEM program .

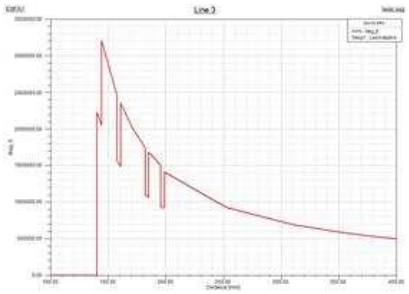




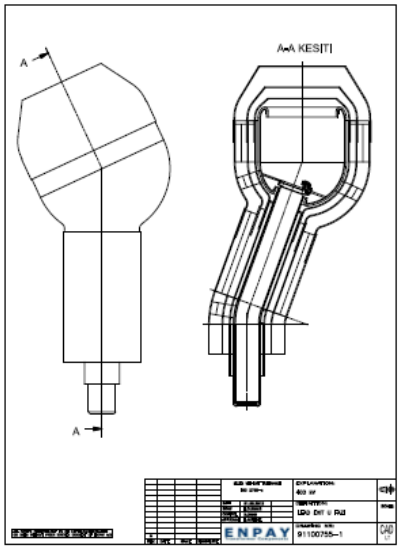




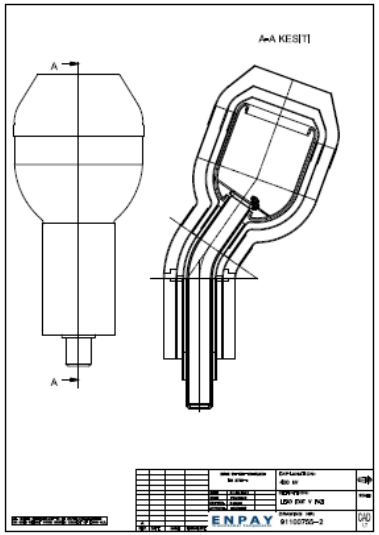

After FEM 2D electrical field calculation, the design of lead exit can be realize. According new instruction of Grid, the Bellows were not used. For all 3 phases designed separately.

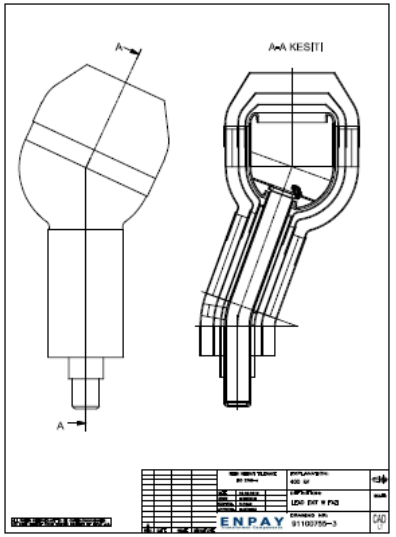






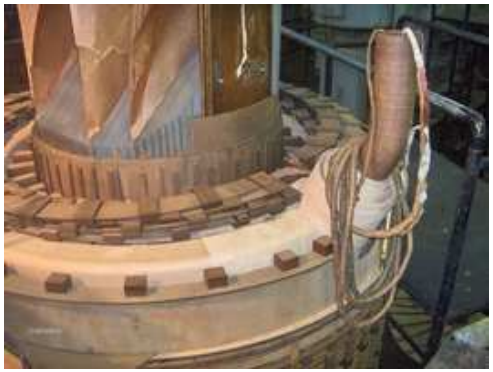


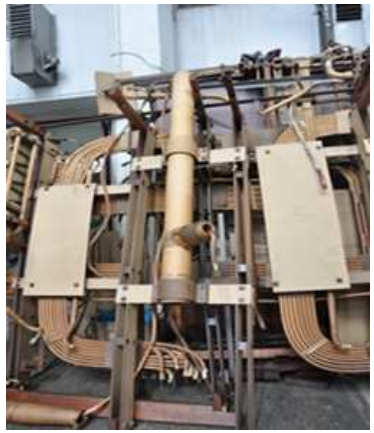




The pictures below shows end montage of the new insulations system.

After testing of the transformer putted in operation.



6-Conclusion

Reliability is a key word for HV power transformers.

If the life of transformers is limited to the life of its solid insulations, so we must use a good quality material and successful engineering in winding technology.

The upper end and lead exit of HV windings are very risky parts. FEM models 2D-3D can find best design solution for these parts.

Pls.do not forget, the more paper in active part, the sooner aging occurs.

Due to its hygroscopic nature paper can carry a lot of moisture.

Instate of Barrier system, to use thick wrapped thin kaft or crepe paper absorb more moisture, cause in shorter time aging.

In the case study of a faulted 420 kV, 125 MVA Generator transformer gives detailed information about new design of upper part insulation and lead exit.

The type of lead exit and upper insulation parts were completely changed.

Thank You For YOUR Attentions