COMBINED INSULATION BUSHING

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INTRODUCTION

One of the major current trends in the transformer industry is dry bushing insulating technologies, combined with silicon outer insulators to provide the safest service conditions.

STATE OF THE ART

A conventional non-condenser core bushing in lower-voltage voltage range is typically composed of a conductor bolt (usually brass or copper), a porcelain insulating part and oil as the primary insulation. These so-called conventional porcelain bushings are low-cost components in comparison to the valuable assets in which they are used. Bushing failure – after either an internal breakdown in the main transformer unit (bushing then acts like an exploding "plug") or an internal bushing failure – can have dramatic consequences not only for the transformer itself, but also for its immediate surroundings. Shattered porcelain projectiles are likely to cause secondary damage to other equipment or any human presence in the vicinity. Additionally, after such a dramatic failure, the insulating oil spreads out in small droplets, and combined with a secondary arcing can easily ignite and caused further collateral damage. Atmospheric contamination build-up on electrical apparatus generated from industrial plants contribute heavily to black-outs and brown-outs. This contamination builds up on insulators and bushings. Depending on the resistance values associated with said contamination, tracking, and in extreme circumstances, arcing takes place usually during periods of light to moderate rainfall. When this contamination make a bridge of conductive material over your porcelain non-conductor (insulator) the high voltage electricity finds a path to ground (phase-to-ground fault) resulting in a number of possible inconveniences for your firm including, but not limited to: insulator explosion, insulator etching, insulator chipping, circuit-trip, exposed live-lines, damage to transformers and breakers, loss of production, injury to personnel, exposure to electrocution risks to personnel, expensive and time-consuming repairs, and fires. [1]

Picture 1 Conventional porcelain bushing

SILICON RUBBER: A BETTER OPTION

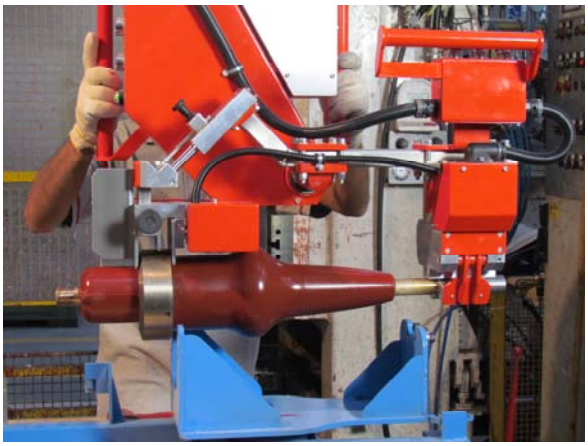
Silicone rubber has been in use as outdoor insulation for suspension insulator and in other applications from more than 25 years. Today silicone rubber is the most used polymeric material for medium and high voltage outdoor insulator.

The need for cleaning the insulator is almost eliminated when using silicon rubber. Porcelain, on the other hand, might have to be cleaned more often in medium polluted areas as well. The leakage current level along the insulator is very low compared to porcelain. A typical value for porcelain is 10 mA and for silicone < 1 mA. This property also reduces the risk for flash-overs and thus increases the reliability of the product and eliminates the disturbances in the power grid resulting from such events. [2]

Picture 2 (Silicon rubber)

EPOXY RESIN: HIGH PERFORMANCES

Epoxy resin is well reputed in electro technical field since 40 years. It is a special insulating material that can be shaped according to specific need and use. Thanks to its electrical features in the past years it has been used for bushings for both transformers and switchgear applications. Resin material is also having excellent dielectric and mechanical properties. Thanks to the perfect molding performance, the epoxy resin became the perfect solution to in globe electrical screen.



Picture 3 (Epoxy resin)

THE PERFECT COMBINATION OF HIGH PERFORMANCES INSULATION MATERIALS

Today the combined insulation bushing can provide the needed performances.
Maximizing cast resin and silicon rubber now-how, we have been developing a new highly performing insulation bushing.

While start our project we have been focusing on the weakest performances of a convention porcelain bushing, which are:

- Weakness insulation material
- High maintenance
- Low partial discharge level
- Leakages
- Poor prevention of vandalism act
- Explosion risk
- Low creepage distance
- High tolerances
- Poor thermal performances

Our challenge was to minimize all these poor performances in a new high performing bushing.
We have been combining our know how in 50 years of experience in the transformer components.
The epoxy resin was the best option for the core. This was immediately evaluated for the following aspects:

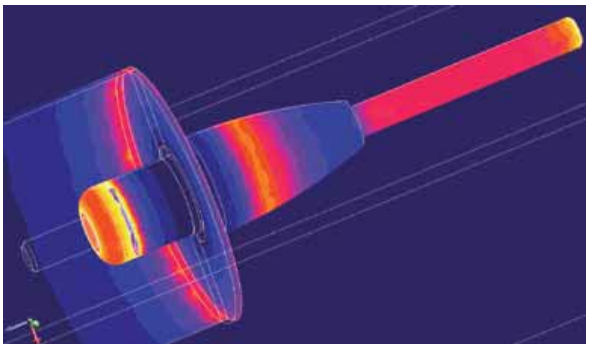
- Easy to shape
- Enabling to insert a simple cylinder electrical screen (to grant a low partial discharge level)
- Good insulation level
- High prevention of oil leakages

The silicone rubber was the best option for the housing for the following reasons:

- Thanks to the simple shaping, the creepage distance can be designed much higher
- Non fragmental material
- Self-cleaning
- High prevention of vandalism act
- Minimizing the risk of explosion
- Reduced tolerances thank to the molding process

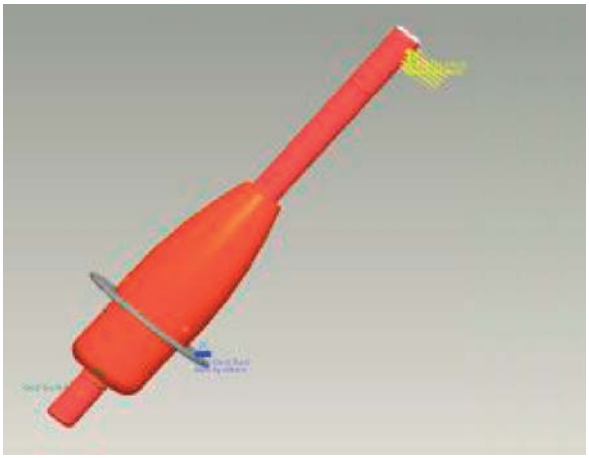
It was a matter of evidence that the combination of the here above describe insulating material was the solution of the poor porcelain insulation bushing performances.

We immediately start with the distribution of the electrical field evaluation in order to design the electrical screen.

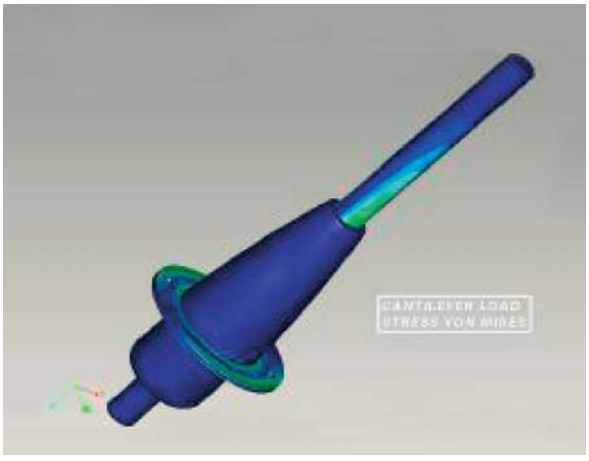


Picture no. 4 - Fem 3D electrical field

Having design the perfect electrical screen, we were ready to start with mechanical design using a 3D FEM analysis.



Picture no. 5 (Load point and fixations)



Picture no. 6 (Results)

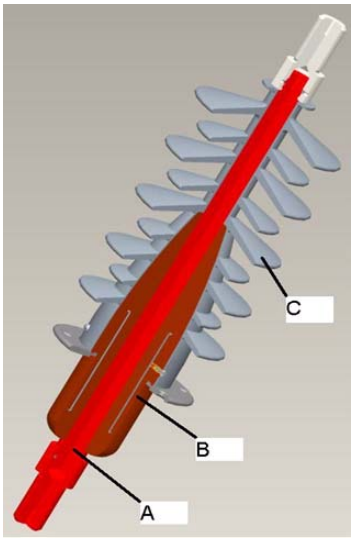
At this stage our bushing was shaped and our project was ready to because a prototype ready for all testing approval. We performed successfully all tests required by international standard IEC 60137.

The risk for transport damage is almost eliminated as well. The safety of personnel is increased due to the non shattering material in the case of an unexpected failure on site.

This bushing has its conductor directly molded in a primary organic resin insulation layer, which is in turn protected by a shed-formed silicone rubber overcoat. This unique combination of insulation layers eliminates shattered bushing fragments (no porcelain) and drastically reduces the risk of fire (no oil), greatly mitigating the risk of collateral damage after failure, while also providing excellent insulation properties in harsh environments (silicone rubber housing).

A COMPLETE FAMILY OF BUSHINGS

The new bushing consists of a full range of standardized transformer bushings up to 72.5 kV AC applications, up to 6300 A , with a level of partial discharges meeting the IEC60137 and IEEE C57.19.01-2000 and IEEE C57.19.00-2004 standard specifications thanks to an embedded internal capacitance screen. With its exclusive combination of superior materials and robust construction, this bushing addresses modern insulation requirements while simultaneously providing a safer and easier solution for handling, transporting and assembling bushing units.



Picture 7 (CRS construction)

A. Copper conductor

B. Primary insulation core (epoxy resin) with embedded electrical shield
C. Outer insulation layer (silicone rubber sheds)

Picture 8 Combined insulation bushing CRS type

REFERENCES

For a paper citation:

[1] Optimized use of HV composite apparatus insulators: field experience from coastal and inland test stations Cigré conference - Session 2004

[2] Comparision between porcelain and silicone rubber for use as outdoor insulation on high voltage bushings ABB Power Technology Products AB Components