MANAGEMENT AND EASY COMMUNICATION OF TEMPERATURE RISE ON DISTRIBUTION CAST RESIN TRANSFORMERS CONNECTIONS LINKED TO NETWORK DURING THE LIFE OF TRANSFORMER AND/OR AFTER INSTALLATION

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ABSTRACT

This paper describes the monitoring of distribution cast resin transformers with wireless sensors (self supplied) to prevent electrical failure due to lack of maintenance, screws loosening due to vibration, on the LV/MV connection terminals as well as MV tapping connections.

INTRODUCTION

Nowadays, management of electrical equipment outage is becoming more and more important, especially for electrical distribution equipment involved in critical processes (Transformers, Switchgear, Breaker, Motor, and HVAC ...). The transformers being a key product of the electrical distribution, its outage represents a severe impact for end-users. Consequently, an adapted maintenance plan considering their lifespan becomes an essential need for most of customers.

The main causes of a transformer outage are electrical breakdown and thermal aging. Electrical breakdown can be due to external phenomena or be a consequence of loose connection terminal. Beyond, this thermal effect can impact interface parts, as bushings connection, connection links, cables pad terminal, cables ..., leading to important electrical failures.

The aging is due to the long term thermal effect on insulating material, which can be accelerated in abnormal operating conditions (e.g.; overheating, overloading, high transitory phenomena...) or if installation recommendation instructions are not respected (e.g.; bad local cooling, high ambient temperature ...).

The repartition of distribution cast resin transformers failures modes can be divided in two main families:

- Non Predictable failures (Mainly due to electrical disturbance and lightning)
- Predictable and preventable failures (Mainly due to insulation deterioration, windings thermal effect, connection thermal effect).

In the predictable and preventable failure modes, loose connection screws, inadequate or lacks of maintenance, are issues which lead to thermal hot spots and could be detected before failure by measuring critical parts of the equipment. This kind of defect can lead to failures which mainly occur on the first period of transformer exploitation (Fig. 1).

Insulation deterioration is due to thermal aging depending on various parameters such as transformer load, unbalanced voltage, harmonics, high ambient temperature, bad cooling, ... These severe operation conditions which impacting directly the insulation are reducing the transformer lifetime and can lead to electrical failure after several years of exploitation. This impact could be estimated by monitoring the windings hot spot temperatures coupled to a SCADA and an aging algorithm computing lifespan. (Fig 2)
This digitization century is pushing for smart connected systems demand, and in the next coming years the phenomenon will grow more and more. Consequently, a smart solution, easy to use, easy to install, which predict and prevent failures due to thermal effect will respond to these digital demands.

In the past, these measurements using wired sensors and acquisition devices wired were a real roadblock to massive monitoring deployment on distribution small transformers. Mainly due to the high installation costs but also because of the electrical risks generated by the presence of medium voltage near the installed sensors.

A self supplied wireless technology is now available to reduce these installation and electrical risk constraints. This sensor allows deployment of versatile solution adapted to customer digitisation requests for the temperature monitoring:

- These sensors wireless (Fig 3 [1]) can be placed directly on active-part or interface parts (as well as, on low and medium voltage connection).
- These sensors are self-supplied by the transformer current crossing.

With the benefit of is small sized sensors and technology (30x30mm, wireless, self supplied and ZigBee) we can now be easily in direct contact with the conductive parts. The assembly electrical risks on the MV side (difference of potential, creepage distance, insulation distance because of wiring crossing) are suppressed and installation costs reduced, enabling an easy to install solution. With the self-supplied, wireless and ZigBee solution enabling an easy to use, its data’s acquisition system could be connected to any network and customers can observe and analyze in real time the information of all his electrical equipments, at the same time and from one location.

**Figure 3**: Self supplied thermal sensors installed on the transformer medium side.

This sensor has been tested up to 5500 A, in addition of the EMC tests, and for a dielectric withstand up to 50 kV for applied voltage test at industrial frequency and 125 kV for the impulse test [2].

**BENEFITS FOR CUSTOMER**
- Digitization solution in 3 simple steps (Fig 4).
  1. Easy to measure,
  2. Easy to connect,
  3. Easy to monitor.

**Figure 4**: Versatile communication scheme.
- Reduce the outage risk due to connection ,
- Monitor behavior and performance deviation,
- Reduce the OPEX (scheduled maintenance),
- Ensure predictive alerts on smart phone (SMS, @mail),
- Increase and optimize the capacity use of transformer,
- Manage CAPEX (forecast provision for technical risks),

Reduce and manage downtime to decrease the CAPEX and OPEX using connected sensor's linked to a condition monitoring (local or network) for cast resin distribution.
transformers is today a reality.

Up to now, end users were notified about an electrical connection failure when they were facing an outage. With connected wireless sensors and appropriate settings, a system of alerts could be developed (algorithm) to fix an abnormal behaviour detected, consequently, customers could act and solve the problem before failure of devices.

This smart solution easy to install and easy to use can be implemented on new purchased transformers (sensors assembled during the manufacture time. As well as, on the transformers already under operation (full installed transformers fleet) because of the light installation work:

- wireless sensors (no need of heavy installation),
- no important installation modification (no need of new cables),
- ZigBee communication protocol,
- Sensor powered by transformer itself,
- Easy to install (max 2h transformer shutdown),
- On demand a simplified solution with SMS or @mail alerting on smart phone (end users, facility managers, ...) is available,
- On demand an ambitious solution with SCADA/RTU/HMI (Fig 6) architecture for a local or on line monitoring managed by end users or manufacturer can be designed.

NEXT STEPS OF THIS TECHNOLOGY

Other sensors could be added to current above model in order to manage aging monitoring (Fig 6) of cast resin transformer and predict maintenance or failures. The manufacturer knowhow and his expertise are the added value which can improve smart solutions by elaborating specific algorithm and dedicated solutions when full digitised system are requested.

- Ambient temperature sensor (wireless, zigbee),
- Current transformer on the LV side (wireless, zigbee and self-supplied) as well easy to install.
- A SCADA mode including the manufacturer added value based on his expertise and patented algorithm.

The main aging root causes are listed in the above chapter (page 1) and will lead to the insulation deterioration with at the end the transformer failure. So to prevent such thermal effect the condition monitoring for cast resin distribution transformers will be the appropriate solution.

Their installation considered as the above ambitious one vs the simplified (page 2) is requesting more expertise because of the architecture to be designed and algorithm setting needed. Therefore such solution is specifically under the manufacturer engineer supervision.

REFERENCES

[1] P.Brun, V.Ferraro 2015, Evolution of control and monitoring functions will lead to more embedded electronics within switchboards, MATPOST Lyon, N°0010.