Diagnostic control of oilpaper insulation based on method of “direct” measurement of paper moisture content

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Moisture of oil-paper insulation and primarily of paper represents one of the major parameters that characterize condition of high voltage oil-filled electrical equipment (HV OF electrical equipment). While in operation of HV OF electrical equipment, there is a gradual increase of moisture content of oil-paper insulation. As a result, physical and chemical processes of oil-paper insulation degradation speed up. This lowers its dielectric strength which inevitable leads to a breakup and equipment failure. That is why, moisture control of oil-paper insulation is essential for a reliable operation of HV OF electrical equipment.

Lately, requirements for a maximum moisture value of oil-paper insulation were tighten. It is believed that relative moisture content of oil-paper insulation W_r is not to be over 2%, while it was not until fairly recently that allowable value of oil-paper insulation measured value was 4%. It is worth noting that while decreasing the value of measured variable, requirements for measuring equipment grow, in particular for measurement errors.

It is possible to receive quite reliable data of oil-paper insulation moisture content analyzing response of transformer insulation to multi frequent electric potential pilot impulses. Hoverer, these methods based on ratio of dielectric permeability of oil-paper insulation vs. moisture content may be applied exclusively on the equipment taken out of service. Despite the fact that the rate of oil-paper insulation moisturization is usually quite low, the content of moisture in it may exceed critical level in time between overhauls. Therefore, the most effective method of a timely detection of oil-paper insulation moisturization is permanent moisture control.

Current tools for on-line monitoring of oil-paper insulation measure relative moisturization of dielectric oil. Generally, using it, it is possible to determine moisture content of oil-paper insulation itself. Yet, this method may result in large errors that derive from sophisticated and poorly studied nature of moisture exchange processes between oil transformer and cellulosic materials.

The report represents the development results of device for on-line monitoring of moisture content that measures “directly” moisture content in OPI. The device consists of moisture sensor (MS) and adapter unit (AU). The MS measuring unit is a capacitor submerged into AU with a moisture-sensitive element (MSE) being electrical pressboard. The measurement of MSE capacitance is proportional to measurement of its moisture. The sensor’ design is

executed so that conditions of moisture accumulation in OPI and in MSE were the same. The measurement results of the device for on-line monitoring do not depend on oil transformer.
The adapter unit set in a control cabinet of HV OF electrical equipment or in an automated process control system reads the current information from MS and transfers the measurement results to the upper control level in two independent interfaces: *RS-485* and *Ethernet* that implement protocols *IEC 60870-5-101* and *IEC 60870-5-104*. Allowable connection to an AU is up to 16 MS. The main characteristics of the device for on-line monitoring: operation temperature – up to +90°C, error of moisture measurement (mass) – 0.5%, mean time to failure – 80 000h. MS measures simultaneously the MSE temperature which allows a temperature correction of capacitance value.
The report describes a method to calibrate MS and presents results of its laboratory trials.
Optimal topological schemes of MS installation depending on transformer types are discussed to receive extensive data on OPI condition.