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Improvement of Insulation for Rotating Machine by Dry Ice Method

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Abstract

This paper presents the improvement of rotating machine insulation by the powerful blast-cleaning, dry ice method. In this work, the large synchronous generator, 16.25 MVA 6.9 kV and 78,240 running hour, was investigated and analyzed. The characteristic of insulation such as polarization and depolarization current (PDC), polarization index (PI) and dielectric loss tangent (tan δ) were measured according to the IEEE standard 43-2013. After cleaning with dry ice blasting, the insulation of generator has improved remarkably. The charging current is decreased due to removal of conductive layers from the insulation surface. For other parameters, polarization index and loss tangent are increased 52.03% and decreased 11.66% respectively. Furthermore, the operation time of dry ice method is very short when compared with traditional cleaning methods, resulting in reduced maintenance downtime and increased more productivity.

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Keywords: rotating machine; dry ice method; polarization and depolarization current; polarization index; dielectric loss tangent

1. Introduction [1,2]

The insulation is an important part of electrical machine; especially rotating machines are used in heavy industries such as power plants, cement plants and petrochemical plants. These machines operate in closed and restricted areas; high temperature, high relative humidity and high pollution level. The deposited of contaminant creates the conductive layer on winding insulation and decreases insulation distances. The enhancement of electric field is occurred around this layer and can lead to insulation failure by partial discharge (PD) or insulation breakdown. Some pollutants, dust and oil, may block the ventilation path that result in an increment of machine

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temperature. Those of them reduce efficiency of the electrical rotating machinery. In order to mitigate the problems of rotating machine, cleaning is the most important maintenance that can be done. There are several methods for cleaning rotating machine such as abrasive blasting, soda blasting, high pressure water blasting, solvent cleaning, and so on. These methods are laborious, toxic and time consuming. Therefore, a new cleaning method call dry ice blasting has been introduced.

2. Background

2.1. Dry ice method [3, 4]

Dry ice blasting is a cleaning technology used to remove contaminants such as adhesives, varnish, oil, grease, and dust on metal, semiconductor and insulator surface. This method is accelerated the dry ice pellet in a pressurized air stream to impact a surface to be cleaned. The cold temperature of dry ice, about -79 °C, freezes contaminant and cause it to crack and loosen from the surface. After that the dry ice pellets dissolve into carbon dioxide (CO_2). Therefore, it does not generate any secondary waste that saves additional cleanup labor and expense. Furthermore, dry ice is non-abrasive, non-flammable and nonconductive then it will not damage the machine surface and can be safety used on energized machine.

2.2. Insulation characteristic [5-9]

Typically, several characteristics of insulation material can be used to evaluate the condition of electrical rotating machine. In this work, we use three important characteristics to assess the insulation of rotating machine; polarization and depolarization current (PDC), polarization index (PI) and dielectric loss tangent (tan δ).

2.2.1. Polarization and depolarization current (PDC)

When a DC voltage is applied to the insulation, molecules of insulation will align themselves to the electric field. The current flowing through the insulation during this period is called polarization current. If the DC voltage is removed by a proper circuit, the molecules of insulation will return to their normal state and the current discharge from the insulator is called de-polarization. These currents are influenced by the properties of the insulation material as well as by the geometric structure of the insulating system. The time constant and curve shape of each current are related to ageing and life consumption of machine. The equation of polarization current is shown in the following,

$$I_{polarization}(t) = C_0 U_0 \left[\frac{\sigma_0}{\varepsilon_0} + \varepsilon_\infty \delta(t) + f(t) \right] \tag{1}$$

where C_0 is geometrical capacitance of test object, U_0 is charging voltage, σ_0 is dc conductivity of the test object, ε_0 is vacuum permittivity, ε_∞ is high frequency component of the permittivity, $\delta(t)$ is the difference between the time from apply voltage at $t = t_0$, and $f(t)$ is function response of dielectric material in time.

Depolarization current can be shown as in Eq. 2.

$$I_{de-polarization}(t) = -C_0 U_0 \left[f(t) - f(t - t_c) \right] \tag{2}$$

where t_c is period of time applying DC to test object, 1020 s in this work.

2.2.2. Polarization index (PI)

The value of polarization index can be defined as the ratio of 10 minutes resistance value (IR_{10}) to 1 minute resistance value (IR_1) as shown in Eq. 3.

$$PI = \frac{IR_{10}}{IR_1} \tag{3}$$

The polarization index is one of parameters which can be used to determine the contamination level of machine winding from oil, dirt or soaked with water.

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