A Study on Locations of Electrical Discharge in a Motor

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1. Introduction

In modern automobiles, the ratio of the electric motors used has been increasing every year. Therefore, it is important to produce motors with high quality in automobile manufacturing [1]-[2]. The quality of the motors depends on insulation characteristics of the stator coil of motors and the strict insulation test has been conducted during the manufacturing process of the stator. However, this test cannot show the defect point of the insulation and so it is difficult to reuse the stator by repair. If we could know the insulation defect point, the stator can be reused by minor repair and the productivity can be much improved.

In a large scaled motor for a power plant, the electrical partial discharge due to the insulation defect at the stator coil has been monitored by non-wired measuring systems [3]-[4]. However, this is the monitoring system whether the motor works normally or not. This is not used to predict the location of the electric partial discharge point.

In this paper, we propose the measuring system to predict the insulation defect point due to electric partial discharge. In section two, the measuring system is described and in section three, measuring results to predict the location of the electric partial discharge will be shown. Section four is concluded with major remarks.

2. Measuring method of the electrical partial discharge in a stator of a motor

Fig.1 shows the structure of the stator with coordinate system. Also, table1 shows the major specification of the stator. The stator consists with star connection, distributed winding, insulating paper and varnish in the slots. The stator core is made of laminated magnetic steels formed with a number of slots. Stator size is outer diameter 260mm, inside diameter 200mm with a thickness of 100mm. A formed rectangular wire is coated with enamel film. In addition, stator core edges cause defect of enamel and insulating paper when the rectangular wires are inserted. Therefore, it is highly likely that the insulation defect occurs at the edge of the stator core. However, it is difficult to find damage of the enamel film and the insulating paper. Then, we choose measurement of electromagnetic radiation caused by partial discharge at defects. The insulation defect location was artificially made at the position of z of +50mm and direction \( \phi \) of 180° that corresponds to the edge of the stator core.

In order to cause partial discharge, peel off enamel film of enameled wire; the enamel wire conductor is exposed from the insulating paper. This sample is not short-circuited between the stator core and the coil. Fig.2 shows the measurement method. A shielded loop antenna measures range 5MHz-1000MHz of the frequency by using Anritsu’s EMI probe MA2601 B. A digital oscilloscope is Tektronix's
DPO4104. Applied voltage was measured with the oscilloscope by using a high voltage probe of 1000:1. The antenna is terminated with 50Ω at input point of the oscilloscope. The shielded loop is placed in close proximity of the inside horizontally and vertically. The coordinate origin is a center of the stator. The stator can be rotated in the direction of φ. The between the shielded loop antenna and the stator core is 10mm.

3. Measurement results

The shielded loop antenna defects electromagnetic radiation. The sampling rate of the oscilloscope is 5GS/s. Fig.3 shows the frequency spectrum obtained by Fourier transform of the measured time-domain waveforms.

The average frequency spectrum is shown in Fig.3. We can see that the electric discharge peak of this stator presents in 30–180 MHz. Higher sampling rate results in long time data processing. In order to raise productivity, it is necessary to lower a sampling rate, here we chose the sampling rates of 100 MS/s that it is possible to acquire dominant spectrum around 30MHz.

Applied voltage Ve is normalized by the maximum value; this is express in arbitrary unit. Fig.4 shows receiving voltage of antenna as a function of φ in terms of applied voltage. The antenna load voltage is an average of maximum voltage among ten times measurement. The sign ○ shows the receiving voltage for horizontal antenna arrangement. And, the solid line shows the average value of the voltage for each angle. On the other hand, the sign △ shows the results for vertical arrangement and the dotted line shows the average value.

Fig.4 (b) shows the first peak is 52mV at φ of 180° and then value is about 2.5 times larger than the second peak of 21mV at φ of 270°. On the other hand, there is no dominant peak in the case of vertical arrangement.

There is no dominant peak in Fig.4 (a). Because applied voltage is lower than PDIV (partial discharge inception voltage) as shown in Fig.5.

Fig.5 shows a measurement of the amount of the electrical discharge charge of the stator sample. The amount of the electrical discharge shows a sharp increase at applied voltage of Ve=0.74(arb. unit). In addition, the discharge intensity shows second increase at Ve=1.0(arb. unit). We can see that the maximum peak in Fig.4 (b) with φ of 180° is agree at PDIV. These results confirmed that we can detect the electrical discharge of location of the insulation defect at apply voltage of PDIV.

Furthermore, Fig.4 (c),(d) have no dominant peak. However, we can find a peak from average value. From these results we can conclude that location of defect is available by applying equal to or higher voltage than PDIV.

4. Conclusion

This paper investigated the possibility of the insulation defect location of a stator by detection of electromagnetic wave. Sinusoidal voltage with 50Hz is applied between the stator and stator cores. And, the maximum antenna load voltage was measured. We have confirmed the following two results,

(1) The electrical discharge of location of insulation defect can be estimated in the applied voltage of PDIV. Detection of electrical discharge location is possible in applied voltage higher than PDIV by exploiting frequency of detected voltage.

(2) Our experimental results, confirmed that the detection accuracy of the insulation defect location depends on polarization of a shielded loop antenna.
References

Table 1: Stator specifications.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Phase Number</td>
<td>3</td>
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<tr>
<td>Outside Diameter</td>
<td>260 mm</td>
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<tr>
<td>Inside Diameter</td>
<td>200 mm</td>
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<tr>
<td>Stator Thickness</td>
<td>100 mm</td>
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<tr>
<td>Winding</td>
<td>Distributed</td>
</tr>
<tr>
<td>Stator Coil</td>
<td>Rectangular Wire</td>
</tr>
<tr>
<td>Location of Insulation Defect</td>
<td>( \phi = 180^\circ )</td>
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</tbody>
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Figure 1: Geometry of the stator.

Figure 2: Measurement system of the stator.

Figure 3: Frequency spectrum of discharge.
Figure 4: Receiving voltage in the antenna load.

Figure 5: Discharge intensity of characteristics.