Measurement of magnetic characteristics of traction motors at driving

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The issues for a traction motor of HV, EV are miniaturization, low cost, and low loss. The volume of the motor has been miniaturized by such as high rotation, oil cooling, utilization of flat wires, and high voltage. In order to reduce the cost of the motor, reduction of the use of rare earth elements, which are high-cost materials, was mainly involved. Examples include reducing the amount of magnets by using reluctance torque, and reducing the use of heavy rare earth elements by using grain boundary diffusion magnets. The loss of the motor has been reduced by thinning an electromagnetic steel sheet and increasing the electrical resistance of the sheet. The characteristic of the traction force of a car is that high torque at the time of start (low speed range) and high-speed driving are compatible, and the area used frequently is in the medium speed range. A traction motor often requires a wide operating range, since they cover the entire operating range without a transmission. Furthermore, in a traction motor, it is important to reduce the loss in the medium speed range. In order to reduce the loss in the medium speed range, it is necessary to reduce the iron loss as well as the copper loss. Iron loss generated in the sheet of the motor core is caused by magnetic flux fluctuation in the sheet. The causes of the magnetic flux fluctuation include the arrangement of coils, current harmonic components due to switching operation of an inverter, and changes in magnetic resistance due to the rotation of the rotor. On the other hand, iron loss changes in the state of the sheet also . The difference in the grade of the sheet, the stress applied to the sheet, etc. cause the difference in iron loss. In low loss motor design, it is important to clarify the above factors of iron loss change and incorporate them into the motor design. Our motivation to measure iron loss is to design a low loss motor.

Iron loss measurement is done by reproducing the condition with test pieces. We also measure iron loss in test pieces, which is important. On the other hand, it has not been clarified yet to what extent iron loss measurement in test pieces can reproduce phenomenon for an actual motor where various factors overlap. Therefore, by measuring the actual motor in actual driving conditions, we are challenging the measurement in the actual motor driving condition with the purpose of confirming the certainty of iron loss measurement in test pieces. In order to realize this measurement with the actual motor, we have newly developed a magnetic flux sensor that can measure magnetic flux in three directions inside the motor core without disturbing the flow of magnetic flux[1)]. Figure 1 shows the developed sensor. In order not to disturb the flow of magnetic flux, the developed sensor has 2 ideas. The first idea is that the thickness is 170 micrometers thinner than a magnetic steel sheet by using a layered flexible printed board. The second idea is that it is not necessary to make a hole in a magnetic steel sheet by combining the technique of a needle probe method. Using the needle probe method, the flux in the radial direction can be calculated by measuring the induced voltage between r1 and r2, the one in the circumferential direction can be calculated by the induced voltage between θ1 and θ2. The magnetic flux in the axial direction is calculated by measuring the induced voltage of the square search coil located on the flexible printed board.

We have been able to measure the magnetic flux inside the stator core of an actual motor in the actual driving condition using this sensor. In the future, we will measure the actual motor using this sensor, confirm the phenomena that occur with the actual motor, and organize the relationship between the phenomenon of the actual motor and the measurement using the test piece.

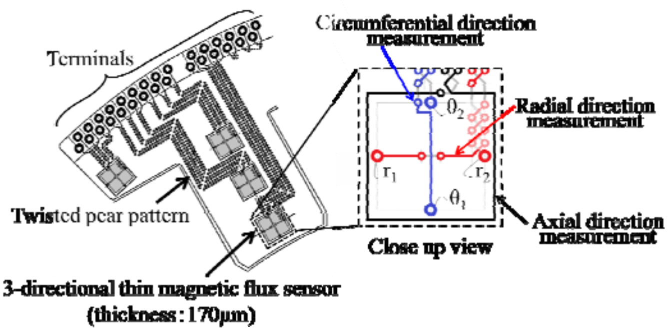

Fig1. Thin sensor capable of measuring 3-dimensional magnetic flux

Reference

1) Y. Maeda *et al.*, IEEE Trans. on Magnetics, Vol.54, No.11 (2018)