Examination of magnetic sensor core material for strength identification of automotive steel

Tatsuya Kai[a], Yuji Tsuchida[a]

[a] *Oita University, Oita, Japan.*

In this paper, the core materials of magnetic sensors used for non-destructive strength evaluation are examined. The core materials are electrical steel sheets with high permeability and a pressed iron core with low permeability. The strength of the actual product is estimated using both sensor core materials. The difference between the estimated strength of the actual product was smaller when the core material with low magnetic permeability was used than the one with high magnetic permeability. It is considered that the core material with low magnetic permeability is more suitable for strength estimation.

Keywords: Non-destructive strength evaluation; Magnetic sensor; Sensor core material

1. Introduction

Currently, one of the measures to achieve carbon neutrality is to reduce the weight of automobile bodies. To achieve this, it is effective to increase the strength of steel materials used in automobiles through heat treatment and to make the steel thinner. However, it is important to evaluate whether the steel material strengthened by heat treatment has reached the appropriate strength for actual use. A tensile test is generally used to check strength, but this test destroys the material, making it impossible to evaluate the actual product. To solve this problem, we aim to establish non-destructive strength evaluation using magnetic sensors. In this study, we examined the core material of magnetic sensors used to assess the strength of materials.

2. Results and discussion

Figure 1 shows the relationship between the magnetic sensor and the sample to be measured. The strength of the actual product is estimated using electrical steel sheets with high magnetic permeability and a pressed iron core with low magnetic permeability as the magnetic sensor core material. Table 1 shows the details of the samples. The yield stress before heat treatment was 46.5kgf/mm^2, and by adjusting the heat treatment conditions, eight samples with different yield stress up to 132.8kgf/mm^2 were prepared. The magnetic properties of the veneer prepared as the measurement sample were measured to investigate how the magnetic properties changed as the yield stress increased, and a regression line was obtained from the results. The strength of the actual product was then estimated by applying the measured magnetic properties of the actual product to this regression line. Figure 2 shows the rate of change of magnetic loss with respect to yield stress. When an electric steel sheets with high magnetic permeability and a pressed iron core with low magnetic permeability are used as the core material, we can see that the magnetic loss changes linearly with the yield stress of the single plate. Using these regression lines, we estimated the strength of the sheet frame, which is the actual product Table 2 shows the estimated strength of the sheet frame. From this table, we can see that the difference between the strength estimation result and the actual measured value is about 12.2 kgf/mm^2 on average when electrical steel sheets with high magnetic permeability is used as the core material. However, when a pressed iron core with low magnetic permeability is used as the core material, the estimated strength is 3.7kgf/mm^2 on average, which is close to the actual measured value. The fact that the strength was estimated closer to the measured value when a pressed iron core with low magnetic permeability was used as the core material than when an electromagnetic steel plate with high magnetic permeability was used as the core material suggests that a core material with low magnetic permeability is suitable for magnetic sensors for the estimation of strength. In addition to these data, this paper also presents coercive force data and strength estimation results obtained by both sensor core materials. Furthermore, using numerical analysis, the study of core materials with different permeability is presented.

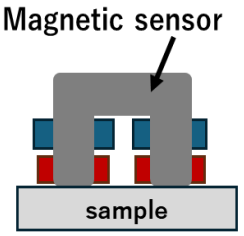

Figure 1; magnetic sensor

Measurement Sample	Yield strength[kgf/mm²]
1	46.5
2	65.1
3	90.9
4	102.2
5	125.4
6	127.8
7	128.3
8	132.8

Table 1; Yield strength of measured sample

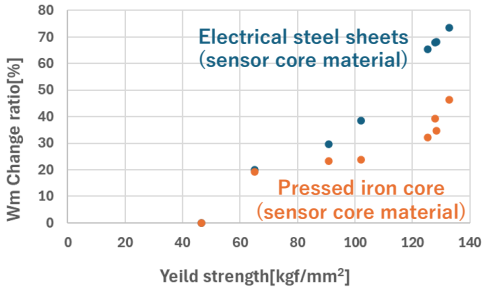

Figure 2; Change ratio to yield strength

Table 2; Difference between measured and estimated values

MeasuredValue [kgf/mm^2] / Sennsor Core material	Bef-A 47.0	Bef-B 48.2	Aft-A 136.4	Aft-B 133.2	Average different
Electrical steel sheets [kgf/mm^2]	63.2	63.5	124.9	127.7	12.2
Pressed iron core [kgf/mm^2]	52.6	54.3	134.7	131.9	3.7

Reference

[1] Yuji TSUCHIDA, Taisuke MATSUDA, Masato ENOKIZONO, Journal of the AEM society of Japan, Vol. 20, No. 4, pp. 665-670, 2012