High-strength Soft Magnetic Composite with Self-lubricating Resin

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Abstract

Improvement of the strength is one of the most important subjects on soft magnetic composite (SMC) to increase the applica ble items. In this study, lubricants for inner lubricating SMC, which can be produced in lower cost than die wall-lubricatin g SMC, varied to investigate their effect on the strength. The newly developed SMC with self-lubricating resin shows high st rength equivalent to that of SMC obtained by die wall lubrication.

Keywords: **Soft Magnetic Composite, Self-Lubricating Resin**

1. Introduction

Soft magnetic composite (SMC)[1,2] is preferred in electromagnetic application, which requires complex shapes or 3-D magnetic fields, for its ease of 3-D shaping and magnetic isotropy.

There have been some studies on compacting process such as die wall lubrication (DL) and warm compaction (WC) for high density, and on insulation coating and binder for improving magnetic properties and strength. Although inner lubricating process has an advantage in complex shaping and mass productivity compared with die wall lubricating process, SMC materials made by inner lubricating process have lower strength than that of SMC materials made by die wall lubricating process, because the lubricants inhibit the adhesion of binder. In this study, improvement of strength of inner lubricated SMC by use of self-lubricating resin was investigated.

2. Experimental and Results

The starting powder was a mixture of iron powder, which was a water-atomized powder with electrical insulated layer on its surface made by Höganäs AB (Somaloy500), and 0.4mass% polyimide (PI) resin as a binder. Several lubricants such as Zinc stearate, amide wax and self-lubricating resin were added to this starting powder, and then compaction was performed with the pressure of 600MPa at room temperature. These compacts were heat treated at 548K in atmospheric air for hardening PI resin. Mechanical Strength was measured by three-point bending test on the specimen with 60mm×10mm×5mm. Magnetic properties were measured on ring-shaped specimen with OD35mm, ID25mm×H5mm.

Figure 1 shows the relation between strength and additive rate of lubricants. SMCs with self-lubricating resin showed lower strength reduction than SMCs with conventional lubricants, and maintain 80% strength of SMC only with 0.4mass% PI employed DL-WC. These results indicate that self-lubricating resin has less harmful influence to adhesive function of PI resin.

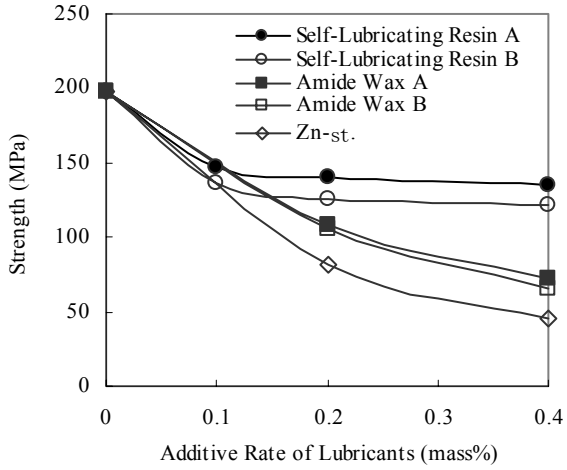

Fig. 1. Strength of SMCs vs. Additive Rate of L ubricants.

Figure 2 shows the strength of SMC with 0.4mass%PI resin and 0.2mass% self-lubricating resin at several temperatures. Decrease of strength by temperature elevation was less than that of conventional SMC with 0.6mass% self-rubricating resin (polyamide/PA), and maintain above 100MPa at 473K.

Next, the formability property of newly developed SMC, which is added 0.4mass%PI resin and 0.2mass% self-lubricating resin, was investigated. The height variation of thin-walled cylindrical compacts (OD30mm, ID28mm) is shown in figure 3, and appearances of compacts were shown in figure 4. The height variation in developed SMC was little enough insofar as height of 30mm. On the other hand, the height variation in SMC with 0.6mass% PA resin was increased with the elevation of the height. It is though that this result was caused by the lower softening temperature

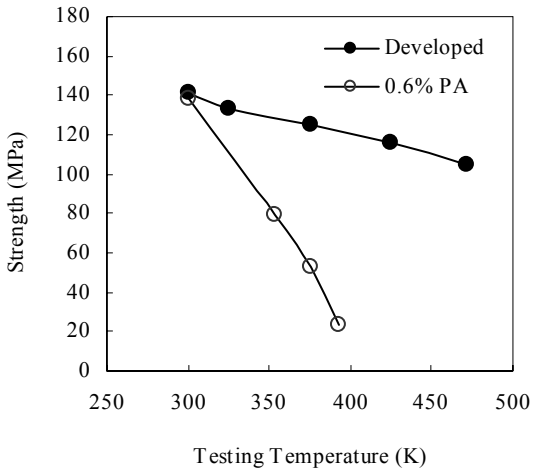

Fig. 2. Temperature Dependence of Strength in Developed SMC.

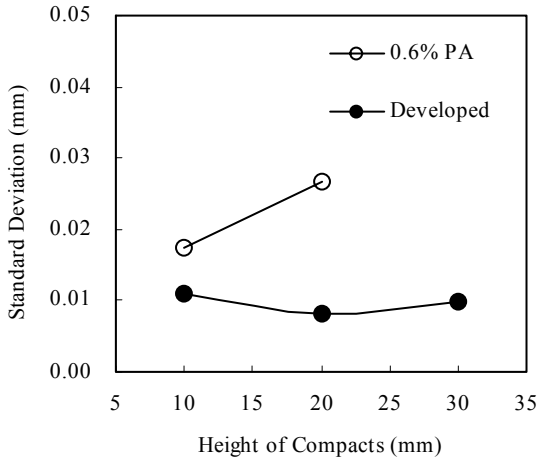

Fig. 3. Height Variation of Thin-Walled Cylindrical Compacts (OD30mm, ID28mm).

Fig. 4. Example of Thin-Walled Compacts.
(OD30mm, ID28mm with Height of 10, 20 and 30mm)

of PA resin than that of self-lubricating resin used in developed SMC. The die wall temperature is getting higher as the height of compact is increased, the flowability of SMC with PA resin was deteriorated, and the height variation was increased.

Magnetic properties of SMC materials were compared in Table 1. Developed SMC employed WC at 353K provided high permeability comparable with that of SMC employed DL-WC at 425K.

Table 1. Magnetic Properties of SMC Materials

Additives	μmax /μ0	$B_{10kA/m}$ (T)	Hc (A/m)	Process
0.2%Polyimide	490	1.60	350	DL-WC
0.4%PI+0.2%Self-Lubricating resin (Developed SMC)	440	1.50	350	WC
0.6%Poliamide	210	1.26	390	-

3. Summary

Newly developed inner lubricating SMC shows high strength equivalent to those of SMCs obtained by die wall lubrication, and provide enough formability to obtain thin-walled compacts with low height variation.

4. References

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2. L. Hultman, O. Anderson and A. Jack, Proc. SAE, World Conference, Detroit, USA, 2003-01-0449, 69-77 (2003).