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Compound Magnetic Wire Sensor Assembling Cylindrical Ba Ferrite Magnet

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Abstract. A new type of the compound magnetic wire sensor is developed. A search coil is wound around the wire which has a uniaxial magnetic anisotropy along the axis direction of the wire. In order to apply a negative magnetic field to the wire, two pieces of cylindrical Ba ferrite magnets are appended at the both ends of the wire. The sensor induces a constant pulse voltage of about 0.7 mV/turn which is independent of the changing rate of the positive external exciting field. The sensor consisted of the compound magnetic wire and 3000 turns search coil induces a stable output voltage of about 2V. It is also advantageous that this simple-structure sensor can be fabricated at a low cost.

1. INTRODUCTION

A compound magnetic wire is made of Vicalloy (40wt%Fe-50Co-10V) wire, which is a semi-hard magnetic material. And the wire is twisted around its axis. When an asymmetric external magnetic field, which consists of a negative set magnetic field and a positive reset magnetic field, is applied to the wire and the magnetization of soft layer is parallel to that of hard core, a large Barkhausen jump is induced as the output voltage. The output voltage is independent of the frequency of external magnetic field and a sharp pulse voltage with a half width of about 15-20 μ s. However in this case the sensor requires two kinds of magnets that have an opposite polarity and a different amplitude. If the output voltage is induced when only a reset field was applied to the wire, it's quite beneficial. In this article, a structure of a new magnetic sensor which performs with only a positive magnetic field is reported.

2. STRUCTURE OF WIRE SENSOR AND MEASUREMENT METHOD

The compound magnetic wire has a uniaxial magnetic anisotropy along the axis direction of the wire. And the coercive force of the wire is about 20 Oe in the outer shell near the surface called a soft layer and 60 Oe in the inner core of the wire called a hard core [1],[2]. The twisted wire has been reported that a coercive force of the surface shell is larger than that of the inner core of the Wiegand wire [3],[4]. In this point, the situation in the compound magnetic wire is opposite. The improvement study using different wires consisting of the alloy Co-V-Fe and Ni-Fe have been also reported [5].

The compound magnetic wire used in the experiment is twisted vicalloy wire of 0.25 mm in diameter and 30 mm in length.

Fig. 1 shows a measurement method for a distribution output voltage. A pair of cylindrical Ba ferrite ($\text{BaO} \cdot 6\text{Fe}_2\text{O}_3$) magnets are appended with opposing their N and S poles at the both ends of the compound magnetic wire. A magnet spacing is d mm. The magnets are 5 and 2.2 mm in outside and inside diameter, respectively and 2.6 mm in length. In this case, an amplitude of the negative magnet magnetic field H_{mag} varies with a measurement point. Thus a distribution of output voltage V_s is measured by 100 turns movable search coil of 1.5 mm in width on the wire. Measurement position x is a distance from the center of the wire to the center of the search coil.

Fig. 2 shows the wave form of the exciting magnetic field. The exciting field consists of a negative magnetic field H_{mag} and a positive external magnetic field H_{ex} with a half-wave [Fig. 2(a)]. As a result, a composite field consists of the reset field H_r and the set field H_s is applied to the sensor as indicated in Fig. 2(b).

3. EXPERIMENTAL RESULT AND DISCUSSION

Fig. 3 shows a distribution of the magnetic field by two cylindrical ferrite permanent magnets. A magnetic field H_{mag} at the center of the wire is $H_{\text{mag}} = 20$ Oe for a magnetic spacing $d=21$ mm and $H_{\text{mag}} = 9$ Oe for $d = 30$ mm, respectively.

Fig. 4 shows a distribution of the output voltage. The output voltage has its maximum value at the center of the wire and decreases with closer to the magnet. Because H_{mag} acts more strongly than the proper set field H_s with measuring point is closer to the magnet, $H_r = H_{ex} - H_{mag}$ decreases and an orienting magnetization of the hard layer becomes weak. Fig. 5 shows a hysteresis loop for the external field $H_{ex} = 100$ Oe at a frequency of 50 Hz. In the figure, it is observed that a sharp output voltage V_s with a large Barkhausen jump effect which corresponds to the jump A of the hysteresis loop.

It is composed that a sensor which consists of a wire of 30 mm in length and a 3000 turn search coil of 20 mm in width on the wire. When the external field H_{ex} is constant at 100 Oe, the output voltage is about 2 V. The output voltage is almost constant for the lower frequency below 0.1 Hz. The jitter of the output voltage of the sensor is about 60 μ s at $H_{ex} = 100$ Oe.

4. CONCLUSION

Two pieces of cylindrical Ba ferrite magnets are attached at the both ends of the wire in order to apply negative set field H_s . With applying a positive reset field H_r to the wire, the distribution characteristic of the output voltage in each position by the search coil was examined. As a consequence, this new type of magnetic sensor with a simple structure can be fabricated at a low cost and perform successfully only with the positive external magnetic field.

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Fig.1 Measurement method for distribution output voltage

Fig.3 Distribution of magnetic field by two cylindrical ferrite permanent magnets

Fig.2 Exciting magnetic field

Fig.4 Distribution of Output voltage

Fig.5 Hysteresis loop