The Application of Amorphous-Ferromagnetic Fiber to High Gradient Magnetic Separation

Kaneo MOHRI* and Eiji SUDOH**

Abstract-Experimental results for the application of amorphous-ferromagnetic fiber to High Gradient Magnetic Separation (HGMS) are expressed. Amorphous fiber has the following superior features in comparison to stainless steel wool with the same cross-sectional area and same matrix weight : (i) capture amount is larger, especially for ferromagnetic particles, (ii) flushing of matrix is easier due to smaller remanent induction, (iii) matrix-dust mixing into filtrate or flushed water does not occur due to its extremely large anti-tensile strength, (iv) various kinds of matrix form such as axially-ordered one are well designed by using amorphous fiber due to its smooth and straight form and desired sectional shapes and finer diameter, (v) anti-corrosiveness is nearly same, and (vi) production cost will be made lower because of high-speed production and simple process.

INTRODUCTION

The application of amorphous-ferromagnetic ribbons [1], developed in 1973, has been still few, notwithstanding huge attention has been laid on due to its high permeability, small coercive force, high anti-tensile strength, anti-corrosiveness, and high speed production rate. On the other hand, recently, HGMS is rapidly developed and very widely applied to the commercial processing of micron size feebly magnetic particles in purification of clay, coal, minerals, wastewaters and so on [2]

The key element of HGMS is fine ferromagnetic fiber or wool which compose filter or matrix. And the essential conditions of this wool are: high capturing capacity, anti-corrosiveness, anti-tensile strength, especially for oil processing, low remanence flux for flushing, easiness of producing fine and optimal shapes, and low cost. Traditional stainless steel wool cannot realize the whole conditions. On the point of view, we naturally think of using amorphous fiber for HGMS filter.

EXPERIMENTAL RESULTS AND DISCUSSIONS

Fig. 1 shows the experimental results of capturing and flushing (releasing) characteristics for Fe_3O_4 (100 ppm) using stainless steel wool (s.s. wool) with the cross section of 90 μm width and 35 μm thickness in average and amorphous fiber ($Fe_{4.7}Co_{70.3}Si_{15}B_{10}$) with 125 μm width and 25 μm thickness. Both materials are in same matrix weight of 300 mg and matrix form of 0.5% density and 4 cm length. Applied DC field in HGMS is 4 KG and feed velocity is 6 cm/s. Feed of 20 ℓ is circulated and capture rate is measured by using a colorimeter.

The captured amount on amorphous fiber is about 10% larger than that of s.s. wool at 40 min., and the released amount from amorphous fiber ($p \rightarrow q$; H_{dc} off at the point p) is about 2.3 times that from s.s. wool ($p' \rightarrow q'$; H_{dc} off at the point p') under the flushing water velocity of 6 cm/s. These results are considered due to that the value of magnetic flux, so gradient of field, of amorphous fiber is larger than that of s.s. wool at $H_{dc} = 4$ KG for capturing, and the remanence flux of amorphous fiber is smaller than that of s.s. wool for flushing.

We, next, introduce a new technique for improving flushing rate by applying a modulated AC field $\tilde{H}_{ac}$ of 60 Hz and 34 G maximum at Fig. 1 $q \rightarrow r$, and $q' \rightarrow r'$ as illustrated in Fig.2(a). About 90% of captured amount can be released by applying $\tilde{H}_{ac}$ in Fig. 1. The effect of $\tilde{H}_{ac}$ is considered that

* Associate Professor at the Department of Electrical Engineering,
** Student at the Department of Electrical Engineering, Kyushu Institute of Technology, Tobata, Kitakyushu 804.

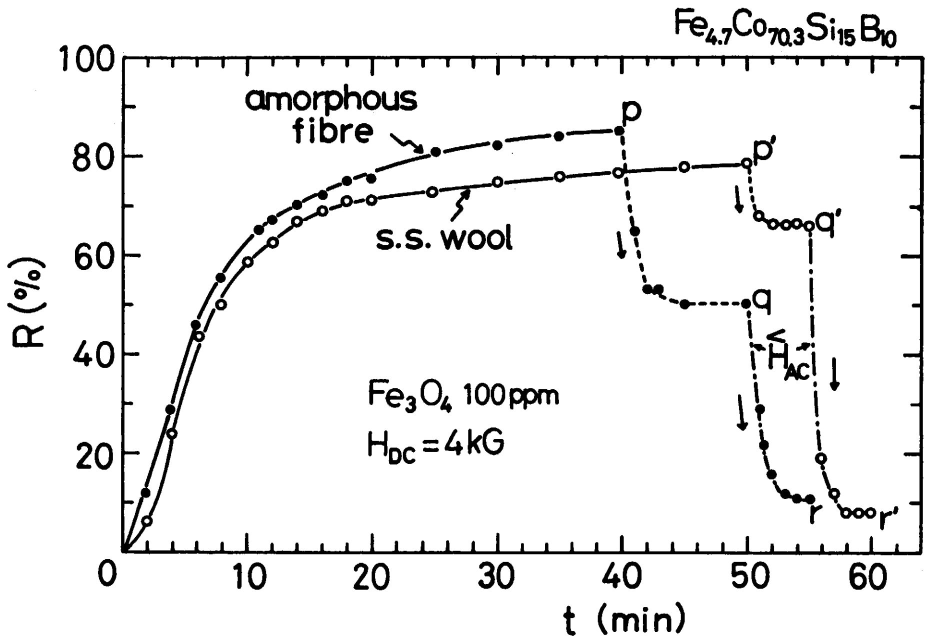
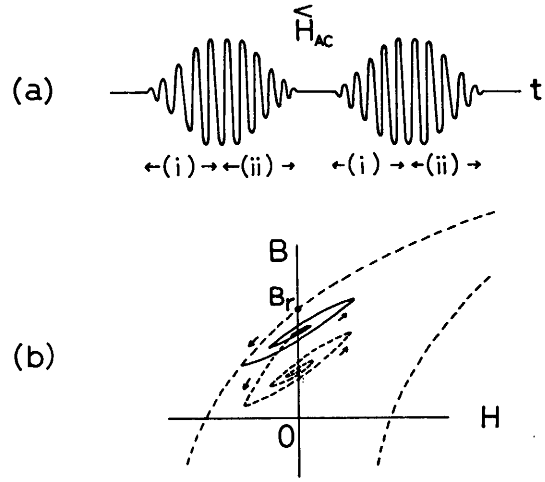


Fig. 1. Experimental results of HGMS for Fe_3O_4 using stainless steel wool (s. s. wool ; white circles) and amorphous fiber (black circles) : real lines show the capturing process, and dotted and chained lines show the flushing processes without and with modulated AC fields, respectively.



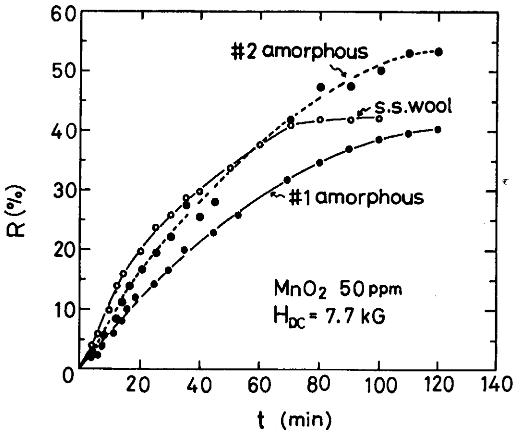


Fig. 2. (a) schematical shapes of a modulated AC field,
(b) schematical illustration of decreasing remanence due to AC demagnetizing effect.

Fig. 3. Experimental results of HGMS for MnO_2 using s.s. wool and two kinds of amorphous fibers with cross-sectional shapes of 125-25 μm at #1 and 65-50 μm at #2.

reversing-pole effect on fiber surface releases particles at the period (i) and AC demagnetizing effect (Fig. 2 (b)) at (ii) also release ones.

Fig. 3 shows the capturing process of MnO_2(50 ppm) by two kinds of wools as shown in Fig. 1 at H_{dc} =7.7 KG. In this case, the captured amount of s.s. wool is larger several percent than #1 amorphous fiber with the cross section of 125 μm width and 25 μm thickness. This is considered that the value of flux of s.s. wool is larger than that of #1 amorphous fiber at higher field. However, #2 amorphous fiber with 65 μm width and 50 μm thickness inversely several percent larger than that s.s. wool does. This cross-sectional shape effect is explained in Fig. 4. That is, total captured amount C_t on matrix is approximately expressed as the follows when all fiber are laid perpendicular to the applied field and uniformly distributed in the feed tube ;

$$C_t \propto (D/W) V_p M_p (\partial H/\partial x) \quad (1)$$

where V_p and M_p are volume and magnetization of particle, respectively. The value of $\partial H/\partial x$ measured for iron bars with various values of W/D are plotted in Fig. 4. So, the value of C_t becomes maximum at $W/D = 1$.

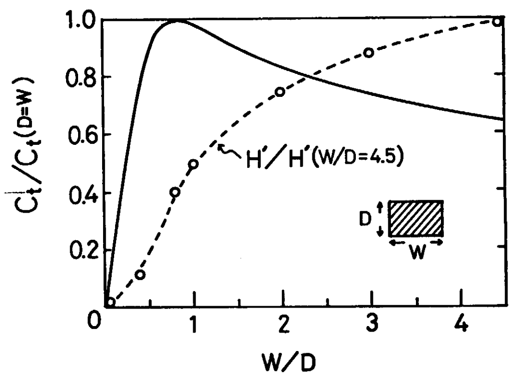


Fig. 4. Fiber cross sectional shape effect on capturing capacity.

CONCLUSIONS

(i) amorphous fiber captures larger amount of particles, especially for ferromagnetic particles, than that s.s. wool does,

(ii) flushing is easier for amorphous fiber due to its lower remanence flux than that of s.s. wool,

(iii) matrix dust does not flow out by using amorphous fiber, even for oil processing, due to its huge anti-tensile strength, while s.s. wool usually flow out its dust,

(iv) anti-corrosiveness is similar for both materials,

(v) optimal cross-sectional shape of fiber is square or circle which is easily made for amorphous fiber at the speed of 40 m/s,

(vi) flushing is made easier by applying modulated AC field.

ACKNOWLEDGMENT

The author wishes to express his gratitude to Professor K. Harada of Kyushu University for his interest in this work and to Dr. S. Yokoyama of TDK Electronics Co., Ltd. R&D for his arranging amorphous fiber.

REFERENCES

[1] Chem. and Eng'g. News, pp. 24—25, 19 November 1973.

[2] Proceedings of Magnetic Desulfurization of Coal Symposium published in IEEE Trans. on Magn., Vol. MAG-12, No. 5, pp. 423—551, September 1976.