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Wear of soft fabric by magnetite green compact -How to evaluate the life time of bag-filter in dust collector-

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The purpose of the present study is to apply a new technique, magnetic measurement, to evaluate the lifetime of the bag-filter in a dust collector. The bag-filter is an exhaust gas processing equipment from which the toxic substance in the exhaust gas is removed through a filter cloth. With the development of bag-filters for dust collectors in waste incinerators and to prevent failure while in service due to wear, a reliable method for prediction of the lifetime of those bag-filters is needed. One of the main difficulties when studying the wear behavior on bag-filter by ash dust is that the ash dust could be embedded into the bag-filter during the testing process. In this study, sintered magnetite compact was used to simulate the ash dust. Wear tests of soft fabric (buff) by sintered magnetite compact were performed in different wear conditions. The precise amount of magnetite particles embedded into buff was determined by means of saturation magnetization. Then, net amount of wear of buff was evaluated.

Key words: Wear, Saturation magnetization, Magnetic material

1. INTRODUCTION

In recent years, with the increase of awareness regarding environmental issues, dioxin has been identified as a major concern relating to health problems. At present, common and industrial waste incineration is estimated to account for 90 percent of dioxin present in Japan [1]. It is known that dioxin degrades in the dust collectors at temperatures over 800°C. However, waste incineration at 300°C was regarded as the best condition in dust collector, although dioxin is easily generated at temperatures between 200°C and 400°C [1]. Thus, attention is focused on the bag-filters to prevent the formation of dioxins and to keep low temperatures in the dust collectors, where the bag-filter is the product which enlarged collection capacity by making a usual pre filter into the letter of the back. Bag-filter could clear ash dust and microscopic particles of deleterious material by passing exhaust gas through a fabric that was treated with a special coat.

A dust collection system was broadly used for the processing of exhaust gas and dioxin controlling measure in the dust collectors. Recently, the use of dust collectors system where the bag-filter is a fiber matrix let to an improvement in performance and diversification. Unfortunately, sometime accidents occur, namely, the bag-filter failed by being worn out due to flying ash dust. Since a reliable method for prediction of the lifetime of those bag-filters was needed, wear mechanism of bag-filter should be known. Wear of the bag-filter is considered to be caused by collision of the ash dust. However, no direct evidence for the wear mechanism was presented. One of the main difficulties when studying the wear behavior of bag-filter by ash dust is that the dust ash could be embedded into the bag-filter during the wear test. Therefore, there is a need to develop a new technique to evaluate the net amount of wear on the bag-filter.

Meanwhile, magnetic properties of magnetic materials are proportional to the weight of the magnetic materials. In other words, if magnetic measurement of the magnetic material is performed, the weight of the magnetic material can be calculated. Using this phenomenon, net amount of wear of bag-filter could be precisely evaluated by the magnetic measurement, if the magnetic particles were used as a model of ash dust.

In this study, sintered magnetite compact was used to simulate the ash dust. Wear tests of soft fabric (buff) by sintered magnetite compact were performed in different wear conditions. The precise amount of magnetite particles embedded into buff was determined by a vibration sample magnetometer (VSM) measurement. Then, the net amount of wear of buff was evaluated.

2. Theory

It is well known that saturation magnetization of magnetic materials is proportional to the weight of the magnetic materials. Therefore, the amount of magnetic material-particles embedded into bag-filter could be determined by means of magnetic measurement; M_m (emu) / I_s (emu/g), where, I_s (emu/g) is saturation magnetization of magnetic material-particles and M_m (emu) is measured magnetization. Then, net weight loss due to wear on the bag-filter, DM (g), can be evaluated by the following equation.

$$DM\,(g) = M_o(g) - [M_w\,(g) - \{ M_m(emu)/ I_s(emu/g)\}] \quad \text{....... (1)}$$

Where M_o (g) and M_w (g) are the weights of the bag-filter before and after wear test, respectively.

3. EXPERIMENTAL PROCEDURES

3.1 Production of magnetite green compacts

In this study, Fe_3O_4 (magnetite) particles were used as a magnetic material to simulate the ash dust. The magnetite particles were poured into a mold. They were pressed up at room temperature to 19.6MPa with autograph and kept for two minutes. The shape of magnetite green body is rod, and rod diameter and length are 10 mm and 15 mm, respectively. Then the magnetite green body was sintered at different sintering temperatures (from 100°C to 900°C every 200°C) and different sintering period (1 or 2 hours) with a muffle-oven. The macroscopic view of fabricated sintered magnetite compact is shown in Fig. 1.

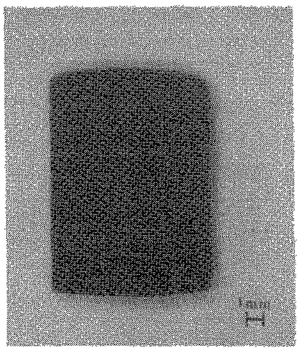

Fig. 1 Sintered magnetite compact.

3.2 Wear test

Wear tests were performed with a rod-on-disc type wear apparatus as shown in Fig. 2. Steel disc was covered by a round sample of buff. The counter sample is a sintered magnetite compact rod. Saturation magnetization of the buff after wear test was measured by a VSM. At that point, the buff was cut out 12 mm in diameter. The weight of magnetite particles embedded into the buff was evaluated from the value of saturation magnetization, and the net weight loss of the buff by the wear test was calculated.

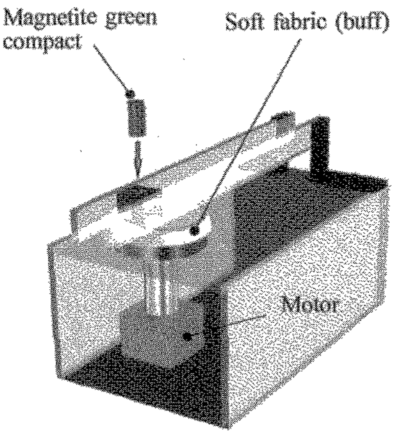

Fig. 2 A rod-on-disc type wear apparatus.

4. RESULTS AND DISCUSSION

4.1 Properties of sintered magnetite green compacts

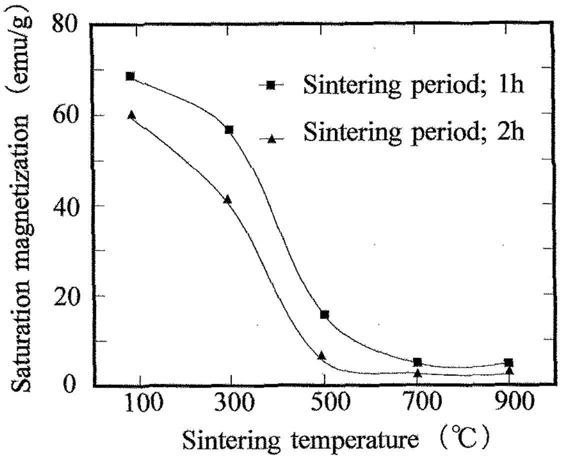

Fig. 3 Saturation magnetization of sintered magnetite compact sintered in air.

As feasible studies, magnetic and mechanical properties of sintered magnetite compact were measured. Figure 3 shows the variation of the saturation magnetization of sintered magnetite compact that was sintered in air. It is observed that as sintering temperature increases the saturation magnetization of sample decreases. The observed variation in the saturation magnetization is likely to be due to phase transformation of magnetite into non-magnetic phase during the sintering in air.

Figure 4 shows XRD pattern of the sintered magnetite compact after sintered at 900°C for 2h in air. Magnetite transformed into α-Fe_2O_3 by the sintering in air. It is well known that the transformed α-Fe_2O_3 phase is a non-magnetic material. Therefore, transformation (oxidation) during the sintering must be prevented.

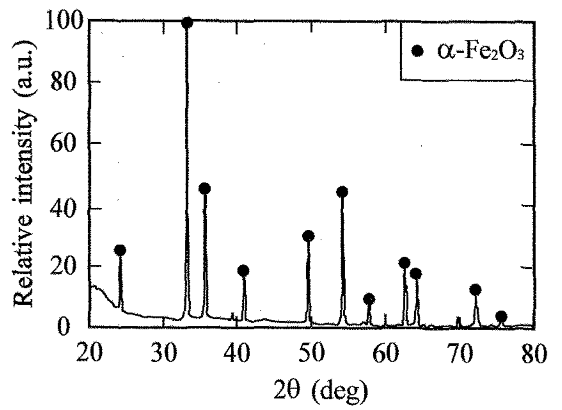

Fig. 4 XRD pattern of the sintered magnetite compact (900°C, 2h). Sintering was carried out in the air.

Therefore, sintering was carried out in vacuum condition to avoid the phase transformation. Figure 5 is a plot of the saturation magnetization of sintered magnetite compact, which was sintered in vacuum condition, as a function of sintering temperature. One may have noticed that sintered magnetite compact sintered in vacuum kept in the saturation magnetization as the sintering temperature rose.

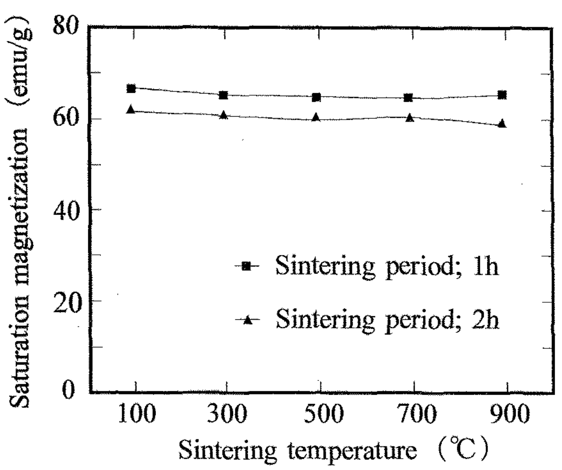

Fig. 5 Saturation magnetization of sintered magnetite compact sintered in vacuum.

Figure 6 shows the amount of wear of sintered magnetite compact sintered in vacuum condition. Buff was used for the counter surface. As shown in Fig. 6 the amount of wear of sintered magnetite compact was reduced with increase in sintering temperature. Moreover, higher wear resistance is found for the samples sintered for longer sintering period. Therefore, the following wear tests were carried out for sintered magnetite compacts sintered in vacuum condition at high sintering temperature (900°C) and longer sintering period (2 hours).

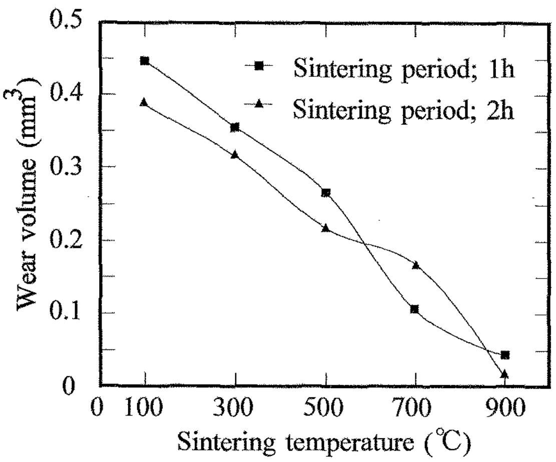

Fig. 6 The wear resistance of sintered magnetite compact sintered in vacuum. Counter surface is buff.

4.2 Wear of buff by sintered magnetite compact

Wear of buff by sintered magnetite compact was carried out under varying conditions. Figure 7 gives an example of the buff after wear test. It is clear from this figure that the magnetite particles are embedded into the buff. The amount of embedded particles was evaluated from Equation 1.

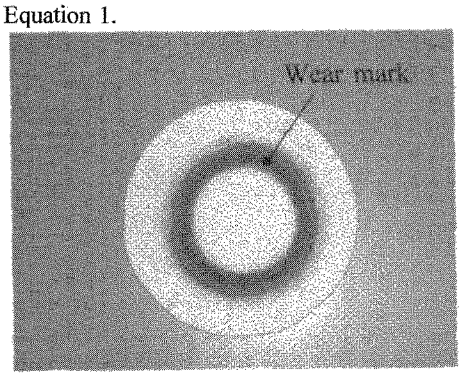

Fig. 7 An example of the buff after wear test.

Figure 8 shows the net amount of wear of buff with a change of the wear distance. Sliding speed and applied load were fixed to be 0.25 m/s and 70 g, respectively. The amount of wear of the buff increases with increasing the wear distance. It is worthwhile to note that a linear relationship between the amount of wear of buff and the applied load was not found. This may be because magnetite particles were heaped up on the buff as the wear distance increased.

The effect of applied load on the amount of wear is shown in Fig. 9. Wear distance was 75m and sliding speed was 0.25m/s. It is found that the relationship between the amount of wear of buff and the applied load is almost linear.

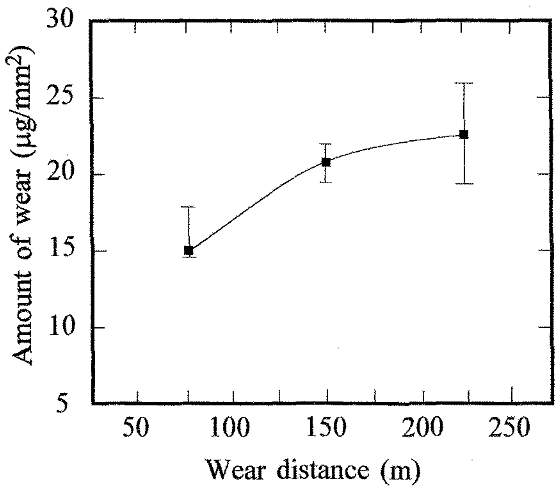

Fig. 8 The net amount of wear of buff with a change of the wear distance.

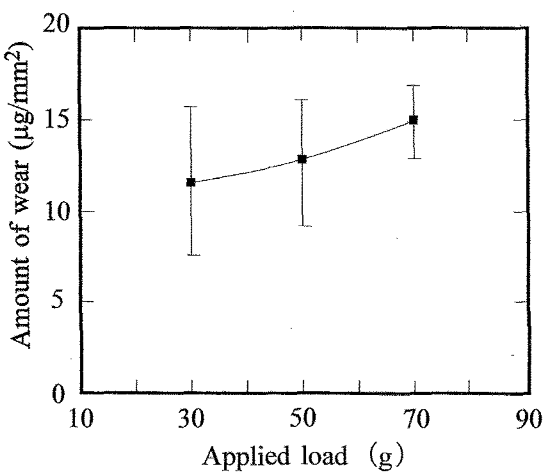

Fig. 9 The net amount of wear of buff with a change of the applied load.

Figure 10 shows the amount of wear of buff as a function of the sliding speed. Wear distance and applied load were 150 m and 70 g, respectively. From this figure, the wear volume of buff with a change in the sliding speed was reduced as the sliding speed increased. In general, it is known that the coefficient of dynamic friction is reduced as the sliding speed increases [2]. Although the dynamic friction was not measured during the wear test, the dynamic friction may affect the amount of wear of buff.

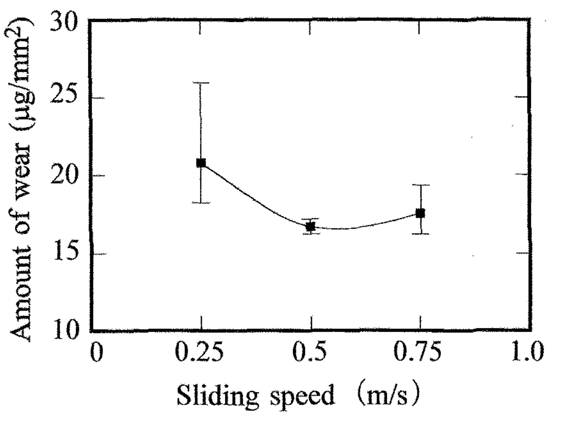

Fig. 10 The net amount of wear of buff with a change in the sliding speed.

4. CONCLUSION

In order to study the wear of bag-filter by ash dust, buff and sintered magnetite compact were used. The amount of magnetite particles embedded into buff was determined by means of magnetic measurement. The obtained results are summarized as follows.

1) Best conditions of sintered magnetite compact were sintered in a vacuum condition at a high sintering temperature (900°C) and a longer sintering period (2 hours).

2) Net amount of wear of the buff could be precisely determined by the magnetic measurement.

3) It was found that the amount of wear of the buff increases with increasing the wear distance and applied load.

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