Recovering Magnetic Powder from Sludge Discharged during Magnetic Separation of Oily Wastewater at Oil Production Sites

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1. Introduction

When bitumen is extracted from oil sand, a large amount of wastewater is discharged because a large amount of hot water is added to the oil sand to reduce its viscosity. Also, a large amount of wastewater is produced along with crude oil at various conventional oil production sites because water infusion is required in the oil production process.

That wastewater includes silt, clay (SS: suspended solids), and oil emulsion. However, the wastewater is being directly discarded without recovering oil and clarifying the water[1-2]. Therefore, we developed a system that separates SS, oil, and clarified water from wastewater to reuse the water and to reduce the impact on the environment.

2. Water treatment system with magnetic separation

Our system uses a technique for coagulation and magnetic separation[3-5] (Fig. 1). This technique is enhanced from coagulation sedimentation used in water treatment plants. First, a flocculant and magnetic powder are mixed into wastewater and agitated. Moments later, flocs of impurities and magnetic powder are formed. The flocs are then removed from the wastewater by magnets, and clarified water and sludge are produced.

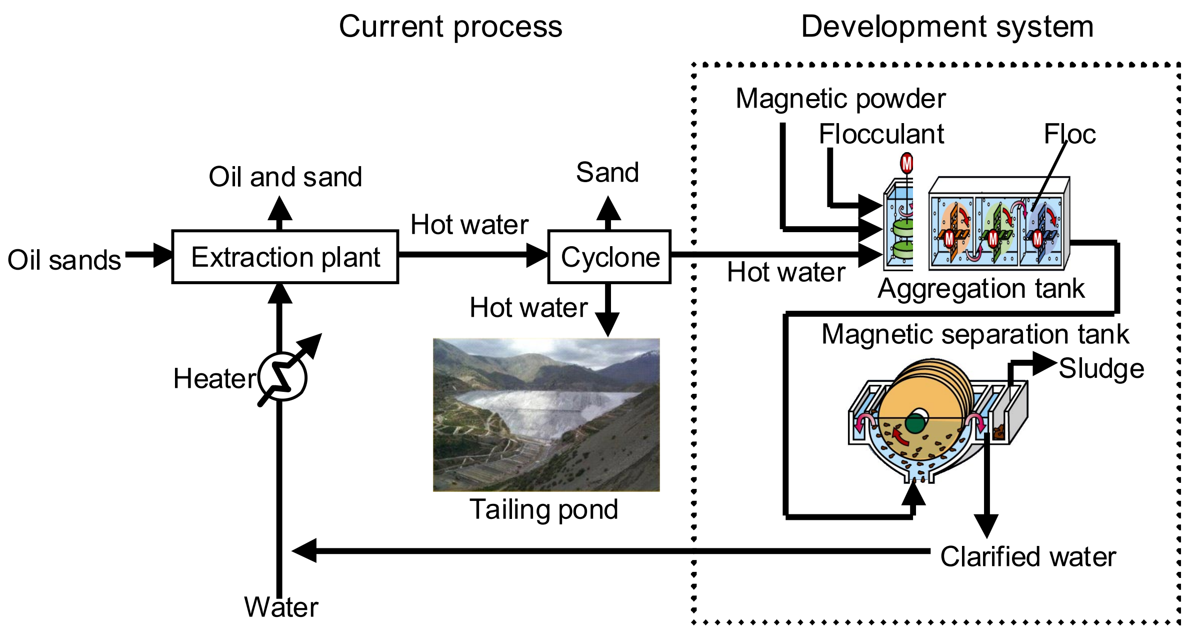


Figure 1 Application to wastewater treatment system for mining

The amount of magnetic powder used in this system increases in proportion to the amount of wastewater being treated. Because there is a large amount of target wastewater, a large amount of magnetic powder is drained with the wastewater when the magnetic powder is not recoverable. Therefore, recovering the magnetic powder from sludge is important.

3. Magnetic powder recovery system

In this study, we investigated the effectiveness of hydrothermal treatment on decomposing sludge that contains magnetic powder. When sludge is heated, flocculant is expected to lose its function of coagulation due to the chemical reaction, and magnetic powder can be recovered. We designed the system as follows.

The magnetic powder recovery system is shown in Fig. 2. First, sludge discharged from the magnetic separation equipment is discharged into a stainless steel tube by a high-pressure pump. Next, the sludge is preheated by a heat exchanger, and a chemical reaction with sludge is caused in a heated reactor. Then, the sludge passes through the heat exchanger and a back-pressure regulating valve to maintain the saturated vapor pressure. Finally, a magnetic separator mounted on a permanent magnet recovers the decomposed magnetic powder.

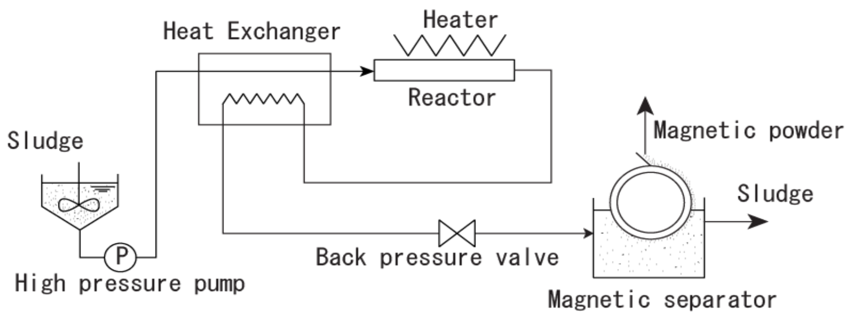


Figure 2 Magnetic powder recovery system

When the treatment temperature increases, not only the flocculant but also the magnetic powder is known to change in composition due to a chemical reaction. Therefore, we examined the decomposition temperature of the flocculant and the phase-change temperature of the magnetic powder and optimized the magnetic powder recycling system.

4. Experimental results and discussion

We examined the effect that temperature has on chemical change with flocculant and magnetic powder using a batch method of hydrothermal treatment. The flocculant used in the experiment is poly ferric chloride and the magnetic powder is magnetite.

Fig. 3 shows the hydrous rate of the sludge with the hydrothermal treatment temperature. Fig. 4 shows a picture of the treated sludge after stirring and standing for 30 min. The experimental results show that the hydrous rate sharply decreases at 200°C or more (Fig. 3). Also, the transparency of supernatant liquid sharply decreases at the same temperatures (Fig. 4). Because flocculant generally has a high water holding capacity, we conclude that the capability of the flocculant clearly deteriorated at these high temperatures.

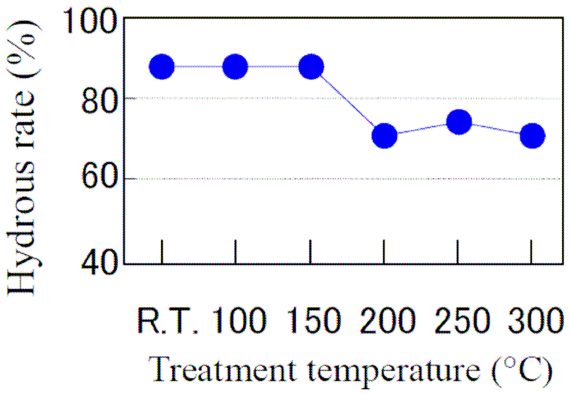


Figure 3 Hydrous rate of sludge with hydrothermal treatment temperature

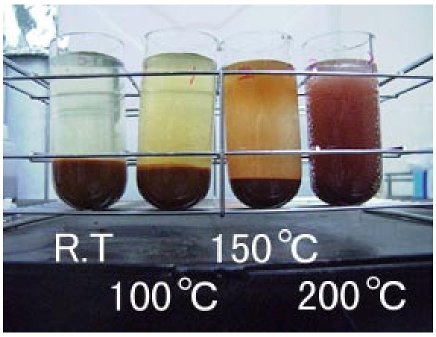


Figure 4 Treated sludge at various temperatures

Fig. 5 shows the saturation magnetization of the magnetic powder measured by a vibrating sample magnetometer with the hydrothermal treatment temperature. SEM pictures of the hydrothermally treated magnetic powder are shown in Fig. 6 (a)(raw material), Fig. 6 (b)(200°C), and Fig. 6(c)(300°C). Fig. 7 shows the XRD spectra of the hydrothermally treated magnetic powder.

The magnetic powder cannot help us detect a significant change in the saturation magnetization. But, the SEM picture of the magnetic powder heated at 300°C shows that the edges of the particles are more round than the raw material or the magnetic powder heated at 200°C. We observed the spectrum of hematite only in the XRD spectrum of the magnetic powder heated at 300°C (top of Fig.7). Because a minimal amount of hematite is produced at 300°C, we conclude that most of the magnetite changes into hematite when the treatment time is increased. In other words, the more the number of recycling increases, the more hematite is produced. Therefore we decided that the best temperature for a hydrothermal treatment of sludge is 200°C.

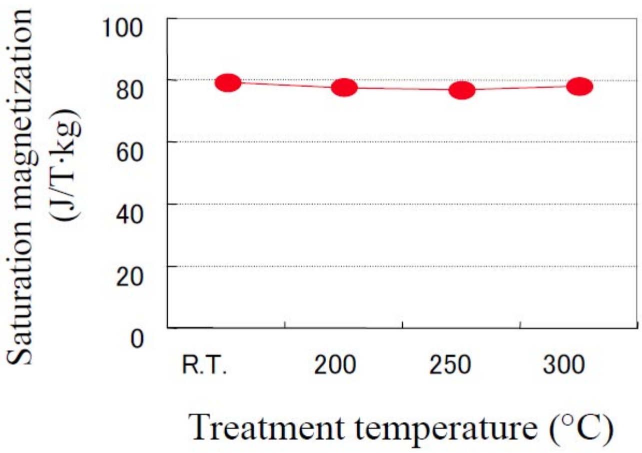
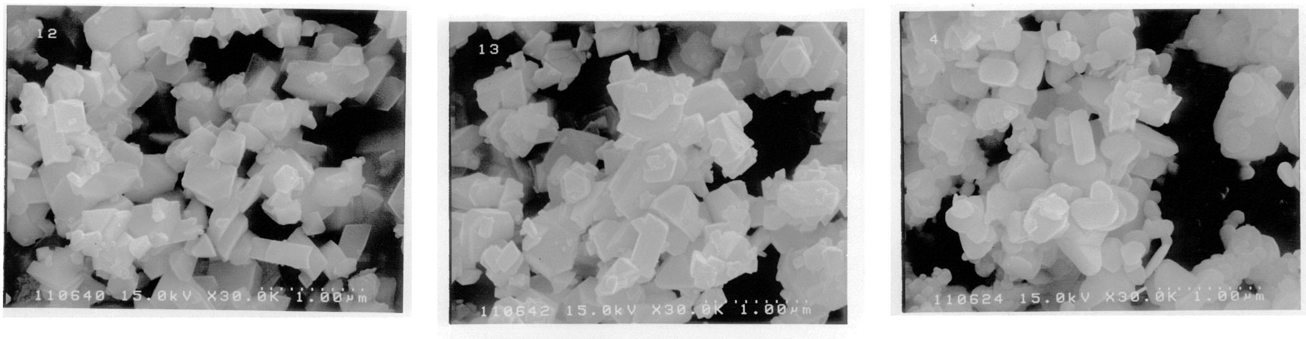


Figure 5 Saturated magnetic moment of magnetic powder with hydrothermal treatment temperature



(a) Raw material (b) 200°C (C) 300°C

Figure 6 SEM pictures of hydrothermally treated magnetic powder

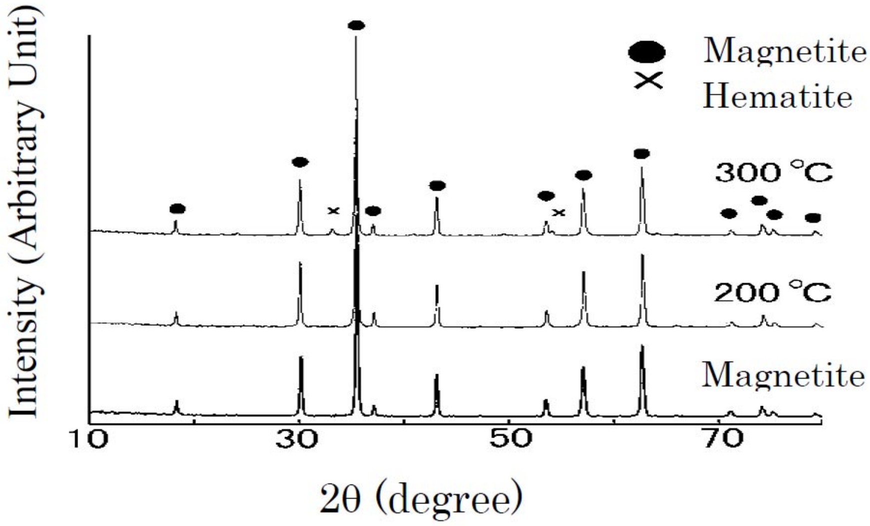


Figure 7 XRD spectra of hydrothermally treated magnetic powder

4. Conclusion

The major conclusions that can be derived from the present study are summarized as follows:

1) We designed a magnetic powder recovery system for sludge discharged during magnetic separation from oily water at oil production sites.
2) We found that the ideal hydrothermal treatment temperature for a magnetic powder recovering system is 200°C.

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