Superconductivity and Cryogenics
Vol.11, No.4, (2009), pp.8~11

The treatment of coolant wastewater of rolling plate process by High Gradient Magnetic Separation

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Received 13 October 2009; accepted 19 November 2009

Abstract-- **This study introduced wastewater treatment method by High Gradient Magnetic Separation (HGMS). HGMS treatment was high efficient method for various industrial wastewaters. The system is currently research state, but we have surveyed commercialize the technology for industry. In rolling plate process, coolant wastewater was recycled by sedimentation and sand filter system. It needs several large reservoirs and long time to remove suspended solid (SS) like metal fines and iron oxide in hot rolling plate making process. If removing rate of suspended solid in rolling coolant wastewater is improved by using HGMS system, the productivity of working process can be increased and the area of reservoir can be reduced. We manufactured high temperature superconducting HGMS system that had a purpose to treatment of coolant wastewater in rolling plate process. We fabricated the prototypes of magnetic matrix filter consisting of stainless steel 430 mesh, which is a core component in the magnetic separation system. In our basic preliminary experiment using HGMS system, it has been clear that the fine paramagnetic particles in the coolant wastewater obtained from rolling plate process of POSCO can be separated with high efficiency.**

1. INTRODUCTION

It is important to recycle industrial wastewater in the aspect of energy saving and minimizing the environment damage. Steel hot rolling plate manufacturing process make an effort to purify and to recycle coolant wastewater from the hot rolling processes, a steel manufactory company in Korea [1]. POSCO also has concerned about the treatment of coolant wastewater for long time. The coolant of roller at steel making factory includes suspended solid (SS) like metal fines, iron oxide and emulsified oil. The used coolant wastewater is generally recycled by a re-circulating system that is constituted of screening, grit chamber, sedimentation, and filtration process. However the existing coolant wastewater treatment facilities need large-scale equipment and wide space to purify the coolant wastewater of rolling plate process. HGMS system has the merits to purify the coolant wastewater rapidly because of large voids at filter and to occupy small space [2].

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In this study, we have researched recycling treatment of steel hot rolling plate manufacturing process coolant wastewater by HGMS system. We fabricated the prototypes of vertical type superconducting HGMS system, which was constituted with continuous stainless steel 430 filter apparatus [3].

2. EXPERIMENT

High temperature superconducting magnet was used for HGMS system, which was shown in Fig. 1. The superconducting magnet is composed of 8 double pancake coils. Each double pancake coil is wound on the bobbin by wet winding method using the Bi-2223 HTS tape, and can generate a magnetic field up to 4 T. The diameter of a room temperature bore is 70 mm.

It is necessary pre-treatment of coolant wastewater before HGMS process. The flock formation treatment is consisted with ferromagnetic particles and other particles are made coagulation reaction process, as shown in fig.2. In order to remove suspended solid (SS), coagulation reaction was treated by using inorganic substances ($Al_2(SO_4)_3$, $FeCl_3$, $FeSo_4$) and organic substances (anion,

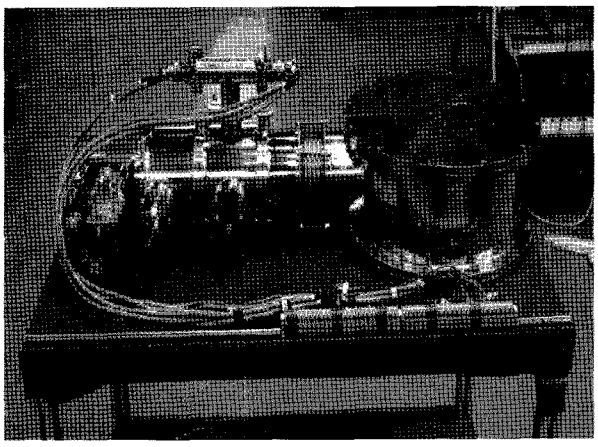


Fig. 1. High temperature superconducting magnet for HGMS system.

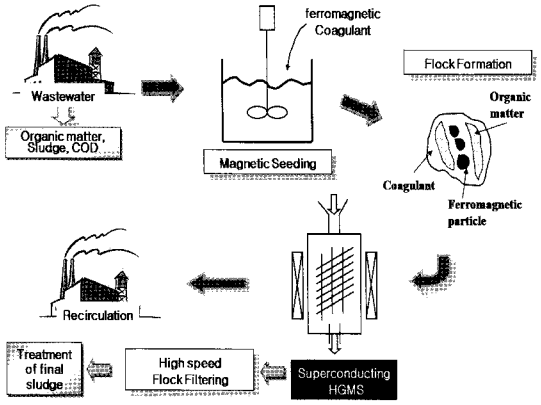


Fig. 2. Pre-treatment of coolant wastewater for HGMS process.

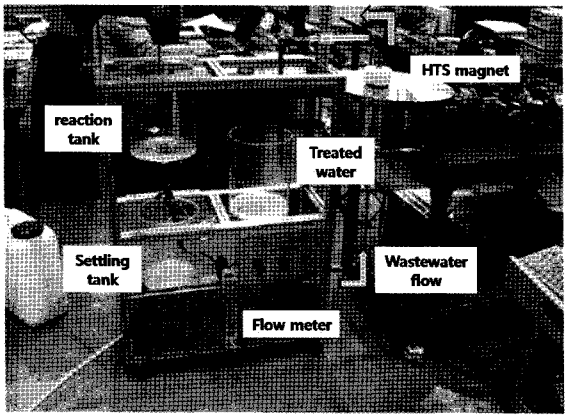


Fig. 3. Vertical type HGMS system using superconducting magnet.

non-ion, cation) with H2O2. And these coagulations were investigated magnetic property [4].

We made a vertical type HGMS system, as shown in Fig. 3. Magnetic separation filter sited through the room temperature bore of the superconducting magnet [5]. Fig. 4 shows XRD analysis of coolant wastewater. The Main component consist of iron oxides, the content is in order FeO, Fe_3O_4, Fe_2O_3 particles of suspension solid.

Magnetic flock that was mixed with suspended solid (SS) and coagulation substance in coolant was formed by coagulation process with several kinds of coagulation substance, and the formation degree of magnetic flock was investigated [6]. Table.1 shows the formation degree of magnetic flock by using inorganic substances ($Al_2(SO_4)_3$, $FeCl_3$, $FeSo_4$) and organic substances (anion, non-ion, cation).

When three kinds of inorganic substances were used, the magnetic flock could not form in coolant. But in case of polymer substances, the magnetic flocks were formed well. So, proper content of inorganic material and polymer coagulant for coagulation process was investigated. Previous studies also showed the improved removal efficiency with the pre-treatments. Coagulants collect fine particles and form flocks [7].

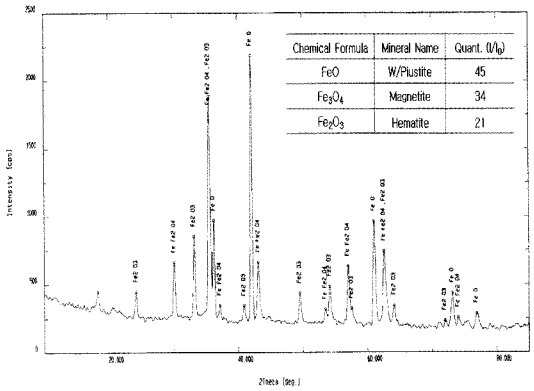
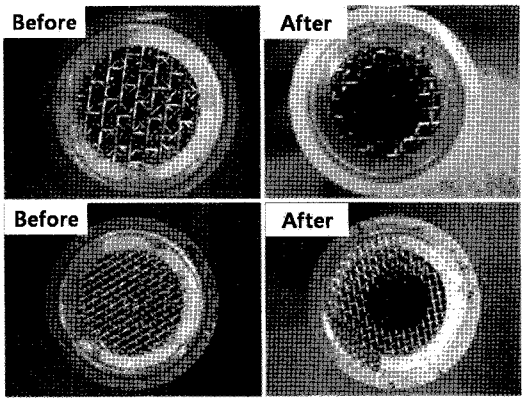


Fig. 4. Analysis XRD of iron oxides component in coolant wastewater.

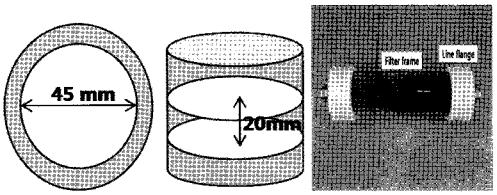
TABLE I
FORMATION DEGREE OF MAGNETIC FLOCK IN COOLANT WITH SEVERAL KINDS OF COAGULATION SUBSTANCE.

Material type	Coagulation substance	Formation degree of magnetic flock
Inorganic matter	$Al_2(SO_4)_3$	Bad
	$FeCl_3$	Bad
	$FeSo_4$	Bad
Polymer	Anion	Good
	Noion	Good
	Cation	Good

3. RESULTS AND DISCUSION



(a) Filter mesh disk stainless steel 430 of HGMS.



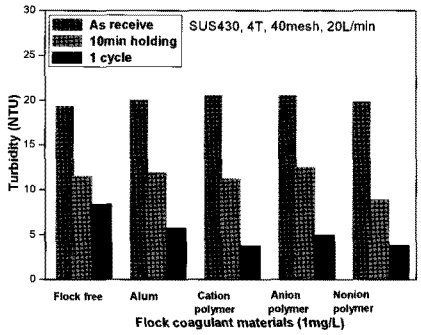
(b) Filter diagram and line flange of HGMS.

Fig. 5. HGMS filter mesh disk type stainless steel 430.

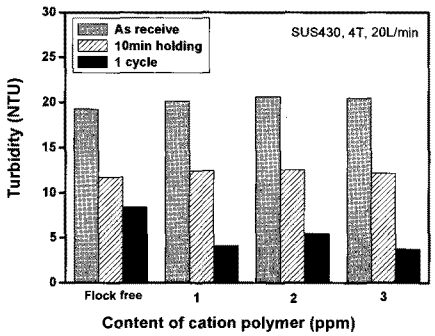
HGMS treated before and after magnetic matrix filter shown in Fig. 5. The effect of flock formation was investigated with various input coagulant, as shown in Fig. 6. Two types of coagulants, an inorganic ($Al_2(SO_4)_3$) and organic (anion, non-ion, cation) were used for coagulation reaction test. The results showed that cation polymer coagulant was better HGMS treatment property than other coagulant.

The experiments were conducted at 4 Tesla of magnetic field with stainless steel 430 filter and 20 L/min of flow rate. The initial turbidity was 20 NTU and the coolant wastewater was held for 10 min after adding the coagulant and about 30 % of turbidity was removed by precipitation. By the high gradient magnetic separation additional 40-50 % of turbidity was removed while about 15% of turbidity removal was achieved without the coagulant indicating the coagulation step is needed before the magnetic separation. However, the dose (1-3 mg/L) showed very similar results meaning 1 mg/L of coagulant dose or less will be enough for the coolant wastewater, as shown in Fig.6. A highly turbid wastewater (initial SS = 200 mg/L) was tested with the same experimental condition of Fig. 4. The results showed that more than 50% of the SS was removed by precipitation before the magnetic separation indicating the most of particles are heavy and formed big flocks [8].

However the fine particle could aggregate in the pipeline and cause clogging problem at the nozzle system. With the magnetic separation, the effluent concentration was about



(a) Turbidity properties of various coagulants.



(b) Turbidity properties of cation coagulant.

Fig. 6. HGMS treatment turbidity properties of coagulants.

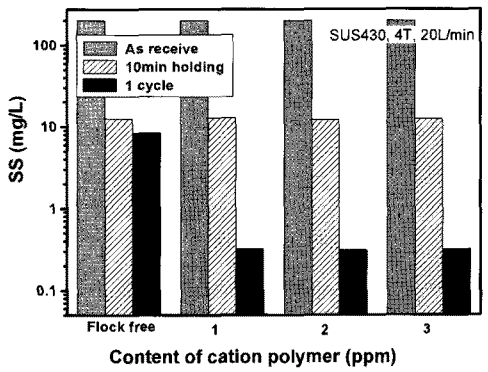
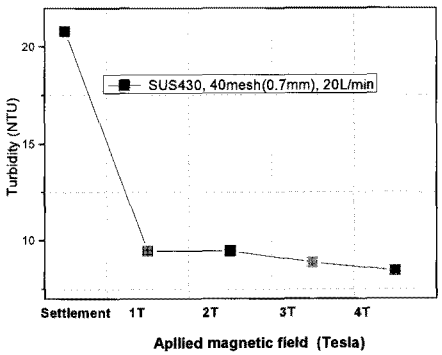


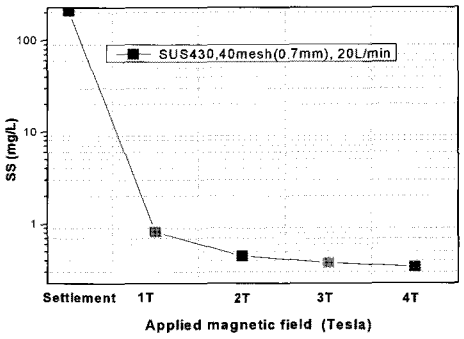
Fig. 7. High gradient magnetic separation removal rates of suspended solid properties of coolant wastewater after coagulation reaction coagulant.

0.3 mg/L showing the HGMS is quite effective for the removal of fine particles. It should be noted that the removal efficiency of the high turbid water is higher than that of the lower turbid wastewater. This can be possible coolant after coagulation reaction as the content of organic polymer, cation input in coolant.

In fig. 7, coagulation reaction in coolant had a distinct difference through the analysis of the concentration of SS.



(a)Turbidity removal as applied magnetic field.



(b) Removal rates of suspended solid properties as applied magnetic field.

Fig. 8. HGMS efficiency of coolant after coagulation reaction as applied magnetic field.

The concentration of suspended solid (SS) in purified coolant without coagulation reaction showed 8 mg/L. The concentration of suspended (SS) in purified coolant after coagulation reaction showed 0.3 mg/L. The removal rates of suspended solid (SS) were 99.9% at coagulated coolant and 96% at non-treated coolant. So coagulation reaction process was very effective to purify rolling coolant that contained magnetite particles.

Fig. 8 shows HGMS treatment efficiency of coolant wastewater as applied magnetic field. As increase of as applied magnetic field the high gradient magnetic separation, the concentration of turbidity and suspended solid (SS) water was decreased. Removing ratio showed over than 98% in the wastewater containing magnetic fines. These results were not satisfaction value because there was a little mistake during magnetic separation. For example, the size of iron oxide particles was too large, and it was difficult to remove of attached particle on mesh without particle down. Next experiment will be carried out well by the improvement on the basis of these results.

4. SUMMARY AND CONCLUSION

We manufactured high temperature superconducting HGMS system that had a purpose to treatment of coolant wastewater at hot rolling plate processes, a steel manufactory company in Korea. We investigated the ability of magnetic flock formation, which used inorganic materials and polymer coagulants. When cation polymer coagulant was added in coolant, the formation of magnetic flock was better than added much of it. High gradient magnetic separation system was used for removing of magnetized suspended solid. Removing ratio showed over than 98 % in the coolant containing magnetic fines as applied magnetic field at 4 Tesla.

ACKNOWLEDGMENT

This research was supported by a grant from foundation research program funded by Korea Electrotechnology Research Institute, Republic of Korea.

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