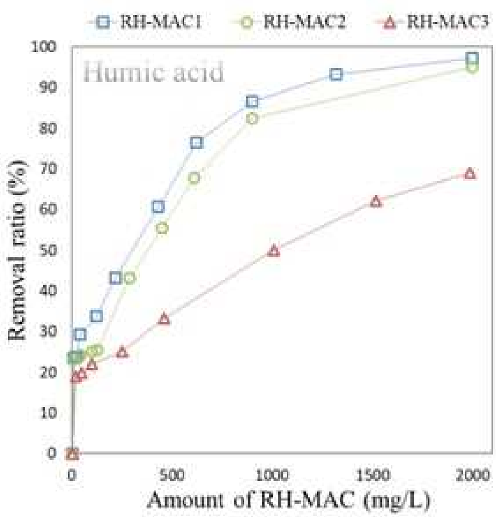
APP8-1

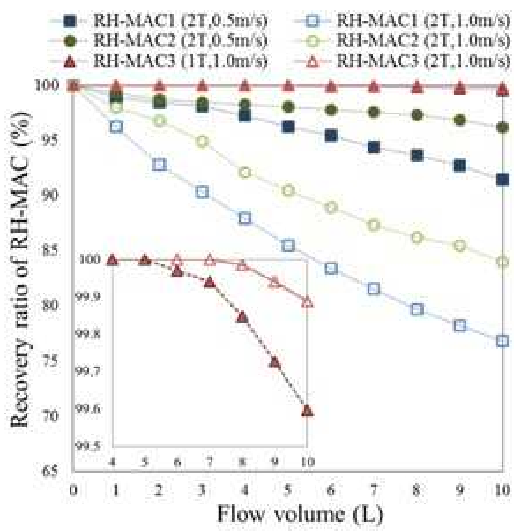
Removal of humic acid and hazardous heavy metals in water environment by magnetic separation utilizing rice hull magnetic activated carbon

*Keisuke Ishida[1], Tatsuya Shiina[1], Osuke Miura[1]

Dept. of Electrical and Electronics Engineering Tokyo Metropolitan University, Japan[1]

We have newly developed a rice hull magnetic activated carbon (RH-MAC) and studied its adsorption properties for humic acid, lead, cadmium, mercury and arsenic from water and its high gradient magnetic separation. RH-MAC had efficient adsorption properties for such hazardous materials. RH-MAC was synthesized by impregnating rice hull with an iron nitrate solution and heat-treatments in nitrogen and carbon dioxide atmosphere. In those processes, many meso-pores and nano-size magnetite were generated inside the activated carbon grains. The magnetization of RH-MAC increased with increasing concentration of iron nitrate solution. The magnetization of RH-MAC3 made from 1.6 mol/L iron nitrate solution reached 22.2 Am^2/kg at 1 T. RH-MAC was put into a humic acid solution of 25 ppm with a ratio of 0 - 2000 mg/L and stirred for 120 minutes. RH-MAC with the lowest magnetization showed the highest adsorption property for humic acid. The maximum removal ratio achieved 97.2% with a ratio of 2000 mg/L for RH-MAC1. RH-MAC with the lower magnetization also showed the higher adsorption property for lead. The maximum removal ratio achieved 98.3% with a ratio of 2000 mg/L for RH-MAC1. RH-MAC showed the similar adsorption properties for Cd. The maximum removal ratio achieved 99.3% with a ratio of 2000 mg/L for RH-MAC1. Likewise, for mercury and arsenic, RH-MAC showed effective adsorption properties. For magnetic separation studies RH-MAC3 having high magnetization of 22.2 Am^2/kg was magnetically collected of 99.4% by using the high gradient magnetic separation system with a rotary magnet drum with 0.5 T permanent magnets with the flow rates of 230 mL/min. Furthermore, 99.9% of RH-MAC3 **in water of 10 L was captured in the magnetic filter at the high flow speed of 1.0 m/s setting in a superconducting solenoid magnet of 2 T.** These results reveal that this system has a high potential for removal of humic acid, lead, cadmium, mercury and arsenic in water environment.





Keywords: Rice hull magnetic activated carbon, Hazardous heavy metals, Adsorption, Magnetic separation

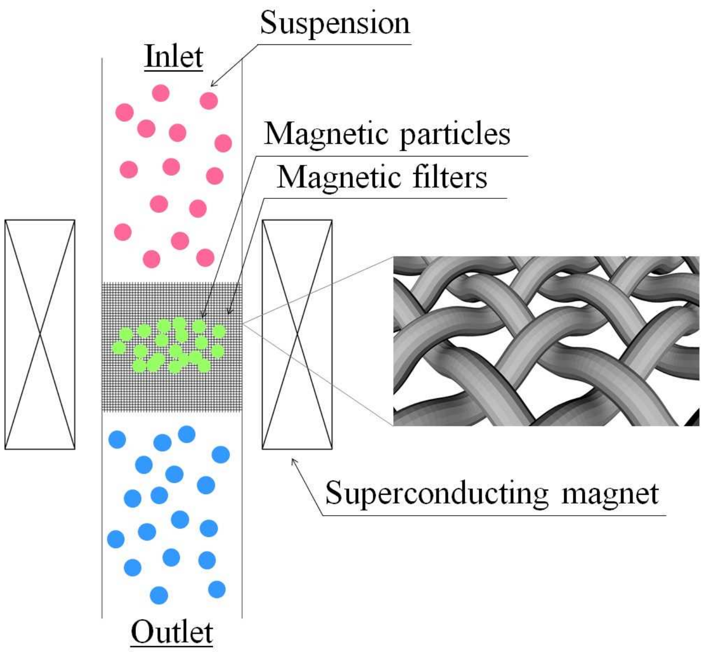
APP8-2

Numerical Simulation on Behavior of Magnetic beads in Magnetic Filter for Medical Protein Screening System using High Gradient Magnetic Separation

*Mikihisa Kubota[1], Yuki Mori[1,2], SeokBom Kim[2], Hiroshi Ueda[1]

Graduate School of Natural Science and Technology, Okayama University,Japan[1]
Okayama University,Japan[2]

Biopharmaceuticals are indispensable medicines for modern medicine aiming for treatment of serious diseases such as cancer and diabetes and research and development of biopharmaceuticals are actively conducted both in Japan and overseas. Especially, Antibody drug with high efficacy and low side effects, is expected to become the mainstream of future medicine. Indispensable technologies for development and practical application of this antibody drug are continuous, large amount and high speed separation or purification technology of medical protein. Therefore, we have proposed superconducting high gradient magnetic separation system (HGMS) for pharmaceutical protein. In this device, a medical protein is attached to the surface of magnetic beads, and then, capture with magnetic beads using the magnetic force generated around the magnetic filter disposed in the high magnetic field by the superconducting magnet as shown in FIG..
If high gradient magnetic separation device using superconducting magnet is realized, processing time of separation and purification work can be greatly shortened, and it is expected to greatly contribute to development and practical application of antibody drugs.
In the previous studies, it was successful to separate 200-nm magnetic beads suspended in pure water, with the result that the capture ratio was 97.8% and the collection ratio was 94.1%. However, depending on the type of the suspension, the clogging of the magnetic filter and non-trapping the magnetic nano-beads have been confirmed.
Therefore, in this study, the numerical simulation on the behavior of magnetic beads around the filter are carried out by using magnetic fluid analysis.



Keywords: magnetic separation , superconducting magnet, particle tracing

APP8-3

Magnetic separation system of boiler feed water scale in thermal power plants with superconducting magnet

*Hidehiko Okada[1], Noriyuki Hirota[1], Fumihito Mishima[2], Shigehiro Nishijima[2], Yoko Akiyama[3], Hidehki Matuura[4], Seitoku Nambu[4], Tomokazu Sekine[5]

National Institute for Materials Science, Japan[1]
Fukui University of Technology, Japan[2]
Osaka Universuty, Japan[3]
Shikoku Research Institute Inc., Japan[4]
Ebara Industrial Cleaning Co.,Ltd., Japan[5]

We are developing a magnetic separation system to remove scale from boiler feed water in thermal power plants with a superconducting magnet.
Most of electric power is generated by thermal power in the world and Japan. Thermal power plants discharge enormous amount of CO_2. Reduction of CO_2 is an important issue to prevent global warming. We expect that increment of energy conversion efficiency of thermal power plant reduces fuel consumption and discharged CO_2. A thermal power plant consists of steam turbine generators, boilers and a system to feed water to boilers. Used steam is condensed to water and supply to boilers again. Deposition of scale in the water circulation system and boilers degenerate energy conversion efficiency of thermal power plants. If we can reduce scale, we may decrease fuel consumption and discharged CO_2.
Scale consists of iron oxides. Iron is transferred from walls of pipes and devices to boiler feed water at low temperature (~ room temperature) and flows to the boiler. When temperature of water > 200℃, most of irons form magnetite (Fe_3O_4) and deposits on walls of pipes.
We expect that the magnetic separation system is required to treat large amount of water and run in high temperature and high pressure with low pressure loss. We adopt the high gradient magnetic separation that consists of a superconducting magnet and matrix. Feed water flows in a bore in the superconducting magnet and the matrix is located in the water. The matrix is constructed by metal wire sheets which are magnetized by the magnet and extract magnetite suspended particles from feed water by the magnetic force.
One candidate of the suitable install locations of the system is the drain of high pressure heater where a part of feed water flows and concentration of scale is high. The system is required to remove scale from 400 ~500 m3/h of water at 200℃ and 20 atm. A superconducting magnet is crucial for the system.
We examine some conditions of the system by experiments and simulation study. We found conditions when the system runs for long time without substantial drop of capture efficiency and increment of pressure loss. We estimated that, if the system is installed in a thermal power plant, capture ratio is higher than 90% for more than one month without significant increment of pressure loss.

Keywords: Magnetic separation, superconducting magnet, thermal power generation, global warming

APP8-4

Levitating separation of precious metals utilizing magneto-Archimedes effect in high gradient magnetic fields

*Kenichi Yamagishi[1], Daiki Yamamoto[1], Osuke Miura[1]

Electrical and Electronic Engineering, Graduate School of Science and Engineering, Tokyo Metropolitan University, Japan[1]

We propose a magnetic separation using magneto-Archimedes effect for valuable resources recovery from urban mine. Magneto-Archimedes effect is a phenomenon that materials levitate at a particular position in a paramagnetic liquid medium by applying magnetic field gradient due to the difference of magnetic susceptibility and density between the liquid medium and the materials. We had studied the magnetic levitation properties for various precious metals and electronic substrate powders etc. However, there are limits to the magnitudes of the magnetic field and the magnetic field gradient due to the realistic specifications of the current superconducting magnet, and therefore some metals that are difficult to levitate exist. In this study, we challenged the magnetic levitation of precious heavy metals by high gradient magneto-Archimedes effect utilizing ferromagnetic materials arranged in high magnetic fields. By setting the iron cylinder at the center of the superconducting magnet, *BdB/dz* increased from 434 T^2/m to 1060 T^2/m at the applied magnetic field of 10 T. As a result, all precious metals, including precious metals that were previously incapable of separating, levitated at own position. It was confirmed that the levitating position for of each material was almost the same as the theoretical one.

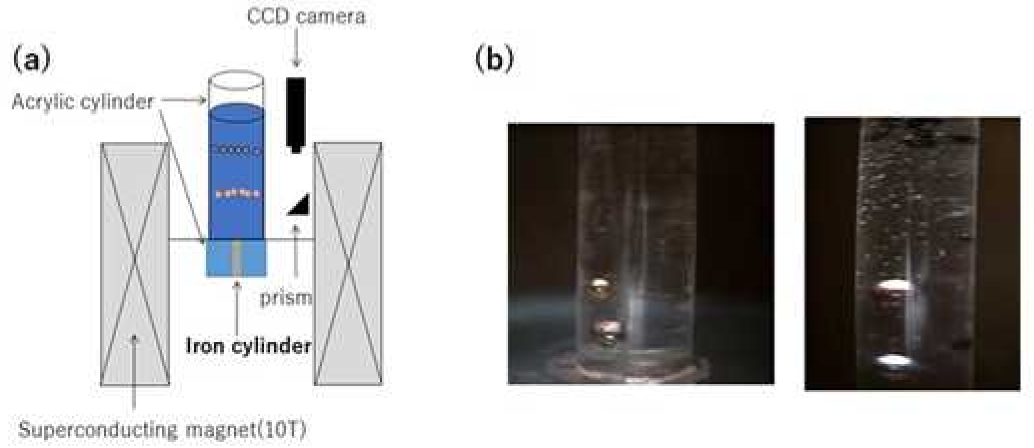


Fig. (a) Experimental device.   (b) Levitating precious metals (Au, Ag, Pt, Cu).

Keywords: magneto-Archimedes effect, valuable resource recovery, urban mine, precious metal