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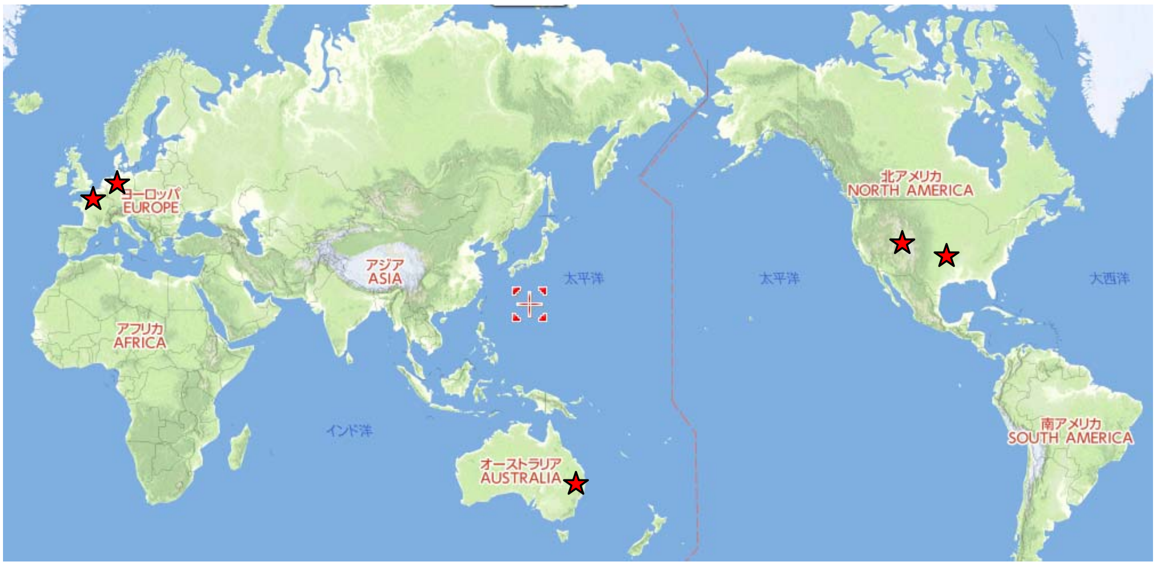
What's New in the World of Superconductivity

초전도 뉴스 -세계의 동향-

超电导新闻 −世界的动向−

chāo diàn dǎo xīnwén - shìjiè de dòngxiàng-

Yutaka Yamada, Principal Research Fellow
Superconductivity Research Laboratory, ISTEC



★News sources and related areas in this issue

▸Power Application 전력응용 电力应用 [diànlì yìngyòng]

RWE and Nexans Form Agreement for the Superconductor System

Nexans (12 March, 2015)

Nexans, RWE Deutschland AG and RWE Netzservice GmbH signed an agreement to exclusively market a cost-effective and innovative solution to meet the rising demand for electricity by selling superconducting power equipment system concept in Germany and other countries. The joint agreement between Nexans and RWE is made under a common project named "AmpaCity", which is funded by the German Federal Ministry for Economic Affairs and Energy. The system allows large high-voltage substations be removed from city centres and replaced with more compact medium-voltage systems, thus freeing up spaces for other urban developments.

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Frank Schmidt, Head of the Nexans Superconductor Activity is quoted as saying, "The rising demand for energy in urban areas, combined with the fact that space is an expensive asset in these locations, forces the move to powerful, space-saving electricity transportation." The technology has been developed and industrialised by Nexans over the last 15 years and thus the aim is to exploit the technological knowledge attained to advance customer projects in order to optimise the superconductor system as a whole.
Klaus Engelbertz, Managing Director of RWE Netzservice GmbH, states, "We have shown that the superconductor system concept is an innovative technology that has proven its practicality and suitability for daily use. From an economic perspective too, the superconductor can also represent a genuine alternative to conventional grid expansion. RWE and Nexans combine the necessary areas of expertise and experience to offer customers a suitable solution portfolio. These customers may require anything from a customised feasibility study right up to an entire superconductor system."

Source:"RWE and Nexans form exclusive joint agreement to promote the superconductor system concept to supply more energy to densely populated urban areas"(12 March, 2015)
Press Release
http://www.nexans.de/eservice/Germany-en/navigatepub_148782_-34273/RWE_and_Nexans_form_exclusive_joint_agreement.html
Contact: Jutta van Bühl, jutta.van_Buehl@nexans.com

SFCL in Augsburg Grid

Siemens (31 January, 2015)

Siemens is to install it's first single three-phase resistive superconducting fault current limiter (SFCL) in Stadwerke Ausburg's medium-voltage power grid, under a project called ASSiST, which is sponsored by the Bavarian State Ministry for Economic Affairs and Media, Energy, and Technology, as part of the German government's Innovative Energy Technologies and Energy Efficiency (BayINVENT) Program.

The SFCL will have a rated current of 817A, incorporating 2G HTS tape provided by AMSC, and providing a connection between Stadtwerke Augsburg's grid and an industrial company. An energy load with a maximum feed-in power of 15 MWt will be fed from the company's grid into Stadwerke's grid. Development and installation are to be completed by the fall of 2015. Siemens aims for a permanent installation after the formal completion of the project.

In normal operation, up to 1,100 MWt of electricity are lost worldwide due to the use of SCLRs, which have been the standard industry method for handling short circuits. Siemens notes that these losses could be reduced by 50 % or more through the use of SFCLs, even considering the energy they require for cooling purposes.

Source: "Siemens to Install SFCL in Augsburg Grid"
Superconductor Week (31 January, 2015)

MgB_2 Wind Turbine in Australia

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University of Wollongong (31 December, 2014)

A research group based at University of Wollongong (UOW), in collaboration with Hyper Tech Research, Inc., is developing offshore wind turbines using MgB_2 coils for a direct drive generator that they anticipated will offer greater efficiencies at approximately one-third of the price of other proposed superconducting models, eliminating the need of a turbine gearbox. This superconducting technology would reduce the size and weight of the generator by 40 %.

The aim of the project is to construct offshore superconducting 10 MW wind turbine systems (tower, generator, blades, and power electronics) for less than AU$15 million ($12.4 million). The project is funded by the Australian Research Council under the Discovery Early Career Researcher Award (DECRA) program.

Shahriar Hossain, leading researcher at the Institute for Superconducting and Electronic Materials at UOW is quoted as saying, "Hyper Tech is a longstanding partner and they are happy to work with us. We are also negotiating with the Korea Basic Science Institute (KBSI) and Korean industry. If government and industry support is available, then it will be possible to install machines within five years." He also commented, "The future projected cost of AU$1 to AU$2/meter ($0.80 to $1.6/meter) for MgB_2 can be compared to the future projected cost of AU$20 to AU$25/meter ($16 to $20/meter) for HTS. Nb-based low temperature superconductors might be a good option but cannot operate without liquid helium, which is becoming costly."

The UOW team plans to sell the generators at AU$3 to AU$5 million ($2.5 to $4.1 million) each. The approximate amount of superconductor wire required for the rotor coils of a direct drive 10 MW generator ranges between 50 to 200 km depending upon the wire or tape size and I_c capabilities. Estimating a projected requirement of 200 km of YBCO-type conductor, the cost maybe as high as AU$4 to AU$5 million ($3.2 to $4.1 million). Hyper Tech projects that the same 200 km length of MgB_2 superconducting wire will cost about AU$200,000 to AU$400,000 ($164,000 to $328,000) within five years.

Source: "UOW Designing Inexpensive MgB_2 Wind Turbine"
Superconductor Week (31 December, 2014)

▸Basics 기초 基础[jīchǔ]

High Magnetic Fields to Probe HTSC Theory

Los Alamos National Laboratory (26 March, 2015)

Researchers based at Los Alamos National Laboratory are exposing high-temperature doped copper-oxide superconductors to very strong magnetic fields in excess of 90 T, modifying the superconducting transition temperature. An unresolved problem in the field of high-T_c superconductors has been to understand what drives the high-T_c's in these materials and whether this occurs at a quantum critical point, where quantum fluctuations lead to strong electron-electron interactions.

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Brad Ramshaw, the lead researcher on the project, is using the world-record high magnetic fields available at the National High Magnetic Field Laboratory (NHMFL) Pulsed Field Facility, based in Los Alamos in order to “pave the way to a new theory of superconductivity.”

High-temperature superconductors, such as yttrium barium copper oxide ($YBa_2Cu_3O_{6+x}$), cannot be explained with BCS theory. By optimally doping $YBa_2Cu_3O_{6+x}$, the researchers found that the electrons move around in a correlated way. “This tells us that the electrons are interacting very strongly when the material is an optimal superconductor,” said Ramshaw. Proof of a quantum critical point has yet to be found, but if it can be shown then this would constitute a significant milestone toward resolving the superconducting pairing mechanism. The Los Alamos team measured magnetic quantum oscillations as a function of hole doping under strong magnetic fields in excess of 90 T, enabling quantum oscillations to be measured very close to the maximum in the transition temperature T_c ~ 94 K. The research findings show that there is a strong enhancement of the effective mass at the optimal doping point, which signifies increasing electron interaction and potentially the quantum critical point. The broken symmetry responsible for this point has yet to be pinned down, although a connection with charge ordering appears to be likely, Ramshaw notes.

Source: ”Using magnetic fields to understand high-temperature superconductivity”
(26 March, 2015) Press Release
http://www.lanl.gov/discover/news-release-archive/2015/March/03.26-high-temperature-superconductivity.php
Contact: Nancy Ambrosiano, nwa@lanl.gov

▸Management and Finance 경영정보 经营信息[jīngyíng xìnxī]

HTS Customer Increased to 31

Superconductor Technologies Inc. (11 March, 2015)

Superconductor Technologies Inc. (STI) reported results for the quarter and year ended December 31, 2014. Jeff Quiram, STI's president and chief executive officer, stated, "During 2014, we achieved key milestones in wire performance, customer development and deployment of high capacity production equipment. These important accomplishments position STI to complete the customer qualification activities necessary to secure commercial customer agreements and to then produce Conductus® wire on a commercial scale in the coming months."

STI's fourth quarter 2014 net revenues were $82,000 compared to $86,000 in the third quarter of 2014 and $150,000 in the fourth quarter of 2013. Revenue for all periods was mainly from legacy wireless products. Net loss for the fourth quarter 2014 was $2.8 million, compared to a net loss of $2.4 million in the third quarter of 2014, and a net loss of $3.9 million, in the fourth quarter of 2013. Net revenues for 2014 were $632,000, compared to $1.7 million for 2013. The net loss for 2014 was $8.3 million, compared to $12.2 million for 2013. As of December 31, 2014, STI had $1.2 million in cash and cash equivalents.

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During the quarter STI shipped Conductus wire to nine customers: four new and five existing. Of these customers, six are in Stage 1 evaluation, which includes wire characterization and performance testing, and three are in Stage 2, which involves significantly more rigorous testing to simulate devices for commercial deployment. At the beginning of March 2015, STI successfully shipped 500 Amp Conductus wire as part of the high power superconducting cable demonstration project, which aims to utilize many strands of Conductus wire in a live test environment. Global electrical equipment companies are selling SFCLs to power utilities. The transition from pilot production to full production will enable STI to meet the industry challenges of price, performance and availability facing the HTS wire market today. Doubling customer count from 15 to 31 during 2014 expanded the company's customer base.

Source:"STI Reports 2014 Fourth Quarter and Year-End Results"
(11 March, 2015) Press Release
http://phx.corporate-ir.net/phoenix.zhtml?c=70847&p=irol-newsArticle&ID=2024521
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Feature Article: Advancements in Superconducting Industrial Equipment Technology
-Trends in Superconducting Industrial Equipment Technology

Yutaka Yamada, Principal Research Fellow
Superconductivity Research Center/ISTEC

The on-going development of a variety of superconducting equipment designed for industrial applications has led to some noteworthy achievements. For example, JR Tokai has made commercial operational plans of maglev trains travelling between Tokyo and Nagoya from 2027. The media has reported that construction has already started and steady progress has been made towards commercial operation. For clinical applications, trials utilizing superconductor technology have been focused on heavy-ion cancer therapy systems in addition to conventional MRIs. The author herewith introduces some recent progress of industrial equipment, omitting those that are published as feature articles in this Web21 issue.

High temperature superconducting motors feature as a promising technology that can reduce motor losses, which account for more than 60 % of the electrical power consumed by industrial sectors. Initially, research and development was mainly advanced by the USA and aimed at large scale motors for industrial use. Later, the focus shifted towards low speed, high torque motors for ship propulsion systems with the development and experiments for large-scale motors undertaken in USA, Germany, Japan and Korea. In Japan, Kawasaki Heavy Industries and the Tokyo University of Marine Science and Technology have actively led R&D for ship propulsion motors over the past few years. For such particular applications, a prototype superconducting motor utilizing Bi-based wires has been fabricated and tested, successfully realizing a high efficiency of 98 % and with specifications of 3 MW of output power and 160 rpms [1). Professor Nakamura, based at Kyoto University and Sumitomo Electric Industries, has been also working on superconducting motors for the next-generation electric vehicles.

Whilst the above-mentioned maglev train employs low temperature superconductors for its operation, the Railway Technical Research Institute has been investigating coils fabricated from Y-based wires for maglev, DC power feeder and flywheel applications. Furukawa Electric has successfully fabricated a Y-based coil applicable to the flywheel [2)]. Future plans involve integration trials with a mega solar power plant, which will be newly constructed at Komekurayama, Yamanashi prefecture in 2015.

Industrial applications involving renewable energies have been actively pursued by Europe and USA in particular over the past few years. The application of superconductor technology in this field has been studied as a route for large power generation by utilizing large-scale wind turbines. Large-scale wind turbines exceeding 10 MW (2 MW max of current commercial wind turbines) have a detrimental mechanical drawback in their design and operation since they have to support the weight of a generator mounted at the top of the turbine, which can be over several hundred tons. The use of superconductor technology would significantly reduce the weight of the generator and therefore make it more compact. In Europe, the development of superconducting wind turbines have been launched under projects named, SupraPower and InnWind, (10-20MW-class superconducting wind turbines have been investigated, with participation by Siemens etc). In Japan also, in 2013, NEDO led a project entitled “Advanced Practical

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Research and Development of Wind Power Generation/Research on Over 10MW-Class Wind Turbines Generators (AIST etc)" [3]. The project aims to fabricate a power generator comprising Y-based wires and the utilization of iron core can reduce the volume of wires required. Future potential points to a 50 % reduction in size/weight compared to a normal conducting generator and costs reduced to more practical levels [3].

A new concept of renewable energy applications has also arisen, referred to as wind heat power. For further details of this technology please refer to the article by Okazaki, ISTEC, in latter part of this Web21 issue. Wind heat power systems stores the energy derived from wind power by transforming energy to heat. By exploiting superconductor technology in the heat storage tank of the system, a superconducting coil could enable greater heat storage at high temperatures in excess of 600 °C, leading to a significant efficiency enhancement.

Professor Nishijima based at Osaka University, has studied superconducting magnetic separation. During the past several years, on site demonstration trials have been conducted to verify the effectiveness of magnetic separation technology in actual contaminated sludge in Fukushima.

As mentioned in this article, the range of superconductor applications has broadened remarkably leading to greater anticipation for their effectiveness in potential industrial applications. In particular, the utilization of renewable energies is currently an issue imposed upon us. The author believes that superconductor technology has significant potential to contribute to the future society.

References:

1) NEDO Research Outcome for the Development of Ship Propulsion Motor System
http://www.nedo.go.jp/library/seika/shosai_201405/20140000000056.html
2) Furukawa Electric Press Release "Successful Development of a High Temperature Superconducting Magnet for Next Generation Flywheels"
https://www.furukawa.co.jp/what/2014/kenkai_140310.htm
3) AIST R&D on High Temperature Superconducting Large-scale Wind Turbines
https://unit.aist.go.jp/energy/event/20140305/proc/B2.pdf
http://semrl.t.u-tokyo.ac.jp/supercom/128/128-2.html

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Feature Article: Advancements in Superconducting Industrial Equipment Technology -High-Temperature Superconducting Motors for Ship Propulsion Systems

Mitsuru Izumi, Professor
Department of Marine Electronics and Mechanical Engineering
Tokyo University of Marine Science and Technology

Electric propulsion ships offer superior advantages including reduced environmental impact, better economic prospects, ship maneuverability, safety, less vibration and greater energy savings. These beneficial characteristics have been actively applied to research vessels, tankers and cruise ships, and their market diffusion has been trialed in Japan. Prospective electric motor ship propulsion systems have conceptually been DC motors and unipolar machines, in addition to induction and synchronous machines. Here, key technological developments have dedicated at constructing compact and lightweight motors with high torque densities, power output densities and greater efficiencies at low-load operations, all attained by elemental development in high temperature superconducting field poles [1).

A 36.5 MW synchronous motor designed for ship propulsion systems, developed by AMSC in USA and a 4 MW-class ship propulsion motor (HTS III) developed by SIEMENS in Europe, have both led in full power system/load testing and long-term durability testing trials.

With recent heightened interest in ocean development engineering, the expectation has again focused on superconducting motors which can deliver energy savings and also compact propulsion systems that can be utilized for work/offshore vessels and icebreakers used in offshore oil and gas development. Kawasaki Heavy Industries have developed racetrack coils employing bismuth-based wires, producing a 3 MW, 160-rpm radial-gap superconducting synchronous motor [2). Present efforts are focused on practical applications, undertaking trials using ground-based facilities, determining performance characteristics for coil applications and establishing power output performance attributes [3). Research on the fabrication of a prototype system with large-scale output characteristics is necessary to demonstrate the remarkable advantages afforded by superconducting motors for ship propulsion systems. In Japan, research has progressed towards systems having greater outputs, and JST's Strategic Promotion of Innovative Research and Development (S-innovation) program has led the way with demonstration studies conducted for key technological components to establish 20 MW-class large output superconducting synchronous machine. The key technological components demonstrated in the program include robust high-temperature superconducting coils and their associated protection measures and thermosiphon-type rotor cooling systems [4). As mentioned above, the numbers of developmental cases undertaken by both Japan and overseas have increased. The author believes that R&D will become more influential in defining the reliability and safety of large-output propulsion systems, whilst further research is continuously dedicated towards the design of high temperature superconducting motors and associated technological components.

References:

1. Mitsuru Izumi, Progress in Technology Development for Superconducting Motors Designed for Ship Propulsion Systems
http://www.istec.or.jp/web21/pdf/13_03/all.pdf

2. Kawasaki Heavy Industries, Ltd.(2013)
http://www.khi.co.jp/english/pressrelease/detail/20130529_1e.html

3. Tamami Oryu, Current Development of Superconducting Motors for Ship Propulsion Systems, “Electrical Propulsion Ship; Present Status and Future Technological Trends” at the Tobu Branch Workshop, The Japan Society of Naval Architects and Ocean Engineers, 10 Dec, 2014

4. Osami Tsukamoto, Development of Key Hardware For Large-scale Superconducting Rotating Machines, JST Symposium for Strategic Promotion of Innovative Research and Development Program, Creation of Advanced Energy/Electronics Industry by Superconducting Systems”, 15 Dec, 2014

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Feature Article: Advancements in Superconducting Industrial Equipment Technology -Decontamination Technology for Naturally Occurring Soil Contamination Using Superconducting Magnets

Shigehiro Nishijima, Professor
Graduate School of Engineering, Osaka University

Kajima Corporation has established a novel decontamination technology employing a superconducting magnetic separation system, able to segregate naturally occurring arsenic contaminant in wasted soil at the shield tunneling construction. The author regards this technology as significant and is therefore introduced herewith.

Recent years has seen problematic pollution due to naturally occurring heavy metal contaminants in wasted soil at construction sites. Future construction plans expected to get underway include underground railways/roads and the Tokyo Olympics taking place in the capital city, in addition to large-scale construction projects such as the Chuo maglev in the near future. It is therefore projected that naturally occurring contaminated soils will pose challenging problems for environmental remediation in the future. Here, heavy metals are defined in the Environment Quality Standards for Soil Pollution as cadmium, lead, hexavalent chromium, arsenic, mercury, copper, selenium, fluorine, boron etc. Arsenic, fluorine, and boron are categorized as heavy metals even though they are not chemically metals as such [1)]. So where do these heavy metals originate? Compared with the elemental composition of the entire continental crust, the mean value measured at the upper crust of the Japanese islands is mainly lead and arsenic. However, zinc, lead and arsenic dominate the mean values measured from river sediments [2)]. The Japanese islands have volcanoes/hot springs and mine/ore deposits signifying the potential existence of naturally occurring heavy metals. The mines generate arsenic, cadmium, lead etc., whilst hot springs generate boron and arsenic. Granite and serpentine generate fluorine and chromium, respectively. Seawater generates boron and fluorine, whilst marine sediments generate arsenic, lead, and fluorine [3)]. Thus, the possibility exists for the entire Japanese archipelago to be potentially contaminated with naturally occurring heavy metals. Reference 2 shows the vital fact of how arsenic, lead, mercury, cadmium and chromium are dispersed throughout Japan, proving that it is fundamentally widespread [2)].

There were 31 out of 78 actual cases where heavy metal contamination was deemed as naturally occurring (case studies taken in October 2002) [4)], with arsenic as the majority contaminant, followed by lead, fluorine and mercury. These results may not reflect the entire situation of Japan since the four types of contaminants namely; arsenic, lead, fluorine and mercury are common and occur naturally. Based on the numbers of districts requiring action and categorized by specific toxic substances in FY2012 [5)], which includes anthropogenic cases, the numbers of unacceptable (pollution) heavy metal contamination cases (type 2), includes cadmium, lead and mercury making up over 80 % of the total pollutants. It is therefore understood that the high frequency of soil contamination is due to heavy metals.

There are two kinds of Environment Quality Standards for Soil Pollution, namely, soil elution standards and

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soil content standards. Naturally occurring heavy metal contaminated soils actually exceed the soil elution standards [6]. Some cases involving arsenic exceed the soil elution standards when measured in sedimentary rocks, alluvium coastlines and diluvial plains, where the arsenic contamination level is not considered high (less than soil contents standard) [2]. The Japan Soil Treatment Association estimates that by 2022 the volume of naturally occurring heavy metal contaminated soil required to be decontaminated will be around 3~5 million tons annually [7]. The author summarizes the above mentioned herewith, i) potential problems associated with naturally occurring heavy metal contaminated soil in Japan nationwide, ii) arsenic, lead, fluorine and mercury can be problematic, iii) it is necessary for construction works to meet soil elution standards, and iv) the expected large volumes of potentially contaminated soils to be remedied.

With these issues in mind, Kajima Corporation and MS Engineering have jointly developed a superconducting magnetic separation system designed to decontaminate naturally occurring arsenic [8]. The technique extracts arsenic (and lead) contained within industrial sludge at construction sites by a shield method. Conventionally, this waste goes through a decontamination process utilizing coagulation method by precipitating out the contaminated soil and heavy metal as a dehydration cake. Cleaning contaminated soils by this method is extremely expensive, because of large volumes of contaminated soil to be treated. Additionally, there are demand constraints issues with intermediate treatment plants such as controlled landfill sites and cement factories. The new method developed here is able to address such shortfalls. The method involves mixing the sludge with Fe powder, which acts as an arsenic absorbent, and then magnetically separating the arsenic-iron powder using superconducting technology. The Fe powder (particle diameter about 120 μ), which is injected into the sludge absorbs the eluted heavy metal ions from the soil. The mechanism is explained as follows. The oxidized arsenic close to the ground surface becomes pentavalent arsenic ions [9]. These ions are anionic $H_2AsO_4^-$ or $HAsSO_4^{2-}$ in the pore water with a soil pH of 4~8 [1]. The understanding is that Fe powder dissolved in water forms Fe ions, which reattach to the surface of the Fe powder as a hydroxide, thereby capturing arsenic ions in the process. Soil decontamination using this method has actually confirmed that soil elution standards were met in 150 m^3 contaminated soil.

Next, an important issue is to recover the Fe powder that is absorbed by this heavy metal ion. Here, superconducting magnetic separation was employed to effectively recover the Fe powder from the sludge. When the Fe powder was suspended at approximately 30 % of the soil weight, with the As elution density reduced to around 1/10, with actual measurements confirmed to be 0.092 mg/L max before treatment and <0.005 mg/L after treatment. (Environmental elution standard of As and As compounds are set as 0.01 mg/L.) However, a key technological requirement of this novel method was to enhance the recovery rate of the Fe powder because of the large volumes of Fe powder required. Figure 1 shows an outline view of the system. The installation of a

Fig. 1 The Superconducting Magnetic Separation System Developed

magnetic filter outside of superconducting magnet is required for the purpose of high volume remediation. The magnetic field domain close to the magnetic filter therefore broadens although the magnetic field strength is low at around 0.2 T. Favorable recovery rates (over 99.9 %) and high throughput (over 60 m^3/h) are realized. The recovery rate was realized with 10~20 mnts of contact time of the Fe powder with the sludge. Also, it was confirmed that the Fe powder did not experience degradation in performance even after recycling it 75-times. The author sees that the results could vary depending on the density of the targeted sludge. However, it is clear that the Fe powder can be recycled several times in case of naturally occurring arsenic elution density. (The saturation of Fe absorbent is considered as around 0.5~1.0 g/kg).

In addition to this technique other competing technologies have been proposed and include a centrifugal separator to recover Fe powder and magnetic separation by permanent magnets etc. Whilst we should closely watch these emerging technologies and whether they become mainstream techniques of the future, the author highlights the considerable advantages afforded by utilizing superconductor technology, which can process large volumes of contaminated soils.

References:

1. Shin-Ichiro Wada, Dynamics of Heavy Metals in Soils and its Global Environment 15 (2010)15-21
2. Homepage on Recycling by Ministry of Land, Infrastructure, Transport and Tourism – Press release, standards, manuals, Countermeasures act manual for naturally derived heavy metal contaminant rock/soils during construction works
3. Japan Gas Appliances Inspection Association HP, Investigation of Soil contamination and the necessary countermeasures
4. Ministry of the Environment HP, Methods and justification to determine whether or not soil contamination is specified as naturally occurring poisonous material. Appendix-3
5. Ministry of the Environment HP, Implementation of soil contamination countermeasures acts, soil contaminant studies and results from countermeasure cases undertaken in FY2012
6. Chihiro Inoue, Elucidation of Form Change of Naturally Derived Heavy Metal Soil Contaminants in the Environment, Research conclusions of the Environment Research and Technology Development Fund FY2013 5B-1107
7. Environmental News 2014/10/22
8. Keijiro Ito, Junichi Kawabata, Takefumi Niki, Application of Iron Powder and Magnetic Separation to Extract Arsenic from Muddy Water, The 20th Research Meeting on the groundwater/soil contamination and their protection measures (2014)S1－03
9. Chemicals Evaluation and Research Institute, Japan, CERI Hazard Assessment Reports: Arsenic and its inorganic compounds (2008)

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Feature Article: Advancements in Superconducting Industrial Equipment Technology
-Development of Superconducting Magnets Designed for Magnetic Field Characteristic Measurements

Takeshi Kato, General Manager
Superconductivity Technology Division,
Sumitomo Electric Industries, Ltd.

B-H curve tracers [1)] and vibrating sample magnetometers (VSM) [2)] are currently employed for scaling magnetization characteristics. There are several issues associated with such conventional systems and include, ① an iron-core type normal conducting coil cannot measure a high-coercive magnet, ② measurements utilizing pulsed magnetic fields are significantly influenced by eddy currents, and ③ the extensive measurement time taken by conventional superconducting magnets.

To address such issues, the author and his research team have developed a cryocooled superconducting magnet system [3)] that utilizes DI-BSCCO wires. The weight of the system has been successfully reduced to 1/4 that of a conventional system, and also the dimensions have been significantly downsized by 1/5, having 0.8 m depth, 0.3 m width, and 0.3 m height. Furthermore, greater magnetization/demagnetization speeds of 6T/30 seconds have been attained, which is around a 20 % improvement from the current record of 5T/30 seconds realized by a conventional system. The system has been developed taking into account potential applications where magnetic characteristic measurements are performed as part of the inspection process of a permanent magnet. Other prospective applications include hard disk inspection systems and manufacturing lines such as in-field heating furnaces.

【Summary of a superconducting magnet system】

Model	DI-BSCCO-MS 6 T-70
Field Strength	±6 T
Room temperature bore diameter	Φ70 mm
Magnetization/demagnetization speeds	6 T/30 sec.
Operating current	250 A
Inductance	About 1 H
Field homogeneity	0.3 %/10 mmDSV
Dimension	0.8 m×0.3 m×0.3 m
Weight	About 100 kg

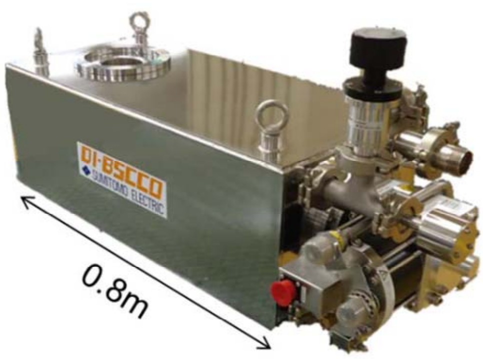

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Figure 1 shows the data attained by repeated high-speed magnetization/demagnetization process. Although AC losses due to repeated magnetization/demagnetization increases the coil temperature, stable operation is confirmed since the large temperature margins due to high critical temperatures do not trigger superconducting quenching, a typical characteristic of a high temperature superconductor. Additionally, various operations can be realized here for example when the cryocooler stops operation; there is no vibration due to the cryocooler during the magnetization/demagnetization process. Initial cooling of the magnet developed takes around 14 hours. If this was switched on before going home on the previous day, the operation will be ready the following morning. The short time cooling makes possible for cooling whenever required.

Figure 2 shows an example of a VSM measurement, demonstrating the clear BH loop trace for a small sample such as a pencil tip. Precise measurements were successfully made in around 6 minutes of measuring time, which is remarkably quicker compared to the conventional systems.

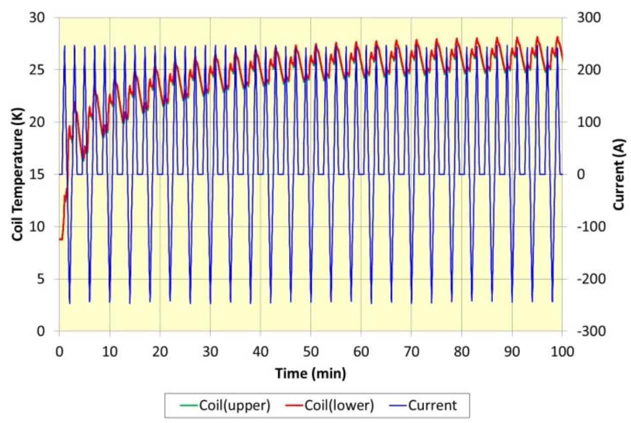

Fig. 1

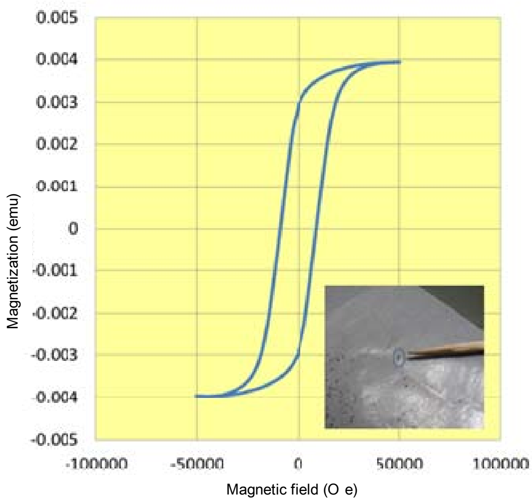

Fig. 2 An example of a VSM measurement performed at Toei Industry Co., Ltd. (SmCo micro piece)

Reference:

(1) http://www.j-ndk.co.jp/product/jikisokutei/bh_curve_tracer.html#sub_03
(2) http://www.toeikogyo.co.jp/products/sei-01/vsm-5hsc.html
(3) http://www.sei.co.jp/super/magnet_coil/system.html#6t

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Feature Article: Advancements in Superconducting Industrial Equipment Technology
-The Current Status of Superconducting Heating Furnace

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1. Induction heating furnace

There are superconductor technology and heating furnace. A high-temperature heating furnace employing superconductor technology requires cryogenic cooling, and current thinking automatically assumes that such furnaces are not compatible even with “high-temperature superconductors (-200 °C)”. However, this technology has actually reached a stage prior to potential industrial commercialization. The author provides a summary and the current status herewith.

Aluminum extrusion manufacturing requires a columnar aluminum block as the raw material. The block is inserted into an extruding machine and shaped similar to extruding pasta. The block however, solidifies at room temperature and therefore a huge extruding machine is required. Here, heating to the necessary temperature before melting makes the block softer, thus making extrusion easier. A conventional heating process employs either gas or induction heating. Whilst gas-heating facilities are relatively cheap, the downside is the long time it takes to heat and therefore running costs are higher due to poor energy efficiencies.

Induction heating utilizes the electromagnetic induction phenomenon, similar principle to an IH cooking heater that you find in homes. An IH cooking heater is heated using AC field generated from the coil, “typically” achieving high heat efficiencies. However, just like an aluminum frying pan is not suitable for IH cooling heater, industrial induction heating is not compatible with heating aluminum. Aluminum and copper exhibits a similar level of resistance as the coil, and thus the same degree of heating as the metal block within the coil. The theoretical efficiency is therefore less than 50 %.

2. Superconducting furnace

Contrary to an induction furnace, a superconducting inductance furnace has a different approach. A constant magnetic field is generated instead of an AC-generated field using coils. Adoption of a permanent magnet with a constant magnetic field is suitable, but even lower power consumptions can be realized using electromagnets. A metal block can be forcefully rotated in this constant magnetic field. Eddy current flow leads to heating when the conductor moves in a magnetic field. This is also described as rotational induction heating (Figure 1).

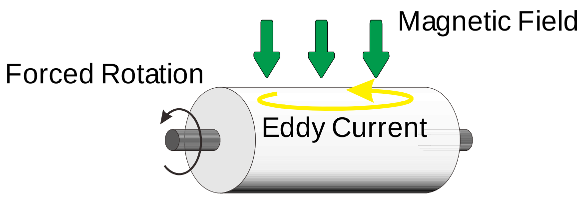

Fig. 1 Rotational induction heating

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If the heated metal block has magnetic properties, the block is then attracted by the magnetic field (this is not shown in Figure 1) either top or bottom of the magnetic poles. This method has been known for some time. In the case of non-magnetic aluminum, the system efficiency deteriorates due to the higher powers consumed to form the magnetic field in a large space. This has prolonged the realization of a system for practical use.

Now, superconductor technology can address this issue. Superconductor technology, which is well known in MRI applications, can generate strong magnetic fields in large spaces with little power consumption. A factory furnace requires robust heating properties since the furnace is installed close to the metal block rotating at 500 revolution/minute. A superconducting furnace for practical use, utilizing high temperature superconducting technology was realized for the first time. Figure 2 shows the superconducting furnace in operation. The power consumption was halved compared to conventional induction heating, and was therefore highly anticipated for further market diffusion because of its advantageous energy saving attributes. Several unit systems are currently in operation mainly in Europe, however, it is unfortunate that the systems are not more widespread than this. One of the possible reasons behind this could be due to a decrease in aluminum extrusion demand. In Japan, peak demand was around 2000, but is now decreasing gradually (Figure 3). The situation now with surplus facilities, has put off new system installation, even though employing a superconducting furnace can attain lower running costs. However, China is significantly increasing their aluminum demand, but they currently struggle since the high initial facility investments are not in their favor.

Fig. 2 Superconducting furnace in operation. Unaware of the underlying high-tech superconductivity.

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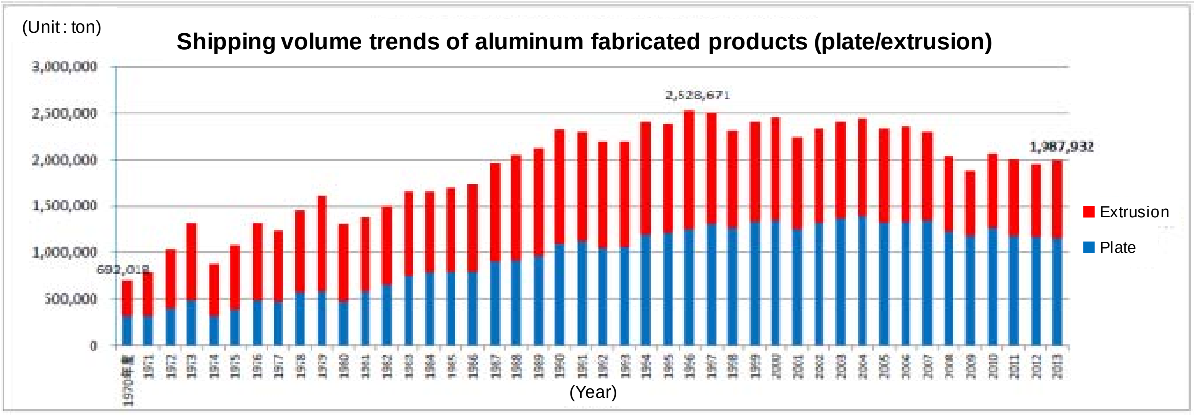

Fig. 3 Shipping volume trends of aluminum fabricated products (plate/extrusion).
From Japan Aluminum Association HP

3. Wind Heat Power Applications

The current proposal is to apply this superconducting furnace technology to renewable energy applications. This is called Wind powered Thermal Energy System (WTES. Renamed from WHP), and aims for utilizing a cheap heat storage system in order to safeguard a stable supply of power. However, heat to electric conversion rates are currently low at around 40 %, which compares to around 70 % for conventional battery storage. However, from the viewpoint of cheaper construction costs, power generation costs can be halved compared to power plants utilizing battery storage. Here, employment of a superconducting furnace can realize operations at such high temperatures where magnetism does not exist. An efficiency of 60 % is foreseeable for gas turbines that are driven at over 1000 °C. Economic projections become important as facility costs increase. Although not essential for this article, gas turbines can be classified into either internal and external combustion types. A supercritical CO_2 gas turbine is now under development, aiming for 50 % efficiency at 700 °C and having a 10 MW power output.

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