July, 2015 Date of Issue: July 15, 2015

Superconductivity Web21

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Contents:

Top of Superconductivity Web21

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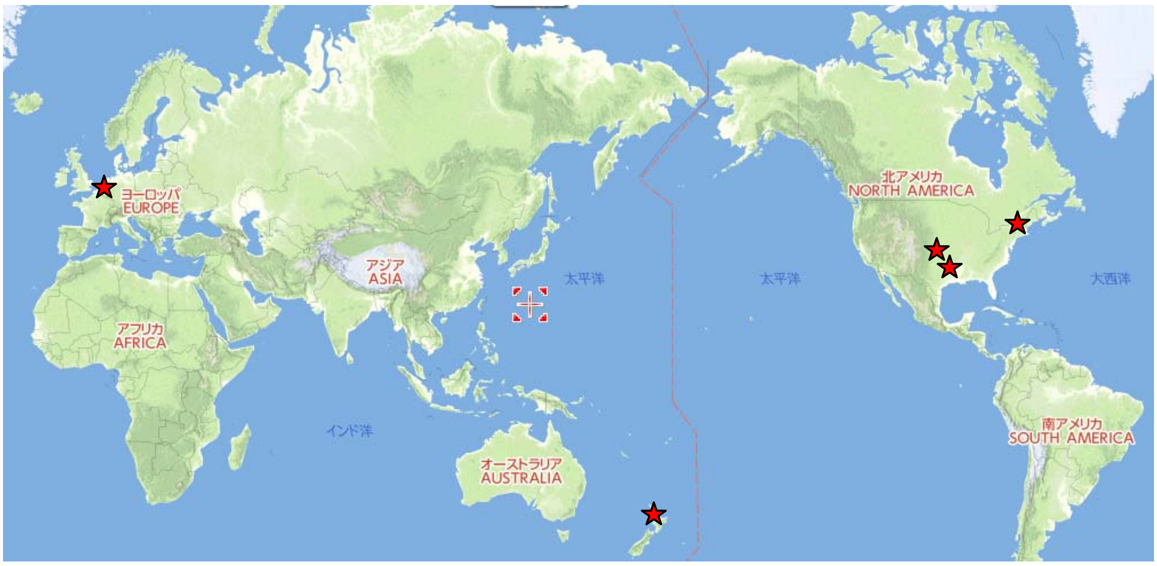
What's New in the World of Superconductivity

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]

New LN_2 Refrigeration System for the "AmpaCity" HTS Cable Project

Messer Group (14 April, 2015)

Industrial gases specialist Messer, has developed a new liquid-nitrogen cryogenic refrigeration technology to cool superconducting cables for the "AmpaCity" project of the energy supplier RWE. This technology offers numerous benefits over the originally envisaged cooling system using Stirling engines. It involves vaporizing nitrogen at below atmospheric pressure, thereby allowing a temperature of -209 °C to be attained and thus meet cable specifications. At this temperature, the refrigerated nitrogen offsets the heat absorbed by the AmpaCity superconductor cable from its surroundings making it possible to transport electricity with almost zero losses. Further cooling is not possible since nitrogen freezes at -210 °C.

"AmpaCity" now qualifies as one of the projects for KlimaExpo.NRW, an initiative from local government in North-Rhine Westphalia and Germany's Federal Ministry for Economic Affairs and Energy. A part of the pilot project involves commissioning the longest superconducting cable, which was trialed in Essen in April 2014. Superconducting cables are able to transport 5-times the amount of electricity through cables having the same cross-section with relatively low voltages. Additional to reducing energy losses, there are anticipated savings on both cost and space for both operators and communities.

Dr. Friedhelm Herzog, Messer's specialist for gases applications in the industry, was quoted as saying that the apparatus used had to undergo rigorous procedures, the principal of which was the safety of the construction and its reliability in operation. For plant safety, the liquid nitrogen supply tank is also used for venting purposes so that liquid nitrogen can be flushed from the cable in the event of the cable suffering damage, rather than it escaping uncontrolled into the environment. The routing system responsible for plant safety is being patented. For system reliability, all pumps and critical fittings have redundancy built in, which also allows maintenance to be undertaken whilst the system is in operation.

The project is drawing immense interest from the media, from politicians and from experts in the field.

Source: "Minus 209 degrees Celsius: New cryogenic technology enables transmission of electricity almost lossless" (14 Apr, 2015) Press Release
http://www.messergroup.com/de/Presse/wpresse/150414_minus-209-grad-celsius_neue-kuehltechnologie-ermoeglicht-nahezu-verlustfreien-stromtransport/index.html
Contact: Diana Buss, Diana.buss@messergroup.com

HTS Power Transformer

Fabrum Solutions (22 May, 2015)

Christchurch hi-tech manufacturer Fabrum Solutions, have developed a HTS power transformer that is environmentally friendly, safe and reduces energy losses compared to conventional transformers.

The industry-led collaboration that includes Victoria University and others, shows that energy losses are indeed half that of a conventional transformer especially when it was at very low temperatures. There has already been interest from Unites States businesses that are safety driven. Mike Staines, Robinson Institute HTS transformers science leader is quoted as saying, "New Zealand has developed a competitive edge in HTS and other new technologies."

Fabrum's specialty is the manufacture of cryostats. They are working on commercializing a project to make Callaghan Innovation designed cryocoolers, which will be launched for commercial sale at a cryogenic engineering conference in Tucson Arizona on July 1.

Source: "FABRUM IN TRANSFORMERS DEAL" (22 May, 2015) Press Release

http://www.fabrumsolutions.com/news-posts/fabrum-in-transformers-deal/
Contact: info@company.com

▸Industrial Application 산업응용 工业应用 [gōngyè yìngyòng]

$8.5 million Contract with US Navy HTS Degaussing System

AMSC (19 May, 2015)

The U.S. Navy has awarded AMSC a contract worth up to $8.5 million to provide HTS-based ship protection system equipment that will employ AMSC's advanced HTS degaussing system, referred by AMSC as "Ship Protection Systems." The components of the degaussing system are applicable to other applications that are being targeted for ship implementation.

AMSC is continuing to expand HTS technology via a number of applications for power, propulsion, and protection equipment. "We've worked with the U.S. Navy for a number of years on the deployment of these systems, and we are pleased to allow the U.S. Navy to purchase ship protection system equipment," said Daniel P. McGahn, President and CEO, AMSC.

Source: "AMSC Announces Contract From U.S. Navy for High Temperature Superconductor (HTS) Equipment" (19 May, 2015) Press Release
http://ir.amsc.com/releases.cfm
Contact: Kerry Farrell, Kerry.farrell@amsc.com

▸Wire 선 재료 线材料 [xiàn cáiliào]

Plans for Superconductor Manufacturing Institute in University of Houston

University of Houston (8 May, 2015)

The University of Houston (UH) will head plans for an Advanced Superconductor Manufacturing Institute (ASMI), aimed at speeding up the commercialization of high-temperature superconductors. Energetics Inc. will join in these efforts.

The United States has five Advanced Manufacturing Institutes but none are involved in superconductor technology. The current plans are to house the industry-driven university research and related projects near the main campus, but consortium members will make the ultimate decision.

Venkat Selvamanickam, M.D. Anderson Chair Professor of Mechanical Engineering at UH, will be the principal investigator, receiving a $500,000 planning grant from the National Institute of Standards and Technology (NIST). The grant was part of the second round funding provided by NIST's Advanced Manufacturing Technology Consortia, which launched in 2013 to address advanced manufacturing of superconductors in the United States.

The grant addresses technical barriers that have hindered superconductor manufacturing from today's small-volume manufacturing to full commercialization, as well as to develop a business plan in conjunction with the industry-led consortium. The consortium will be formed over the next 18 months and will be made up of industry, academia and others, as well as developing plans to address the obstructions to low-cost, high-volume production, quality assurance and reliability testing.

Ramanan Krishnamoorti, chief energy officer at UH and acting vice president/vice chancellor for research and technology transfer, stated "I anticipate a revolution in the scalable manufacturing of low cost, high performance superconductors."

Source: "UH Launches Plans for Superconductor Manufacturing Institute"
(8 May, 2015) News Releases
http://www.uh.edu/news-events/stories/2015/May/0508SuperconductorManufacturing
Contact: Jeannie Kever, jekever@uh.edu

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

2015 First Quarter Results

Superconductor Technologies Inc (12 May, 2015)
Superconductor Technologies Inc. (STI) reported results for the quarter ended March 28, 2015.

During the first quarter, STI shipped Conductus wire to ten of its customers: seven existing and three new, bringing their total customer counts to 34. Six of their customers are in Stage 1 evaluation, which comprises wire characterization and performance testing, and four are in Stage 2, which comprises more stringent trials necessary for commercial deployment. One Stage 2 shipments was to a customer that is completing a superconducting cable demonstration project.

STI's first quarter 2015 net revenues were $55,000 compared to $82,000 in the fourth quarter of 2014 and $389,000 in the first quarter of 2014. Revenue for all periods was primarily from legacy wireless products. As of March 28, 2015, STI had $5.3 million in cash and cash equivalents. Capex is expected to be less than $400,000 for the entirety of 2015 now that the Conductus wire production suite is completed.

Jeff Quiram, STI's president and chief executive officer noted that, "STI strives to be responsive to customer requests aimed at fulfilling customer qualification processes. Customer feedback provides us with our future strategies and STI are the best-positioned to aggressively deploy superconducting devices in the market". The Conductus wire production system is progressing with wire being produced over the entire deposition area necessary to produce long lengths of wire and shipped to customers for qualification testing. The plans for the second quarter include increasing capacities to fulfill existing Stage 2 qualification orders.

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Source: "Superconductor Technologies Reports 2015 First Quarter Results" (12 May, 2015)
Press Release
http://phx.corporate-ir.net/phoenix.zhtml?c=70847&p=irol-newsArticle_Print&ID=2046866
Contact: Cathy Mattison, invest@suptech.com

Top of Superconductivity Web21

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Feature Article: Refrigeration and Cryogenic Technologies -Full Automated Brayton Refrigerator with Single-switch Operation

Ken-etsu Uwamori
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Development & Engineering Division
Taiyo Nippon Sanso Corporation

R&D into High Temperature Superconducting (HTS) power equipment is predicted to be vital for energy saving power technology and is being actively pursued towards practical applications. Recent years have seen superconducting cables and superconducting fault current limiters for practical applications entering the final stages of R&D with some already planned for grid connection trials. The need for a suitable refrigerator to cryocool high temperature superconducting power equipment has therefore heightened. The necessary specifications of a refrigerator applicable to high temperature superconducting power equipment include, 1) to have control of cooling temperatures and cooling capacities required to sustain stable superconductivity; 2) continuous long-term operational reliability; 3) greater cooling efficiencies (low running costs); 4) system compactness (compact footprint); and 5) low maintenance costs.

Typical operating temperatures of refrigeration systems currently employed for cooling HTS power equipment ranges between 20 to 80 K and with cooling capacities varying between 2 to 10 kW, meeting the needs of superconducting cables operating at 70 K. Current compact cryocoolers available in the market provide lower cooling capacities of around 1 kW at 80 K and with frictional bearings require regular maintenance once per year. On the other hand, large-scale cryogenic systems utilized for cryogenic air separation units and helium liquefiers employ expansion turbines equipped with non-contact bearings that have proved durable. However, the cooling capacities of such systems are far beyond the necessities required by HTS power equipment and are therefore being addressed by a NEDO project entitled, “Technological Development of Yttrium-based superconducting power equipment,” which developed a portable 2 kW neon turbo-Brayton cycle refrigerator operating at 65 K using neon as the working fluid.

Further work by Taiyo Nippon Sanso Corporation has led to the renovation of a 2 kW refrigerator. As shown in Figure 1, further compactness has been realized allowing installation of the equipment and cold box (heat exchanger) onto a common base. With the main focus now on enhancing system operations by repeatedly modifying and improving the operational program, has led to the establishment of an automated technology offering a single-switch operation for start-up and controlling the liquid nitrogen temperature set-point. The system is programmed so that the refrigerator stops and operates at the touch of a button, and is already integrated into the product.

Recent trials involve reducing the refrigerator’s power consumption. At a cooling temperature of 70 K and a cooling capacity of 2 kW the compressor consumes around 50 kW. To address this issue a new compressor is currently under development, which if realized will reduce power consumption by several kW and will also simplify components.

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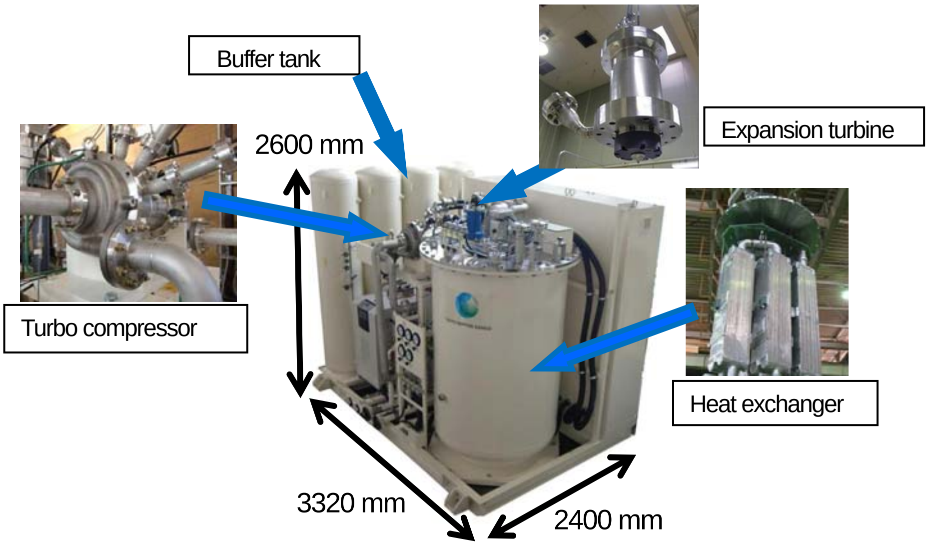

Fig. 1 2 kW turbo Brayton neon refrigerator

Here, while demonstration studies into high temperature superconducting power equipment have reached actual grid-scales, the requirements of large-scale refrigerators with even larger 5-20 kW-class cooling capacities have intensified. The company has commenced a project to develop a 10 kW-class refrigerator, and last year a prototype was fabricated. Figure 2 shows a prototype 10 kW-class turbo Brayton neon refrigerator that has been fabricated. The prototype comprises of a heat exchanger housed horizontally in a cold box and a turbine-compressor installed in upper part of the cold box. Performance evaluations of the 10 kW refrigerators are currently ongoing. Further modifications and enhancements are envisaged and aimed towards a future product line-up.

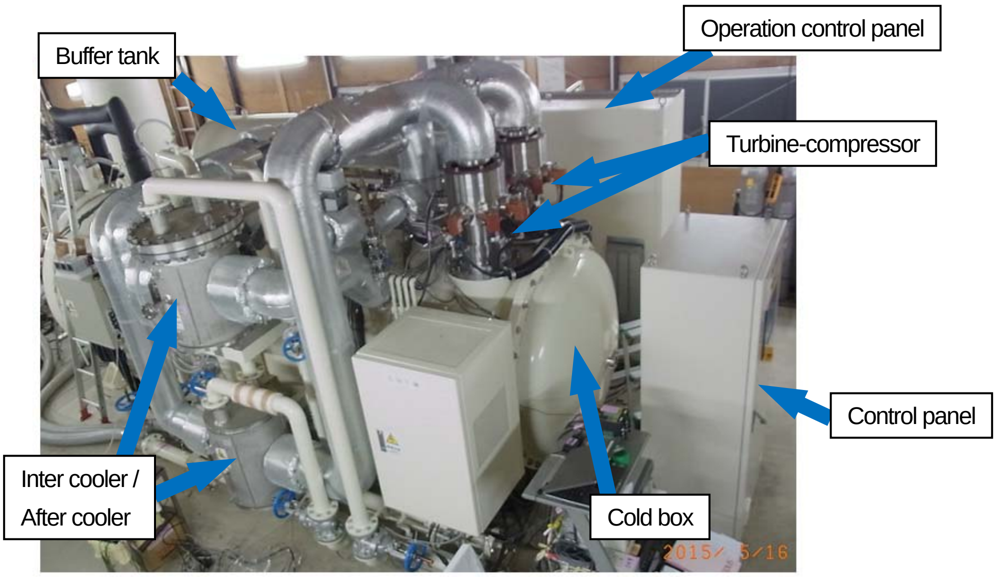

Fig. 2 10 kW turbo Brayton neon refrigerator (prototype)

Top of Superconductivity Web21

July 2015 Date of Issue: July 15, 2015

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Feature Article: Refrigeration and Cryogenic Technologies -Development of High Performance Refrigerator

Naoko Nakamura
Vice Senior Research Fellow
Mayekawa MFG. Co., Ltd.

Under a NEDO project entitled, "Demonstration studies of stability/reliability of the next-generation transmission systems," the author and her research team aims to demonstrate the long term performance, reliability and feasibility of a refrigerator in an actual grid by performing a 1-year continuous operation of a Brayton refrigerator, which has been developed under the "Demonstration project of high-temperature superconducting cable". The author herewith introduces the Brayton refrigerator that has been developed along with a future plan of the project.

The targets for a single-unit Brayton refrigerator are set to have a cooling capacity of 5 kW and COP: 0.1, with maintenance interval of 30,000 hrs. A reverse Brayton cycle has been selected taking into consideration refrigerator targets such as higher capacities and greater efficiencies. A turbo-compressor and a turbo-expander have been employed in order to take advantage of the maximum operational characteristics of the reverse Brayton cycle. Integrating the first, second and third-stage turbo compressors with a turbo-expander and by recycling the power generated by the expander have produced efficiency gains in the refrigerator. Neon gas was utilized by considering the speed of sound, which would greatly influence the architecture and efficiency of the rotor.

A turbo-compressor/expander for air refrigeration system and a super-compact turbo-expander designed for helium liquefaction applicable to the Brayton cycle system, already commercialized by Mayekawa, has been investigated. Elaborate technological studies comprising of design and fluid/structural analysis has led to the development of rotors that have almost realized the targeted adiabatic efficiency of 0.8. Furthermore, performance trials of Brayton refrigerators have met their developmental targets, realizing cooling capacities of 5.8 kW and COP 0.1 at liquid nitrogen temperatures of 77 K, measured at the exit end of the refrigerator.

The utilization of the pressure control method proposed by this development has led to greater operational efficiencies at a stable COP. This is made possible by modifying the circulating gas pressure by controlled rated revolutions, which controls the changing mass flow capacity at a constant volume flow. It is understood that the refrigerator operates with greater efficiency at stable COP with cooling capacities of 0.65 ~ 1.0.

The Brayton refrigerator was transferred to the Asahi Substation owned by Tokyo Electric Power Company and have undergone factory trials. Trial operations are currently ongoing. After the reliability of the cooling system has been verified, future plans involve its connection to high temperature superconducting cables in an actual grid and continuous operational trials to demonstrate refrigerator performance from different perspectives. It is also understood that the efficiency of both the turbo-compressor and expander can be enhanced by further elaborate structural studies and additional investigations are planned. To realize high temperature superconducting cable systems for practical use, the author will pursue further studies aiming

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for compactness and reducing costs of the entire cooling system including the refrigerator.

Brayton refrigerator transferred to the Asahi Substation

Top of Superconductivity Web21

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Feature Article: Refrigeration and Cryogenic Technologies -Single-stage GM Refrigerator for High-temperature Superconducting Equipment

Rui Li
Technology Group, Precision Equipment Division
Sumitomo Heavy Industries, Ltd.

1. Introduction

Typically, cryocooling superconducting equipment can be largely divided into two systems - one utilizing coolants such as LHe and LN_2 and others utilizing cryocoolers. HTS equipment employing cryo-cooling systems are highly anticipated because of greater system reliability and the ease of operation and management. The author introduces herewith a new single-GM refrigerator developed specifically for high temperature superconducting equipment applications.

2. Main specifications of the RDK-500B single-stage GM refrigerator

In order to be applicable to an array of systems, the developed refrigerator has high cooling capacities between 20~30 K and at 80 K. The development with cooling efficiency as the main focus, resulted in not only suppressing the primary factors affecting cooling capacities due to the angle of installation, it also negated the need for a large-scale compressor to operate the refrigerator. The resulting refrigerator is easy to install at the user site since a compressor exempt from the high-pressure gas safety act can be selected.

(1) Refrigerator Unit type：RDK-500B (Fig.1)
(2) Compressor Unit type：F-70LP

(3) Input Power Supply：AC200 V three-phase (50/60 Hz)
Power Consumption：(Steady Operation) 7.5/9.0 kW (50/60 Hz)
(Start-up) 8.5/9.8 kW (50/60 Hz)

(4) Size, Weight：
(Refrigerator Unit) 25 kg, about H570×W180×L325 mm
(Compressor Unit) 100 kg, about H575×W443×L493 mm

(5) Cooling capacity：
(50 Hz) >40 W at 20 K, >80 W at 30 K (Fig.2)
(60 Hz) >45 W at 20 K, >94 W at 30 K (Reference value, Fig.2)

(6) Compliant：comply with UL, CE-marking、RoHS Directive
Exemption from the high-pressure gas safety act

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Fig.1 Refrigerator unit

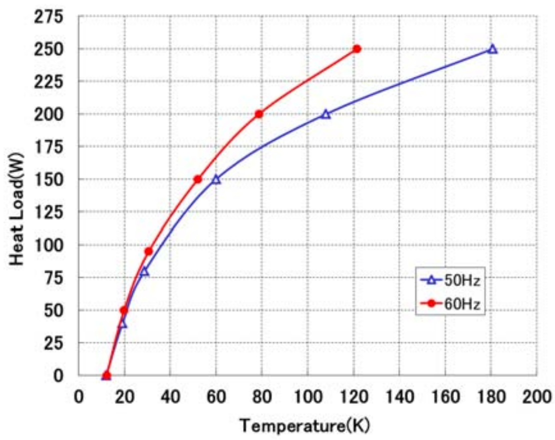

Fig.2 RDK-500B cooling capacity diagram

3. Mounting angle dependency of cooling efficiency and cooling capacity

The cooling efficiency (COP) of a single-stage GM refrigerator can be simply evaluated by the size of cooling capacity versus the input power. The cooling capacity of the system developed exhibited 46 W at 20 K (6.8 kW) and 85 W at 30 K (6.9 kW), both at 50 Hz, resulting in a relatively high value of COP of 0.0068 at 20 K and 0.0123 at 30 K.

On the other hand, regarding the mounting angle dependency of the cooling capacity, this was not entirely eliminated as shown in Figure 3, but in fact was suppressed to less than 24 % at max.

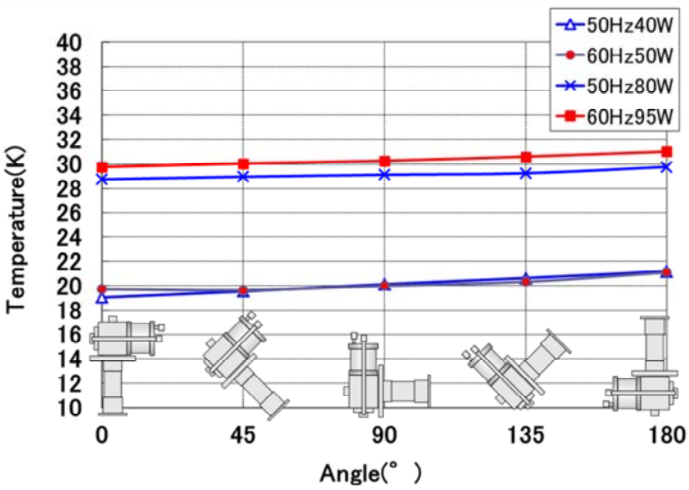

Fig.3 RDK-500B Mounting angle dependency of cooling capacity

Top of Superconductivity Web21

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Feature Article：ISS2014/ISS-IEA Joint session
（Young Generation Award – Best Presentation Award Paper）

-Removal of iron scale with superconducting magnet high gradient magnetic separation from feed-water in thermal power plant, including future energy society and my research work

Saori Shibatani, Osaka University

In November 26, 2014, IEA-HTS-IA and ISS joint session was held, and I made a presentation entitled "Removal of iron scale with superconducting magnet high gradient magnetic separation from feed-water in thermal power plant, including future energy society and my research work". The content of my presentation is as follows.

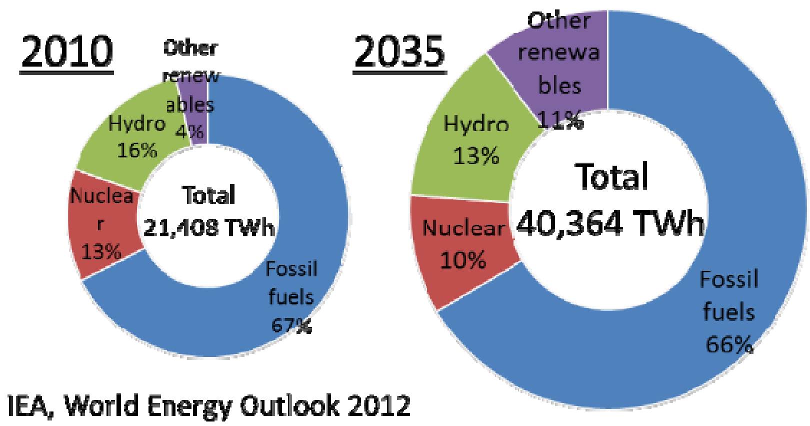

Fig.1 World electricity generation outlook

Fig.1 shows world electricity generation outlook[1]. World's electricity generation will have been increasing and approximately 66 % of electric source is fossil fuels in 2035. This data shows that CO_2 emission will have been increasing in future.

There are some methods to reduce CO_2 emission. One is to increase the renewable energy. Renewable energy is CO_2 free in electric generation, but it has demerits of low energy density, high-cost of power generation and unstable energy. Thus, it takes long term to introduce renewable energy. Another is to increase the nuclear power generation. The nuclear power is CO_2 free in electric generation, high-energy density and low-cost of power generation. However, it involves high risk for a use of nuclear fuel. So, it is difficult to gain public acceptance to increase nuclear power generation.

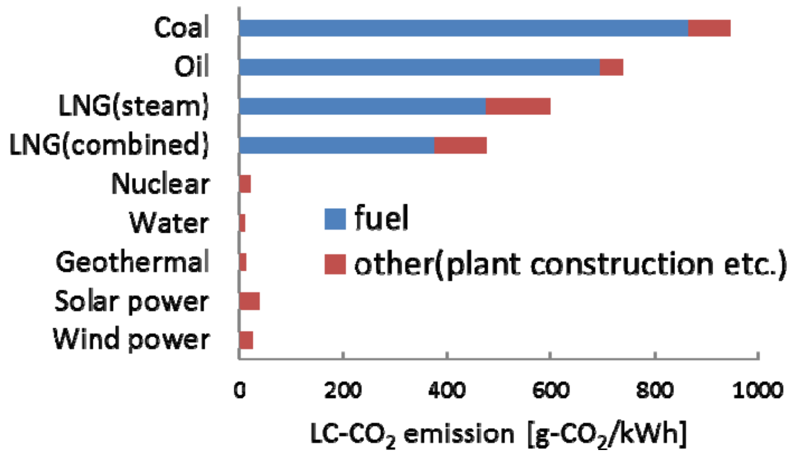

Fig.2 LC-CO_2 emission

Therefore, as a new method for CO_2 reduction, I'd like to introduce my study "improvement of thermal power plant efficiency using superconducting magnet". Fig.2 shows CO_2 emission by electric source[2)]. Thermal power generation releases more carbon dioxide than other electric power generation processes. Therefore, we considered improvement of thermal power generation efficiency. The main factor of decline in thermal power generation efficiency is the scale which adheres to piping wall surface. The scale is iron oxide particles which consist of magnetite, hematite and oxyhydroxide. The thermal conductivity of scale is about tenth part of pipework. So the scale adhesion causes decrease in heat-exchange efficiency and increase in pressure loss. It is known that removal of 20 μm of scale reduces 1% of CO_2 emission[3)]. We examined for the improvement of thermal power generation efficiency by removing the scale.

The scale generates in feed-water of thermal power plant by oxidation of the iron ion which was eluted by corrosion of the pipework as oxide and hydroxide. In low-temperature part (condenser – low pressure heater), the main component of the scale is oxyhydroxide which is paramagnetic and small particle size. On the other hand, in high-temperature part (deaerator – boiler inlet), the main component of the scale is magnetite which is ferromagnetic and large particle size. Moreover, the scale amount in high-temperature part is much larger than in low-temperature part. For these reasons, it is effective to remove the scale in high-temperature part. So we considered a new High Gradient Magnetic Separation (HGMS) system that can be installed in high-temperature part. This technique can be installed to existing thermal power plants, so it takes relatively low cost and short term for the introduction.

Fig.3 shows schematic illustration of the HGMS experimental device. We conducted the experiment under high-temperature and high-pressure condition (200 °C, 20 atmospheres) assuming thermal power plant. We used the simulated scale that was mixture of magnetite 80 wt% and hematite 20 wt%. The simulated scale suspension was flown into the magnetic separation filter, and the scale was separated by a solenoidal superconducting magnet. The separation rate was estimated from the concentration of passed iron.

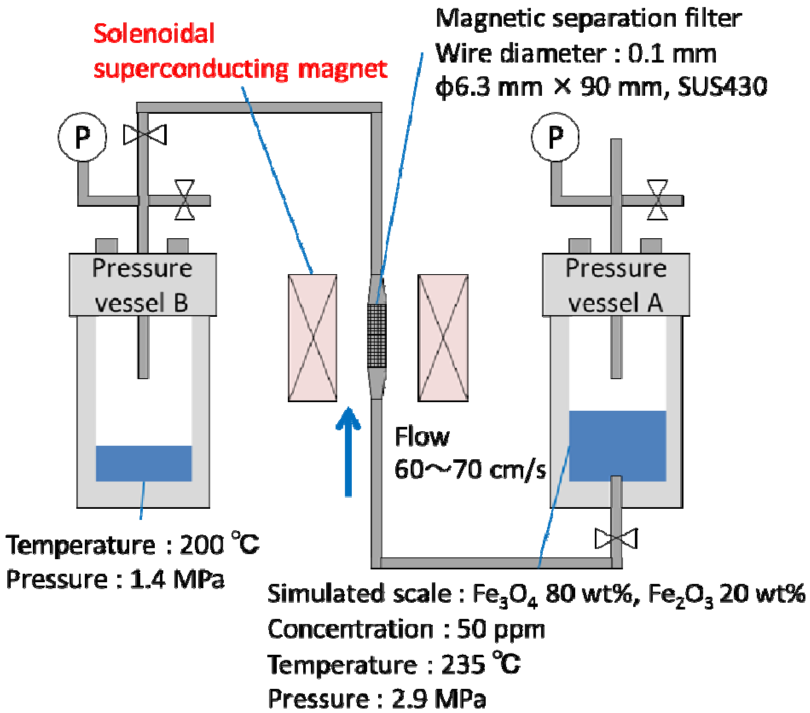

Fig.3 HGMS experimental device

The separation rate of simulated scale is 98 % with 2 T of magnetic field. We succeeded in removing simulated scale under high-temperature and high-pressure condition. As a result, the scale removal by HGMS can be realized by using superconducting magnet. The possibility was shown that the efficiency of thermal power generation can be improved by HGMS with superconducting magnet.

When this technology is realized, CO_2 emission from thermal power plant will be reduced and fuel for thermal power generation is also saved. As mentioned above, most of CO_2 exhausted by generation come from thermal power generation, so CO_2 reduction of thermal power plant has large effect for future. By using scale removal technology, the environmental load by thermal power generation will be reduced in the future.

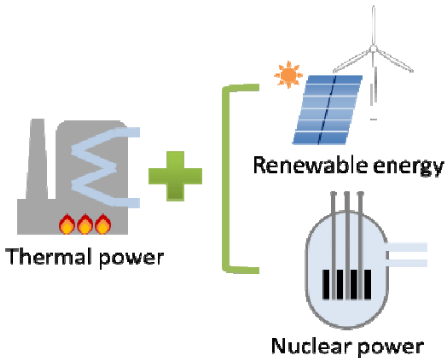

Fig.4 Energy combination

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In the discussions so far, I focused on problems of CO_2 emission. But it is necessary to consider the future energy society from several points of view. So I think it is important to combine improved thermal power generation with other power generation methods (Fig.4). For example, by combining thermal power generation with the renewable energy, it can be used as dispersed power system. On the other hand, by combining with nuclear power generation, energy security is developed.

In this manner, future energy society should aim to the best mix of these power sources. The efficiency improvement of thermal power generation raises feasibility of the energy best mix. So our study about scale removal by magnetic separation looks ahead to the future energy society.

At a later date, I visited National Institute for Materials Science (NIMS) which is the facility collaborating with us for this study. I observed various specifications of superconducting magnets, water-cooled copper magnets, hybrid magnets and NMR. The hybrid magnet (Fig.5) which consist of superconducting magnet and water-cooled copper magnet could produce up to 37 T. It was thought when I used it for magnetic separation, the high speed processing not only for ferromagnetic substances or paramagnetic substances but also for diamagnetic substance will be possible. For example, biomedical materials or DNA can be separated, so we can use it for medical field. Currently, the maximum of the static magnetic field that can be produced is 45 T in America. However, I heard that NIMS tries to produce more than 45 T developing the superconducting material. I have studied only application of the superconducting magnet, so there were many contents to hear for the first time about materials study. In addition, I saw a solenoidal superconducting magnet whose boa diameter is 40 cm at NIMS. In my study, I use a solenoidal superconducting magnet whose boa diameter is 10 cm at the experiment, but it is thought that boa diameter around 40 cm is necessary to be used in pipework of feed-water in the actual thermal power plant. I could watch the actual size of superconducting magnet and was able to sense the size of the scale removal device this time.

Fig.5 Hybrid magnet at NIMS

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1) IEA, World Energy Outlook 2012
2) Central Research Institute of Electric Power Industry, Evaluation of Life Cycle CO2 Emissions of Power Generation Technologies, 2010
3) H.Okada (private communication)

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Top of Superconductivity Web21

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Feature Article：ISS2014/ISS-IEA Joint session （Young Generation Award – Runner-up Presentation Award Paper）

-IEA-HTS-IA and ISS joint session inspired me to dream more

Department of Electrical Engineering, Graduate School of Information Science and Electrical Engineering, Kyushu University, Japan
Kohei Higashikawa (Associate Professor)

In the spring of 2014, I first heard that “IEA-HTS-IA and ISS joint session” was supposed to be held at ISS2014. According to the website, the session was for young researchers under 35 years old, and required them to present their prospects and opinions for future energy society in relation to their own research works. When I was a student, I was relatively high-spirited to know the brilliance of superconducting technology. In recent years, however, I felt slight stress to consider some realistic obstacles to overcome to expand practical uses of superconducting applications. Therefore I applied for this session to energize myself again.

The title of my presentation was “Advanced Diagnostics of Superconducting Wires and Tapes for High-performance and Highly-functional Power Applications Supporting Large-scale Introduction of Renewable Energy.” I have a lecture on “Electrical Energy Environment Engineering” in the graduate school, and deal with large-scale introduction of renewable energies in the future as well as the energy society currently depending on the fossil fuels. Especially for Japan, it has been considered difficult to cover power consumption mostly by renewable energies, e.g., photovoltaic and wind power generations, in terms of climatic and geographical conditions, e.g., narrow land and unstable wind condition. Furthermore, acceptable amount of the renewable energies with largely fluctuating outputs has been limited by the issues of power system stability. After knowing these situations, many of the students come round to thinking that it is inevasible to utilize nuclear power generation again in Japan, while a large part of the lay public is negative about that as a result of the earthquake. However, if all electric power consumption can be covered by renewable energies, all the people will agree to the concept itself at least. This was the main reason why I set the above-mentioned title for this session.

For example, Fig. 1 shows a famous figure, which suggests that electric power consumption in the world can be fully covered by a very small part of the Sahara with photovoltaic power generation[1]. It is true that the area itself is enormous but it is dream-inspiring for me that such a small portion of the earth can fully supply electric power consumed all over the world. However, power-consuming area is often located very far away from such a region; then long-distance power transmission is indispensable. Furthermore, power generation and consumption does not necessarily match with each other within a short time scale; then electric power storage is essentially important. These two keywords, i.e., “long-distance power transmission” and “power storage,” bring an idea with superconducting technologies.

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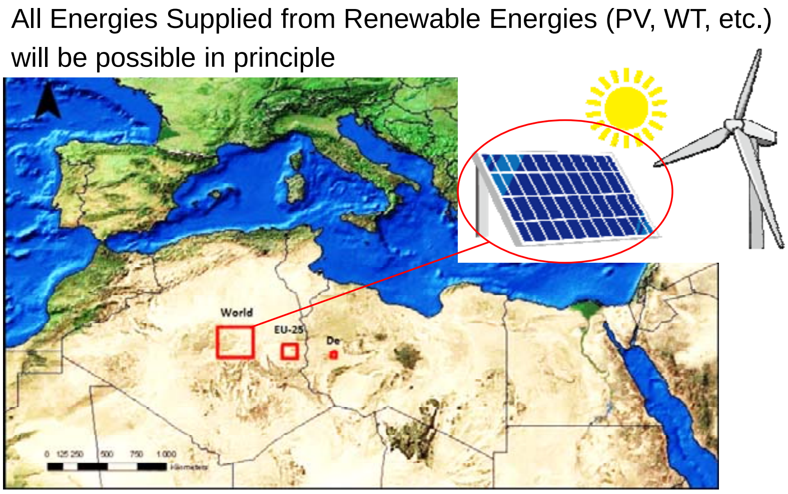

Fig. 1. Area needed for covering electric power consumption by photovoltaic power generation.

Fig. 2 illustrates the concept. The key point is DC power transmission with a global-scale loop structure. DC power transmission will be rather natural considering that the power sources are solar and wind powers. This will also be preferable for superconducting cables from the viewpoint of AC losses. On the other hand, the true aim is to store energy in power grid itself. For example, tera-joule-class energy can be stored by an around-the-globe loop with a DC current of 100 kA. Furthermore, even peta-joule-class energy could be stored supposing a cable with strands tightly twisted around a magnetic core. Namely, both “long-distance power transmission” and “power storage,” which are key items for large-scale introduction of renewable energies, are realized at the same time. Then, this can be called as “ubiquitous superconducting power network” where we can generate and consume electricity anytime and anywhere.

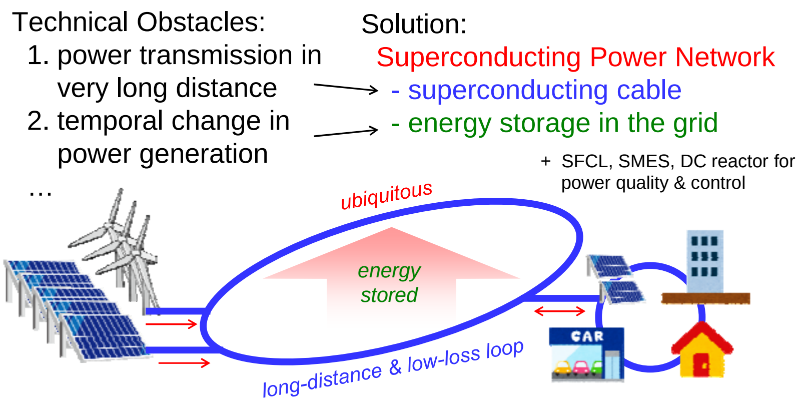

Fig. 2. Ubiquitous superconducting power network with long-distance power transmission and power storage enabled by global-scale DC loop configuration.

In relation to this, I attended a Mongolia-Japan joint seminar on electric power technologies. Mongolia has the Gobi Desert with the world's second-largest amount of sunlight just behind the Sahara. A Japanese organization reports its high potential for huge renewable energy generation, and seeks out an opportunity for business [2)]. For Japan, also from the viewpoint of distance, importing renewable energies from there is much more realistic than the case from the Sahara. This was a reason why I decided to attend the seminar. The attendees were from Mongolian University of Science and Technology (MUST) and power transmission/distribution companies in Mongolia, and from seven universities in Japan. In particular, the attendees from Japan included very famous professors who are in charge with international standardization on smart grids and power transmission/distribution systems. This was also a good chance for me to discuss with such people who were not the specialists for applied superconductivity.

Fig. 3. A scenery in Mongolia a few hours away from Ulan Bator by bus:
endlessly broad land with clear sky which seems to be appropriate for photovoltaic power generation.

After visiting MUST in Ulan Bator first, then we moved to the seminar site at Delgerkhaan by bus together with the Mongolian people. Fig. 3 shows a landscape on the way there. Such a broad land with a clear sky continued the whole way; this reminded me of the great potential for large-scale solar power generation in this country. Furthermore, I received the impression that the wind condition was suitable for wind power generation as can be seen from the flying flags shown in Fig. 4. Eight Japanese people and around 30 Mongolian people attended the seminar, and Fig. 5 shows the atmosphere in my presentation. The person next to me kindly translated my talk to Mongolian because many of the Mongolian attendees do not speak English. I introduced my research and its future prospect; then I felt very good responses from them. In particular, they were excited about a vision for the power transmission from Mongolia to Japan by superconducting cables.

Fig. 4. Another scenery in Mongolia a few hours away from Ulan Bator by bus (2): good wind condition

Fig. 5. Atmosphere for my presentation at the Mongolia-Japan joint seminar.

On the other hand, the current situation in Mongolia needs a fully-established technology such as ultrahigh voltage transmission rather than a highly-advanced technology such as superconducting power applications. Therefore, they would only show favorable responses to my presentation because they might recognize it as dream or entertainment. Contrastingly, Japanese attendees seriously asked me some technical questions because they would know the progresses of superconducting technologies as practical uses in electric power applications: how to take power from a closed loop, how to break a fault current, how to cool such a long object, how to clear political issues, and so on. These experiences reminded me that to enrich the understanding and then to build up achievements first in Japan would be appealing to a foreign country to employ superconducting technologies there. I believe that this kind of intercommunion with leading persons in Japan as well as with those in a foreign country will bear fruit in the form of export of superconducting electric power infrastructure in the future.

Lastly, my main research topics are characterization of superconducting wires including long-length ones [3), design of applications based on their properties[4)] and investigation of their behaviors in electric power system[5)]. The IEA-HTS-IA and ISS joint session was very precious opportunity for me to recall that I was working towards such a dream. Actually, I could not believe that I could receive the award because other presenters were really excellent in terms of well-described story and very fluent English. However, I could confidently say that I was right about applying for this session even if I could not win any award. I hope that this session will continue and develop for many more years.

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Top of Superconductivity Web21