December, 2015 Date of Issue: December 15, 2015

Superconductivity Web21

Published by International Superconductivity Technology Center
KSP, Kawasaki, Kanagawa 213-0012 Japan Tel:+81-44-850-1612, Fax:+81-44-850-1613

Contents:

Top of Superconductivity Web21

Superconductivity Web21
Published by International Superconductivity Technology Center
KSP, Kawasaki, Kanagawa 213-0012 Japan
Tel:+81-44-850-1612, Fax:+81-44-850-1613
Top of Superconductivity Web21: http://www.istec.or.jp/web21/web21-E.html

KEIRIN

This work was subsidized by JKA using promotion funds from
KEIRIN RACE
http://ringring-keirin.jp

December 2015 Date of Issue: December 15, 2015

Superconductivity Web21

Published by International Superconductivity Technology Center
KSP, Kawasaki, Kanagawa 213-0012 Japan Tel:+81-44-850-1612, Fax:+81-44-850-1613

What's New in the World of Superconductivity

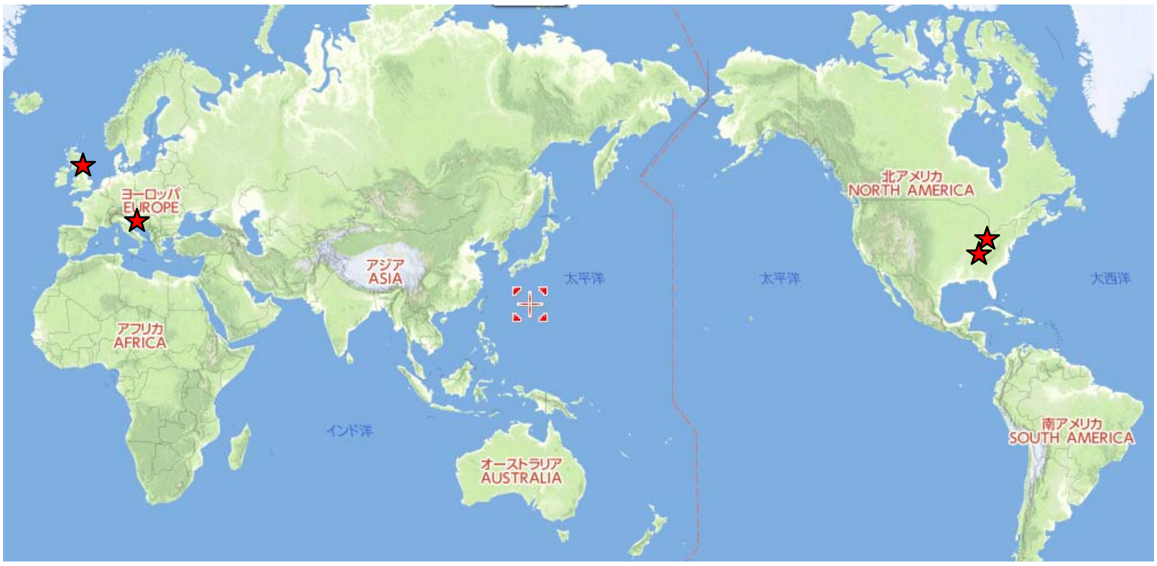
(December, 2015)

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

▸Fusion

1st SC Magnet for Experimental Tokamak Fusion Reactor JT-60SA

ENEA (1 Oct, 2015)

ENEA and ASG Superconductors have presented the first superconducting magnet for the experimental Tokamak nuclear fusion reactor JT-60SA, designed to speed up nuclear fusion research, and currently under construction in Naka, Japan. A total of 50 delegates from Europe and Japan took part in the Technical Coordination Meeting organized by ENEA to evaluate the current progress of the experimental reactor. ENEA's nuclear fusion expertise has been developed at its Frascati Research Centre. Their technological development has generated the knowledge necessary for the highly strategic sectors reliant upon nuclear fusion energy. The programme supports ITER, and is one of the major and most complex international projects, currently being realized in Cadarache, France.

ENEA has the task of providing 9 out of the 18 coils of the superconducting magnet, containment vessels, and power supply systems. The value of this first order is over €17 million for ASG Superconductors, plus €10 million for the structural components made by Walter Tosto, and around €12 million for the magnet power supply systems.

Source: "Entirely Italian the first component of the EU-Japan nuclear fusion reactor"
(1 Oct, 2015) News
http://www.enea.it/en/news/entirely-italian-the-first-component-of-the-eu-japan-nuclear-fusion-reactor
Contact: Press Office uffstampa@enea.it

▸Medical Application

One-room Compact Proton Therapy Solution

ProNova (17 Oct, 2015)

ProNova Solutions announced the development of the Compact SC360 One-Room Solution, a treatment system with full 360-degree gantry angle and advanced imaging capabilities designed to accommodate new proton therapy centers. It offers a 45 % smaller footprint than other compact systems currently available in the market.

The company was founded in 2012 for the development of a more nimble, lower-cost, technologically advanced proton therapy treatment system. Its aim was to develop accessible, economical, state-of-the-art solutions for making proton therapy more widespread across the country and around the world. ProNova utilizes its proprietary, superconducting technology to build more compact, lighter proton therapy gantries and cyclotrons at less cost than its competitors.

Source: "ProNova introduces one-room, expandable proton therapy solution"
(17 Oct, 2015) Media Room
http://pronovasolutions.com/media-room/pronova-introduces-one-room-expandable-proton-therapy-solution
Contact: Bill Hansen bill.hansen@provisionhp.com

World's First Commercial PET/MRI Preclinical Scanners

MR Solutions (14 Oct, 2015)

PET and MRI preclinical imaging systems can now be operated simultaneously for the first time by researchers, allowing faster workflow as well as results from two different imaging modalities, for more accurate comparative results in the same timeframe. A PET/MRI imaging is of major benefit to scientists undertaking cardiovascular, neurobiology, cancer research and help to speed up drug development.

MR Solutions were the world's first company to develop a commercial range of 3 T and 7 T cryogen free superconducting systems. This PET/MRI system is again a world-first. The company, based in Guildford, UK, is the world's largest developer and manufacturer of 3 T to 7 T preclinical MRI bench top systems and spectrometers. This development of this imaging system follows on from the introduction of MR Solutions' commercially available MRS-PET system, which is inserted within the cryogen free 3 T, 4.7 T, or 7 T MRI magnet. In 2012, the company developed the world's first commercially available high-performance 3 T preclinical MRI bench top scanner using super-conducting magnets, eliminating the need for liquid helium cooling.

Source: "MR Solutions introduce the world's first commercial range of simultaneous PET/MRI preclinical scanners"
(14 Oct, 2015) News
http://www.mrsolutions.com/news-events/news-item/mr-solutions-introduce-worlds-first-commercial-range-simultaneous-petmri-preclinical-scanners/
Contact: information@mrsolutions.com

▸Basics

Evidence of HTS in Single Layer

Oak Ridge National Laboratory (30 Sep, 2015)
The research delivered at the Department of Energy's Oak Ridge National Laboratory provides direct evidence of high-temperature superconductivity at the interface of two insulating oxide materials.

The findings are published in Physical Review Letters as "High T_c superconductivity at the interface between the $CaCuO_2$ and $SrTiO_3$ insulating oxides." Cantoni, one of the authors of the report stated that by locally controlling the oxygen in the electronic structure of the material makes this interface superconducting. This could lead to two-dimensional superconductors.

The study investigated the interface between two insulators, calcium copper oxide and strontium titanate oxide, using scanning transmission electron microscopy. Combined with electron energy loss spectroscopy the resulting data confirmed that high-temperature superconductivity occurs within a highly confined region around the interface. They established that a one-unit-cell-thick calcium copper oxide layer at this interface is superconducting at a critical temperature approaching 50 K.

Source: "ORNL microscopy finds evidence of high-temperature superconductivity in single layer"
(30 Sep, 2015) News
https://www.ornl.gov/news/ornl-microscopy-finds-evidence-high-temperature-superconductivity-single-layer
Contact: Morgan McCorkle, mccorkleml@ornl.gov

Top of Superconductivity Web21

December 2015 Date of Issue: December 15, 2015

Superconductivity Web21

Published by International Superconductivity Technology Center
KSP, Kawasaki, Kanagawa 213-0012 Japan Tel:+81-44-850-1612, Fax:+81-44-850-1613

Feature Article: Superconducting Power Equipment -Enhancing Stability and Reliability of Superconducting Power Cables

Masayoshi Ohya
Superconducting Products Division
Sumitomo Electric Industries, Ltd.

Compact HTS cables have advantageous low-loss characteristics and high transmission capacities, which have led to their use in in-grid demonstration trials worldwide designed for their practical deployment. In Japan, an in-grid trial involving a 66 kV-class HTS cable was undertaken at the Asahi substation of Tokyo Electric Power Company. The cable was installed based on the assumption it formed part of a real grid system. It was subjected to a number of tests that included critical current measurements, DC withstanding voltage tests, and heat cycle tests, undertaken prior to connecting it to an actual grid. The cable tests confirmed the stability of the electrical characteristics over the one-year duration as well as the overall system reliability during load fluctuations, which occur on a daily basis, and also due to grid switching. A particular issue however, was the gradual deterioration observed in the cooling performance of the refrigerator over the duration of the trials. A forthcoming topic is therefore how best to maintain the cooling performance characteristics over the long term. To realize practical HTS cables necessitates safety measures to protect against an array of potential incidents, presumed to occur during normal operation and also during actual grid connection.

Amidst this background, Tokyo Electric Power Company, Sumitomo Electric, Furukawa Electric, Fujikura and Mayekawa MFG, have joined their efforts in a three-year NEDO project that commenced in 2014, entitled, “Studies on the safety and reliability of the next generation power transmission systems”. The themes of this project are:

① Safety authentication and investigations of the recovery measures required for superconducting cable incidents
② Enhancing refrigerator reliability and efficiency
Regarding ①, verification trials are being conducted at each voltage level for 22 kV, 66 kV, and 275 kV-class cables based on the three assumed scenarios: short-circuit faults, ground faults, and external damage. Regarding ②, Mayekawa MFG will transfer their 5 kW-class Brayton refrigerator currently under development to Asahi substation. Connecting their refrigerator to an HTS cable for the duration of the trials will allow the long-term operational reliability to be investigated. Table 1 summarizes the testing categories and the responsibilities of each partner company.

Superconductivity Web21

Published by International Superconductivity Technology Center
KSP, Kawasaki, Kanagawa 213-0012 Japan Tel:+81-44-850-1612, Fax:+81-44-850-1613

Table 1 Test descriptions and the corresponding responsibilities for the reliability authentication project

Developmental themes/contents			Tokyo Electric Power Company	Sumitomo Electric	Furukawa Electric	Fujikura	Mayekawa MFG
① Development of safety evaluation method for superconducting cable system							
Testing themes/studies on testing methods, Test results analysis/evaluation			◎	○	○	○	○
Testing	Short circuit testing	22kV		◎			
		66kV		◎			
		275kV			◎	○	
	Ground fault testing	66kV		◎			
		275kV			◎	○	
	External damage testing	Vacuum deterioration in the thermally insulated pipe		◎	◎		
		Liquid nitrogen leak testing		◎			
② Development of highly efficient/highly durable cooling system							
Development of technology to reduce heat inleaks				◎	◎		
Development of highly efficient technology for the cooling			◎	◎			◎
Cooling system design and advanced control technology							◎
③ Investigations on the measures to improve practical feasibility, including early recovery measures			○	◎	○		○

Ground faults trials of a 66 kV-class cable have been assigned to Sumitomo Electric, who is currently performing fundamental feasibility studies using a metallic sheet and a cable core sample to compile a range of test conditions and test descriptions. Ground fault currents are smaller compared to short circuit currents since a neutral grounding system is adopted typically for 66 kV-class systems in Japan. Based on the results so far, ground fault currents are a maximum of 1500 A with incidents lasting no more than 2 seconds. Referred to ground fault tests results for conventional cables, a ground fault incident involving an HTS cable raises issues such as liquid nitrogen leaks due to the resultant arc energies burning through the insulation, pressure increases caused by the shock waves, and the vaporization of liquid nitrogen. To address this, fundamental trials investigating the protective layer structure, which can shield the insulated pipe against arc-perforation, have been undertaken together with measurements of the arc energy generated. Future plans of the project include obtaining fundamental data and eventually conducting ground fault trials of a 5 m-class demo cable.

Top of Superconductivity Web21

December 2015 Date of Issue: December 15, 2015

Superconductivity Web21

Published by International Superconductivity Technology Center
KSP, Kawasaki, Kanagawa 213-0012 Japan Tel:+81-44-850-1612, Fax:+81-44-850-1613

Feature Article: Superconducting Power Equipment -Progress in the Technological Development of Ultra High-voltage Superconducting Power Cables

Shin-ichi Mukoyama
Telecommunications and Energy Laboratories
R&D Laboratories
Furukawa Electric Co., Ltd

Furukawa Electric has advanced the development of an ultra high-voltage superconducting cable, targeting the potential of installing overhead transmission lines underground and future alternatives to high capacity POF and OF cables. The cable under development can realize transmission capacities of 1.5 GW, which is equivalent to existing overhead transmission lines with 275 kV-class voltage currently in the majority of Japan's trunk transmission power system.. The cable employs the 2nd generation wires (REBCO) which provide reduced transmission loss characteristics that equate to around ¼ compared to existing transmission lines. The development of this ultra high-voltage superconducting cable was undertaken between 2008 and 2013 under a NEDO project, entitled, "Technology development of yttrium-based superconducting power equipment". The project completed long-term loading tests at Shenyang Furukawa Cable, in Shenyang city, China, during the final year of the project.

Realizing superconducting cables for practical power network applications requires an essential verification of their safety/reliability from observations studying phenomena and their behaviour during unforeseeable incidents (ground faults/short circuits), in addition to safety evaluation during normal operation. Another NEDO project, entitled, "Demonstration studies related to safety/reliability of next generation transmission systems", launched last year, involves the collaboration of Tokyo Electric Power Company, Furukawa Electric, Sumitomo Electric, Fujikura and Mayekawa MFG. Fujikura and Furukawa Electric are responsible for evaluating the safety of the ultra high-voltage superconducting cable for the project.

The assumed scenarios of serious superconducting cable incidents were ground faults, short circuits, and vacuum breaks of the thermally insulated pipe (external damage). In particular, ground faults triggered by insulation breakdown within the cable and short circuits causing excessive currents due to a breakdown of peripheral equipment, both produced large instantaneous currents of 63 kA max flowing in the superconducting cable (for about 0.6 seconds). It is thus imperative that the cable be mechanically and thermally tolerant, and resistant to pressure variations. Demonstration trials of a 275 kV superconducting cable prototype (Figure 1) are on going as are simulations studies designed to replicate incidents. Figure 2 shows the short circuit simulation tests conducted at the testing facility, which was constructed during a previous project conducted at Shenyang Furukawa. External damage tests of the cable when connected to a liquid nitrogen circulation system are also planned.

Reference:

Osamu Maruyama *et al.*, Safety/reliability studies of superconducting cable systems (1) – Project summary, Conference Report, IEEE Conference on Power Engineering and Renewable Energy 2015

Superconductivity Web21

Published by International Superconductivity Technology Center
KSP, Kawasaki, Kanagawa 213-0012 Japan Tel:+81-44-850-1612, Fax:+81-44-850-1613

Fig. 1 The 275 kV superconducting cable

Fig. 2 Preparation of the short circuit simulation test at Shenyang Furukawa Cable

Top of Superconductivity Web21

December 2015 Date of Issue: December 15, 2015
Superconductivity Web21
Published by International Superconductivity Technology Center
KSP, Kawasaki, Kanagawa 213-0012 Japan Tel:+81-44-850-1612, Fax:+81-44-850-1613

Feature Article: Superconducting Power Equipment
- High Capacity Superconducting Wind Turbine Generators

Hirofumi Yamasaki, Mitsuho Furuse
National Institute of Advanced Industrial Science and Technology

The development of wind turbines with greater power capacities is advancing. For a given wind farm area, adoption of greater capacity turbines can increase the total power generated from the viewpoint of the efficiency of wind energy utilization. Also, reducing the numbers of wind turbines lowers overall operational maintenance costs. Thus, such are the main reasons behind why large-scale wind turbines can lower the overall costs of power generation. However, development of higher-capacity wind turbine generators approaches the technological limitations associated with the drivetrain responsible for transmitting the rotational force to the generator. The requirement for the next generation wind turbines with outputs greater than 10 MW necessitates innovative drivetrain technologies, rather than a developmental extension of conventional technologies.

The compact and lightweight attributes of superconducting power generators are highly expected to address such needs. A NEDO R&D project in 2013-14, entitled, “Research on Over 10 MW Wind Turbines—Generator”, demonstrated the feasibility of superconducting wind turbine generators. In this project, a collaborative research team comprising of AIST, Furukawa Electric, Mayekawa MFG, Niigata University, Sophia University, and University of Tokyo, proposed a highly reliable direct-drive superconducting synchronous power generator, employing a proprietary superconducting coil module with a rotor iron core specifically designed for wind turbines over 10 MW. Here, R&D activities focused on the key components required for practical superconducting wind turbine generators operating over 10 MW, including a superconducting coil module, a highly reliable turbo-Brayton refrigerator, and a cryogenic gas transfer coupling (Figure 1). The conceptual design of the nacelle mounting the superconducting power generator also demonstrated the superior characteristics of ultra large-scale superconducting wind turbines.

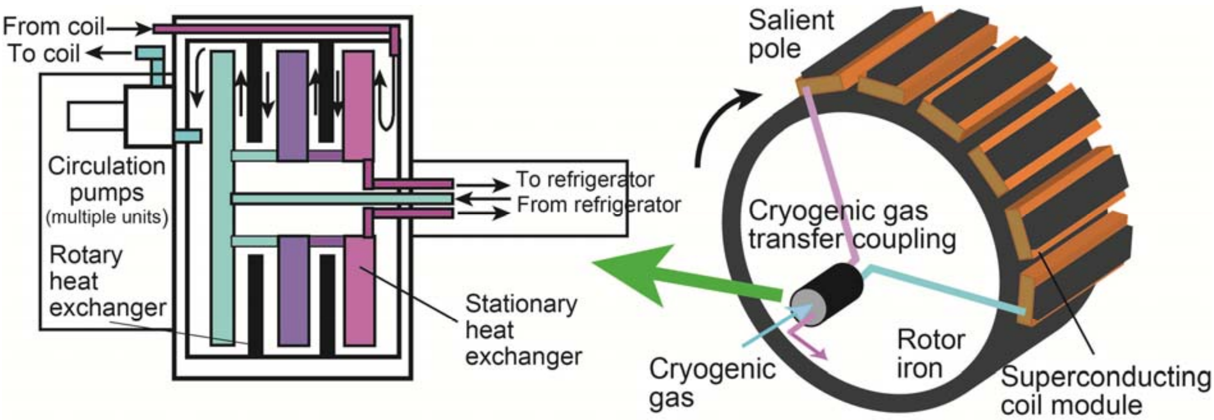


Fig. 1 Conceptual figures of a salient-pole superconducting rotor and superconducting coil modules, and AIST’s proprietary cryogenic gas transfer coupling

Superconductivity Web21

Published by International Superconductivity Technology Center
KSP, Kawasaki, Kanagawa 213-0012 Japan Tel:+81-44-850-1612, Fax:+81-44-850-1613

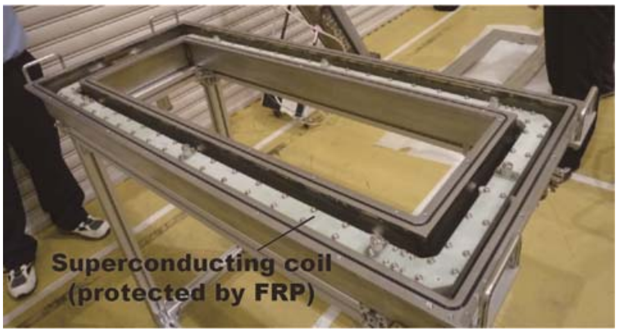


Fig. 2 Prototype racetrack-type superconducting coil placed inside a vacuum vessel (cryostat) for thermal insulation

The superconducting coil module is fabricated from REBCO wires, which are housed in a doughnut-shaped vacuum vessel, cooled via heat conduction using helium gas pipeline at 20-40 K (Figure 2). A multi-pole salient-type rotor using standard coil module units can realize power generators with scalable capacity. The use of a room temperature iron-core rotor significantly saves the volume of superconducting wires, and therefore, power generation costs are lower even if high temperature superconducting wires are employed. Professor Satoshi Fukui at Niigata University, led the electrical design of the overall power generator. Furukawa Electric fabricated a superconducting coil module and conducted loading/excitation tests together with heat inleaks measurements by incorporating a simulated rotor iron. The feasibility of practical power generator mounted with superconducting coil modules was verified experimentally.

To realize greater system reliability and reduce the maintenance costs particularly required for offshore wind power farms, Mayekawa MFG developed a highly reliable turbo-Brayton refrigerator required to cool the superconducting coil module. The design, fabrication, and rotational trials were conducted using a 2-stage compressor unit and an expander-compressor unit. The results demonstrated that the nacelle could house a practical refrigerator, which can cryocool an over 10 MW-class superconducting power generator installed with coil modules. Therefore, the development potential has been confirmed. Related to this, Professor Hiroyuki Ohsaki of University of Tokyo has led the development of an ultra high-speed motor drive technology required for the turbo compressor/expander.

A cryogenic gas transfer coupling is required to supply cryogenic gas from a stationary system to the rotor to allow heat exchange between the superconducting coil modules built into the rotor and the turbo-Brayton refrigerator. To avoid any issues associated with the rotating seal, AIST proposed their own system (Figure 1), which comprised of a heat exchanger between the stationary system and the rotor, and cryogenic gas circulation pumps built into the rotor. The design and fabrication of the circulation pumps have confirmed their validity.

Additionally, a conceptual design of the nacelle was undertaken to house the superconducting power generator combined with the aforementioned components. The superiority over conventional power generators was thus demonstrated, and, therefore, the realization of superconducting power generators for over 10 MW-class wind turbines are foreseeable. Future plans are shifting towards the developmental phase of a compact-sized superconducting power generator demonstration model, running consecutively with the demands of ultra large-scale wind turbines and the progress in technological development of other wind turbine components.

Top of Superconductivity Web21

December 2015 Date of Issue: December 15, 2015

Superconductivity Web21

Published by International Superconductivity Technology Center
KSP, Kawasaki, Kanagawa 213-0012 Japan Tel:+81-44-850-1612, Fax:+81-44-850-1613

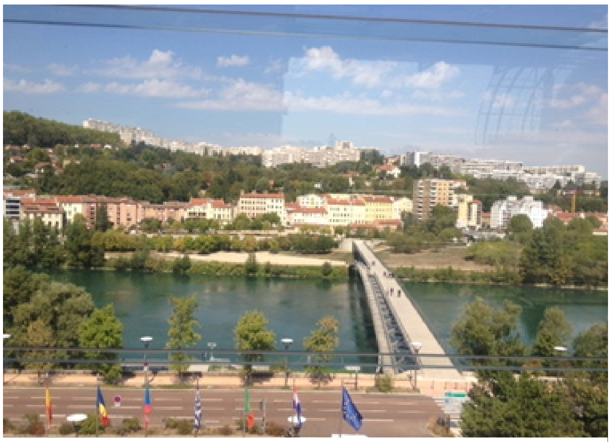
Feature Article: Superconducting Power Equipment

-Report on EUCAS 2015

Yutaka Yamada
Principal Research Fellow
HTS Conductor Processing & Power Applications Divisions
Superconductivity Research Laboratory
Public Relations & International Affairs Division
ISTEC **(Contact, now and after April 1, 2015: yutakayamadahts@gmail.com)**

EUCAS 2015 was held 6th - 10th September in Lyon, south of France. Before reporting mainly on power device applications presented at the conference, information related to the participants is introduced herewith (please refer to the report by Dr. Machi and Dr. Izumi). There were 1137 participants in total attending the conference (o/w 235 students), which comprised of 1060 presentations and 33 corporate showcase exhibitions. Categorized by country, the largest number of participants came from Japan with 200 participants, followed by 110 from Germany and 70 from China. The presentations included 12 plenary lectures, 30 invited lectures, and 775 posters. The posters were categorized as: 305 applications, 189 materials, 163 electronics and 115 wires.

EUCAS2015 venue (Lyon Convention Center)



View from the conference venue, overlooking the river Rhone

An award ceremony was held at the start of the conference. The ESAS (The European Society for Applied Superconductivity) Award for Excellence in Applied Superconductivity was presented to Dr. Goldacker of KIT, who recently led the development of Roebel conductors. This award recognizes the excellence of advancing knowledge in the field of applied superconductivity. Dr. Godacker reported on the developments made up to now.

Published by International Superconductivity Technology Center
KSP, Kawasaki, Kanagawa 213-0012 Japan Tel:+81-44-850-1612, Fax:+81-44-850-1613

The following summarizes the conference presentation highlights. The author felt the presentations were mainly focused on R&D activities conducted in Europe since the major developmental sites are situated there.

① The head offices for both ITER related nuclear fusion and CERN related accelerator are situated in Europe, (ITER has advanced the construction of a facility designed to test large-scale coils at high pace, which is highlighted later in this article). It was emphasized that the development is being progressed by international collaboration, and is of great significance since ITER offers clean power generation amid a 60 % increase in energy consumption expected by 2030.

② High-field coil including MRIs
The ongoing construction of an MRI with the world's largest magnetic field of 11.7 T, at Saclay. Many participants including Japanese attended the visiting tour.

③Progress in Y-based wires
Exhibitions were particularly dynamic. Further development of wire applications, including long-wire production and their commercialization are being targeted.

④ High temperature superconducting power applications such as AmpaCity (High temperature superconducting cables)
In-grid continuous loading trials began in Essen, Germany last summer. German electric utilities company RWE together with Siemens, Nexans, and KIT are all working on this project.

⑤ MgB_2 wires for power device applications
Wire manufacturer Columbus, situated in Italy, can fabricate a large volume of long wires for such applications.

In addition to the aforementioned highlights, only those major presentations the author was able to attend are introduced herewith.

① ITER related to nuclear fusion, accelerator:
Dr. Bernard Bigot (Director-General of the ITER Organization) presented his plenary lecture on the current status of ITER, on the first day of the conference. His presentation was entitled, "Superconductivity and fusion: an enabling technology for the success of ITER". Each country involved in the project, namely, Japan, USA, Europe, Korea, Russia, China and India have progressed their specific roles as designated. A key component is a large-scale coil (a max of 360 ton), which is now 70 % complete. From this, the author perceives the project is progressing smoothly. Japanese corporations involved are Toshiba, Hitachi, Furukawa, JASTEC, and Mitsubishi Heavy Industries. <u>High temperature superconducting current leads (Bi2223) are also being employed</u>.

On the second day of the conference Professor Zhang (President of Northwest Institute for Nonferrous Metal Research Xian) in China, presented a plenary lecture entitled, "Status of superconducting materials and applications in China". The current overall development of superconductors in China was introduced. China, one of ITER members, is remarkably advancing the mass production of metal-based wires (NbTi, Nb_3Sn) for the ITER project. The level of progress in China is equivalent to Japan. It was also the first time for the author to learn of the establishment of three corporations for the development of MgB_2 and Y-based long wires. Whilst the Chinese Academy of Sciences (CAS) has fabricated iron-based superconducting wires, their performance characteristics still remains low with J_c=2x10^4 A/cm^2 (4.2 K, 10 T).

②High-field coil development including MRI:
Professor Denis Le Bihan, (Member of the Institute de France and of the Academy of Technologies, Head of NeurosSpin, CEA, Saclay, France), presented a plenary lecture entitled, "Prospects of ultra high-field magnetic resonance imaging" on 10th September. He also presented a lecture entitled, "The manufacturing status of the Iseult/INUMAC whole body 11.7 T MRI magnet", (Vedrine *et al*.: CEA, Siemens healthcare, and ALSTOM). High-field MRIs include the development of an 11.7 T MRI, which is ongoing at Saclay. He emphasized that MRIs with even greater high-field characteristics can precisely acquire images of a brain's functional performance. Typical MRI's are around 3 T. Dr. Nishijima at NIMS in Japan, reported on an NMR system with the world's largest high-field characteristics given in a lecture, entitled, "Successful upgrade of a 920 MHz NMR magnet to 1020 MHz, using an innermost Bi-2223 coil".

Dr. Hahn from MIT (National High Magnetic Field Laboratory), introduced a fundamental study on the development of high temperature superconducting NMR coils entitled, "No-insulation HTS winding techniques for high-field NMR magnets". Fundamentally, a no-insulation coil (NI coil), does not employ any material insulation between the wires. Dr. Iwasa, also from MIT, first proposed an NI coil two or three years ago. Now, such research is being actively conducted by both Japan and Korea. NI coils can be made more compact with greater current densities. However, excitation speeds are reduced and this may limit their applications. Dr. Hahn's research team fabricated a 26 T NI coil in collaboration with Sunam last year. Additional to this, studies to enhance excitation speeds have been conducted on different metallic materials such as SUS installed between the coil windings of an HTS coil. (Presentation: A (RE)BCO pancake winding with metallic insulation (Dr. Lecrevisse (Saclay) and Dr. Iwasa (MIT)).

③Progress of Y-based wires:
This account only provides a brief summary (for further details, refer to article of Dr. Izumi). Theva and Bruker HTS in Europe have advanced the wire development project, the so-called Euro Tapes Project (2012-2016). Presently, both the wire characteristics and wire lengths have not yet reached the records set by Japan, USA, and Korea.
Examples of the progress include:

Bruker HTS: Production capacities of 25 km/year of 4 mm-wide tape. Single-length of 600 m.

Theva: 1 km-single-length GdBCO tapes fabricated by reactive co-evaporation onto an ISD-MgO layer. Although quality testing is fully automated during deposition, the in-field I_c is most likely as low as before since the conventional ISD method is still being utilized.

Deutsche Nanoschicht: Chemical solution deposition as low-cost manufacturing process (on RABiTS buffer layer). A portion of the equipment to be used for mass production is currently under construction. Information related to this is available to their customers this year onward.

Oxolutia: A unique inkjet-style manufacturing process is being adopted. Deutsche Nanoschicht and Oxolutia are both now moving towards full-scale long-wire production.

December 2015 Date of Issue: December 15, 2015

Superconductivity Web21

Published by International Superconductivity Technology Center
KSP, Kawasaki, Kanagawa 213-0012 Japan Tel:+81-44-850-1612, Fax:+81-44-850-1613

④ High-temperature superconducting power applications such as AmpaCity (High temperature superconducting cables)

The presentations relating to AmpaCity, HTS cables in Japan, USA, and Europe, as well as fault current limiters and SMES were made during the power transmission cable and storage session held on the first day of the conference. Dr. Stemmle *et al*., presented the AmpaCity Project with his talk entitled, "Update on the world's first superconducting cable and fault current limiter installed in the German city center". A 1 km-long, 10 kV three-layer coaxial cable (manufactured by Nexans) is currently in operation in an actual grid system. A fault current limiter was also installed and thus eliminated the need of four substations positioned downstream. The project focuses towards the practical realization of superconducting cables and will identify any issues that arise during the two-year long operation. A site visit was made during ISIS the previous week. The superconducting nature of the operation was not perceived at the substation where the superconducting equipment was installed. No noise emanated from the fault current limiter. The author was therefore impressed with the harmony of the entire system with the town (Refer to photo).

The entire view of the high-temperature superconducting facility (in substation). The red arrow points to a place where the exit of cable (Bi) and the fault current limiter (shown in the photo below) are installed.

A close up of the superconducting fault current limiter (YBCO-coated conductors are employed), highlighted by the red arrow in the top photo.

Dr. Grant, former EPRI, reported on the lessons learned from the past power cable project conducted in USA, entitled "Lessons learned from the 1998-2004 USA Pirelli-Detroit Edison cable demonstration". During that time, the cable project was led by investor-owned private utilities that included Pirelli and Detroit Edison. In addition to receiving no support funding from the state or country, investment issues due to it being an investor-owned utility and deregulation led to the project being terminated early. He went on to comment that projects in Europe, (not purely private utilities), should advance by learning from the lessons from this project, which did not have long-term prospects in mind (the contents are from proceedings since the author was not able to attend the lectures).

The development of a 10 m-class HTS cable has advanced in Brazil, under the Brazilian Electricity Agency, which has funded the work since 2010 (Development of the first Brazilian project on superconducting power cable, Marcelo *et al.*).

December 2015 Date of Issue: December 15, 2015

Superconductivity Web21

Published by International Superconductivity Technology Center
KSP, Kawasaki, Kanagawa 213-0012 Japan Tel:+81-44-850-1612, Fax:+81-44-850-1613

Special session – A panel discussion with each presenter following their presentations.

A special session entitled, "large scale-industries and utilities", held on the afternoon of the second day of the conference, and was dedicated to cables and fault current limiters being developed in Europe, reflecting the intensive work in this field. The chairpersons were Dr. Bruzek (Nexans) and Dr. Hadjsaid (Grenoble-INP/G2Elab). The sessions focused on future issues that could arise based on the experiences in demonstrations trials of power equipment progressed worldwide. The panel members included, Dr. Martini (RSE Central Research Institute of Electric Power Industry, Italy) who presented the introductory session, Dr. Merchel (RWE) who presented the AmpaCity project (1 km, 10 kV, 40 MVA HTS cable with FCL), Dr. Ohya (Sumitomo) who presented the Yokohama project (240 m, 66 kV, 200 MVA HTS cable), Dr. Berg (Airbus) who presented on motors for aircraft, and Dr. Gulliano (RSE) who presented Italian fault current limiters. After their research findings and views were presented, each presenter discussed on stage, future issues with the audience, (Dr. Hayashi from Sumitomo Electric).

Of particular note was the presentation by Dr. Shmidt from Nexans. He highlighted that, for the installation of the cable and fault current limiter for the AmpaCity project in Essen, the company had to consult the residents regarding the implications and the consequences of having liquid nitrogen (installation of a 16 m-high tank), as well as the benefits of superconductor-based equipment in order to get their permission. Not only the technology, but also such additional efforts are required to realize successful infrastructure construction. Dr. Shmidt went onto comment that in addition to cost performance attributes, cable development and equipment capabilities, R&D for cooling was also necessary. The issues arising due to regulations and how to improve reliability (based upon the impressions of public opinions) were also presented. Regarding reliability, question from the audience related the cooling system and the large liquid nitrogen tank at AmpaCity. Dr. Shmidt stated there were no maintenance requirements, like for a refrigerator. A company supplies liquid nitrogen once every two or three weeks so safety is not a concern. Such issues are expected to lead to big discussions with Japanese research groups who are advancing cryocooling technology with the use of refrigerators.

⑤MgB_2 applications for power devices
At this conference a number of noteworthy presentations were made on MgB_2 equipment. The following is one example.

- Design and testing of real scale MgB_2 coils for SUPRAPOWER 10 MW wind generators, Dr. Sarmient *et al*. Tecnalia in Spain, Columbus in Italy.
- Long-length critical current measurement of MgB_2 wires in a coil: Dr. Wozniak *et al.*, Siemens
- The Best Paths project on MgB_2 superconducting cables for very high power transmissions, Dr. Ballarino *et al.*, CERN, Nexans and others.

Superconductivity Web21

Published by International Superconductivity Technology Center
KSP, Kawasaki, Kanagawa 213-0012 Japan Tel:+81-44-850-1612, Fax:+81-44-850-1613

In particular, MgB_2 for wind power applications was presented as having superior advantages at low temperature operation when compared to conventional, normal-conducting wind power applications. The fabrication of a large-scale MgB_2 coil prototype and cooling designs are now underway at KIT. The performance attributes remain inferior compared to REBCO. However, since costs are significantly lower, the project is progressing and aiming to be profitable straight after production.

Conclusions

For high temperature superconductors the cable being utilized for the AmpaCity project is most noteworthy. Whilst the cable is fabricated using Bi-wires, Y-based wires are employed for the fault current limiter. Following demonstration trials of 500 m and a 1 km-long cables conducted at Jeju Island, Korea, has led to further demonstrations worldwide. The author perceives that such demonstrations will change future public opinions (skeptics regarding reliability in particular).

RWE, a German electric utilities company who leads the cable demonstration trials at AmpaCity has appropriately sought to strengthen public relations on the completion of a trial facility, beginning with loading trials and transmission status. Over 100 press releases are available via TV, magazines, and newspapers up to now. The author understands that such kinds of activities are necessary for each company involved in implementing technology for society in order to overcome barriers associated with public opinions in Japan.

Top of Superconductivity Web21