## Shipment of Equipment for Japan-U.S. Smart Grid Project in New Mexico

Examples of µEMS operation displays

µEMS and operation server

The Japan-U.S. Collaborative Smart Grid Demonstration Project is being implemented by the New Energy and Industrial Technology Development Organization (NEDO) with participation by 19 Japanese companies together with utility companies, laboratories, and universities in New Mexico. The Japanese companies are providing equipment for smart grid demonstrations at sites in Los Alamos and Albuquerque. Toshiba is participating in the development of both sites and has supplied a micro energy management system (µEMS), a meter data management system (MDMS), and smart meters for each site.

As the leader of the Los Alamos Site Project, we are in charge of carrying out demonstrations of advanced generation control according to demand forecasting and scheduling, system monitoring, and supervisory control, using batteries and photovoltaic (PV) modules with total capacities of 1.8 MW and 1 MW, respectively. In order to achieve these functions, the µEMS plays the role of controlling the equipment based on information from the systems at the site. It also provides demand response functions with the implementation of a smart house, which is a demonstration house built as a part of this project. Demand response commands are issued by the µEMS, and a smart meter relays them to a home energy management system (HEMS) so that the HEMS can control the home electric appliances in the smart house.

In order to utilize the results from the demonstration sites, we are also organizing three research topics. As part of these activities we have created a demonstration scenario called the Use Case, which is described on the website of the Electric Power Research Institute (EPRI) (http://www.smartgrid.epri.com/repository/repository.aspx).

## Commencement of Commercial Operation of Large PV Power Generating Systems for Electric Power Companies

Seven large PV power generating systems for electric power companies (EPCs) have started commercial operation as follows:

- Okinawa EPC Miyako Island Mega-Solar Demonstration Research Facility:
  Output 4 MW (started in October 2010)
- Hokuriku EPC Shika Photovoltaic Power Station:
  Output 1 MW (started in March 2011)
- Hokuriku EPC Toyama Photovoltaic Power Station:
  Output 1 MW (started in April 2011)
- Tokyo EPC Ukishima Solar Power Plant:
  Output 7 MW (started in August 2011)
- Chubu EPC Mega Solar Taketoyo Power Plant:
  Output 7.5 MW (started in October 2011)
- Chugoku EPC Fukuyama Solar Power Plant:
  Output 3 MW (started in December 2011)
- Tohoku EPC Hachinohe Solar Power Station:
  Output 1.5 MW (started in December 2011)

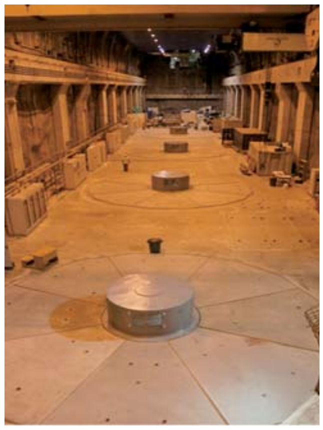
In the case of the Chubu EPC Mega Solar Taketoyo Power Plant, the facility consists of approximately 39 000 solar cell modules, 30 units of 250 kW-class inverters, eight 1 000 kVA step-up transformers, a 7 100 kVA main transformer, and an 84 kV gas-insulated switchgear (GIS).

PV arrays at Taketoyo Power Plant


Inverter system package and step-up transformer

GIS and main transformer

## Delivery of Large-Capacity Hydro Generator to Colombia



Overview of Porce III Hydroelectric Power Plant

Stator frame for Sogamoso Hydroelectric Power Plant

In November 2011, Toshiba shipped the first large hydro generator to the construction site for the 820 MW Sogamoso Hydroelectric Power Plant of Isagen S.A. E.S.P. in the Republic of Colombia, after successfully participating in the construction of the Porce III Hydroelectric Power Plant of Empresas Publicas De Medellin E.S.P. with a total capacity of 720 MW that started commercial operation in September 2011.

The Sogamoso Hydroelectric Power Plant is being constructed on the Sogamoso River, located in the Department of Santander in northern Colombia, and the site erection work for the first unit is progressing toward commercial operation in March 2014. This hydro generator has a capacity of 324 MVA, making it one of the largest hydro generators in the country.

We have supplied more than 30 hydro generators to Colombia including those for the two power plants mentioned above, making a significant contribution to meeting the country’s electricity demand.

The ratings of the hydro generators for both power plants are as follows:

- Porce III Hydroelectric Power Plant of Empresas Publicas De Medellin E.S.P.
  218 MVA-13.8 kV-360 $min^{-1}$-60 Hz × 4 units
- Sogamoso Hydroelectric Power Plant of Isagen S.A. E.S.P.
  324 MVA-16.5 kV-163.63 $min^{-1}$-60 Hz × 3 units

## Completion of Manufacturing Pump-Turbine Stationary Parts and Inlet Valve for Unit 1 of Kyogoku Pumped Storage Power Plant

Shop assembly of pump-turbine stationary parts for Unit 1

Shop assembly of inlet valve for Unit 1

Manufacturing of the pump-turbine stationary parts and inlet valve for Unit 1 of the Kyogoku Pumped Storage Power Plant of Hokkaido Electric Power Co., Inc. has been completed at Toshiba Hydro Power (Hangzhou) Co. (THPC) in China, and these components have been directly delivered to the project site.

The Kyogoku Pumped Storage Power Plant with a net head of about 400 m has three units (200 MW each) equipped with a state-of-the-art adjustable-speed system. The feature of the adjustable-speed system is that the input and output of electric power can be adjusted quickly by changing the rotation speed of a turbine and generator, thus maintaining stability of the frequency of the electric power grid.

Toshiba is supplying the main equipment for this power plant, including generator-motors, main transformers, static frequency converters, and monitoring and control systems, as well as pump-turbines. Commercial operation of Unit 1 is scheduled to start in October 2014.

The ratings are as follows:

- Pump-turbine:
  208 MW/230 MW-369 m/436.5 m-500 $min^{-1}$±5%
- Generator-motor:
  230 MVA/230 MW-16.5 kV-50 Hz-500 $min^{-1}$±5%

## Emergency Restoration of Thermal Power Plants Damaged by Great East Japan Earthquake and Construction of New Electric Power Facilities

The Great East Japan Earthquake on March 11, 2011, caused shortages of electric power in the Kanto and Tohoku regions. In order to increase the power supply, Toshiba, in cooperation with electric power companies, contributed to the speedy restoration of devastated thermal power plants, the restarting of long-inactive thermal power plants, and the installation of emergency power supplies.

As The Tokyo Electric Power Company, Inc. (TEPCO) aimed to restore the seriously damaged Hirono Thermal Power Station by the summer of 2011, we undertook the restoration work of this 2 200 MW plant, allowing it to restart generation on July 14, 2011. Meanwhile, recovery work continued at many other damaged thermal power plants. The recovery work at TEPCO's Shinchi Thermal Power Station was completed on December 19 in the same year, allowing it to restart generation. Tohoku Electric Power Company, Inc. and Toshiba are planning to restart the Haramachi Thermal Power Station by the summer of 2013.

Immediately after the Great East Japan Earthquake, electric power companies, especially TEPCO and Tohoku Electric Power Co., Inc., initiated a study to construct a gas turbine (GT) power plant due to concerns over the shortage of power supplies. Toshiba has been assigned to supply 1 300°C-class GT electric power facilities, and to install and commission these facilities for Kashima Thermal Power Station Units 7-1, 7-2, and 7-3, as well as for Hachinohe Thermal Power Station Unit 5. These facilities started commercial operation in July 2012.

At present, a plan to add a heat recovery steam generator and steam turbine generator to the GT electric power facilities, that is, to create a combined-cycle system, has been initiated for both the Kashima and Hachinohe power stations, in order to generate more power with higher efficiency and to reduce the environmental load.

Three-dimensional rendering of combined-cycle system at Hachinohe Thermal Power Station Unit 5 of Tohoku Electric Power Co., Inc.

## Commencement of Commercial Operation of Tanjung Jati B Expansion Project Units 3 and 4 in Indonesia

Tanjung Jati B Expansion Project Unit 3 in the Republic of Indonesia successfully entered commercial operation on schedule in October 2011, followed by Unit 4 in January 2012. These 660 MW coal-fired subcritical thermal power plants were built in succession to Units 1 and 2, which were completed in 2006.

Toshiba supplied major equipment and components including steam turbines, generators, condensers, feedwater heaters, feedwater pumps, a distributed control system (DCS), substation facilities, a water treatment system with a desalination facility, a demineralized water facility, and a wastewater treatment facility, and carried out the commissioning work for this project.

A special feature of this project is its wide range of water treatment facilities. In particular, the water treatment system is equipped with a desalination facility capable of generating fresh water from seawater at a rate of 630 $m^3$ per hour to fully cover the requirements of the steam cycle system and other facilities. This amount of fresh water is quite large compared with that generated in conventional desalination facilities for thermal power plants.

We are making efforts to contribute to the stable supply of electric power through the construction of thermal power plants taking advantage of the experience and knowledge obtained in this project.

Tanjung Jati B Power Plant, Indonesia

Tanjung Jati B Units 3 and 4 steam turbine and generator building

Steam turbine and generator

## Start of Operations at Toshiba JSW Turbine & Generator Pvt. Ltd., India

As India is facing severe power shortages because of its remarkable economic growth, there is increasing demand for the construction of large-scale power plants. Toshiba, together with the JSW Group in India, has established Toshiba JSW Turbine & Generator Pvt. Ltd. (Toshiba JSW) in Chennai for the design, manufacture, sale, and servicing of steam turbines and generators.

Toshiba JSW will supply state-of-the-art equipment that introduces supercritical technology to the Indian market with an initial manufacturing capacity of 3 million kW per year, and will undertake the entire range of services including material procurement, machining, fabrication, and testing in India, contributing to the country's development.

Partial operation of the factory began in January 2011, and the first shipment of turbine apparatus aimed at the U.S. market was made in July 2011. In February 2012, a ceremony to celebrate the completion of the main plant was held with the attendance of the chief minister of the state and others.

Manufacturing plant and headquarters building of Toshiba JSW, India

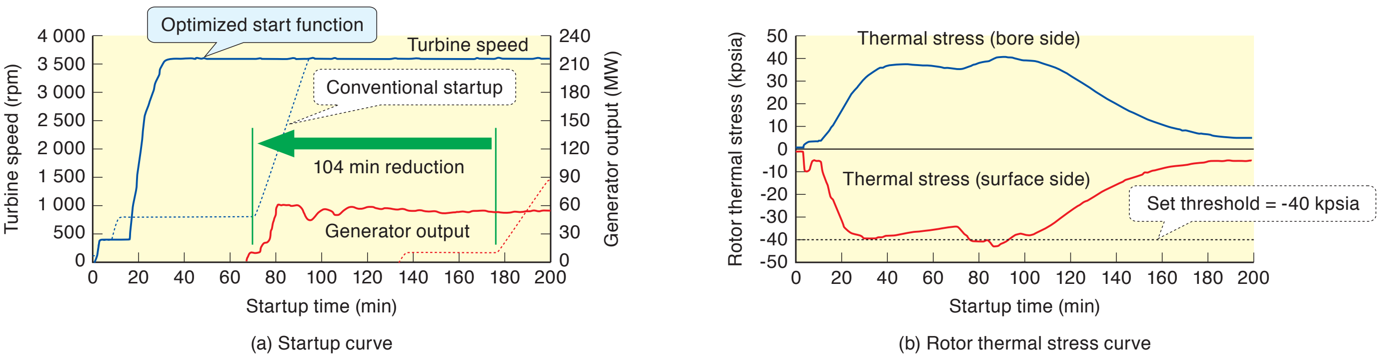
Toshiba JSW has received an order for the supply of equipment to India's Kudgi Super Thermal Power Project (3 × 800 MW) and Meja Thermal Power Project (2 × 660 MW) of NTPC Limited, and the first complete steam turbine and generator set is scheduled to be delivered in 2013. The manufacturing capacity of the plant is to be expanded to 6 million kW per year in the future.

## Substantial Shortening of Steam Turbine Startup Time by Optimized Start Function at Combined-Cycle Power Plants in U.S.

Toshiba has developed and commercialized a new control technology to substantially shorten the startup time of steam turbine units of thermal power plants.

The new technology, called the "optimized start function," is already in practical use at several combined-cycle power plants in the United States. At one of these power plants, for example, the optimized start function has achieved a 104 min reduction of steam turbine startup time from 173 min to 69 min under similar conditions to the previous startup conditions while maintaining the rotor life consumption rate calculated by thermal stress at the same level in as the conventional case, earning a high evaluation from the customer.

Shortening of the steam turbine startup time realizes a number of crucial advantages in a thermal power plant, including a substantial reduction of carbon dioxide emissions and fuel consumption in the turbine startup process, and a significant speeding-up of responses to load changes. The latter will become particularly important with the frequent load changes in electric power systems accompanying the expanding use of renewable energy sources. The incorporation of this new technology into many thermal power plants will enhance the roles of quick startup and rapid responses to load changes that will be indispensable in the coming renewable energy era.




kpsia: kilopounds per square inch absolute

Actual data of steam turbine optimized start function at combined-cycle power plant in U.S.

## Completion of Control System Replacement at Shajiao B Power Station in China

A control system replacement project was completed in March 2011 at the Shajiao B Power Station, which was constructed in the 1980s in southern China and consists of 2 units × 350 MW and common facilities. The project was executed by Toshiba in cooperation with Toshiba Xingyi Control System (Xi'an) Co., Ltd. (TXCS).

The existing equipment for plant control and monitoring was configured with a boiler, turbine, and generator (BTG) bench board, an electric mimic panel, a computer system, and a control system including a boiler modulating control system and a burner management control system supplied by another manufacturer. All of these out-of-date pieces of equipment were replaced with the latest generation of our TOSMAP-DS™ series DCS with digital electrohydraulic control (D-EHC), a digital automatic voltage regulator (D-AVR), and turbine supervisory instrumentation (TSI).

The new control system provides operators with high-quality, stable plant operation including fully automatic unit startup and shutdown, and has been favorably received by the customer.

Before replacement

After replacement

DCS operator station in central control room

## AP1000™ Construction Status: Substantial Licensing Developments in U.S. and Construction Steadily Progressing in China

The revolutionary AP1000™ pressurized water reactor (PWR) put into practical application by Westinghouse is currently under construction in China. Even after the accident at the Fukushima Daiichi Nuclear Power Station in March 2011, the construction of all of the four units has been steadily progressing.

In the United States, the AP1000™ design was again certified by the Nuclear Regulatory Commission (NRC) in December 2011, and in addition, Combined Construction and Operating Licenses, for which two U.S. electric utilities had made applications to the NRC for construction of the AP1000™, were issued in February and March 2012. This is the first time that the construction of a new nuclear power plant has been approved since the Three Mile Island Nuclear Power Plant accident , and full-scale construction work has already started at the site. Toshiba delivered a condenser for the U.S. First-of-a-Kind (FOAK) AP1000™ in December 2011 as part of its scope of supply of the turbine generator and other components.

Sanmen Unit 1 construction site in China

The United States Nuclear Regulatory Commission certifies the amended

AP1000 Standard Design

as set forth in Appendix D of 10 CFR Part 52

Design certification of AP1000™ approved by NRC

Construction preparation work at Vogtle site in U.S.

## Restoration Work at Fukushima Daiichi Nuclear Power Station

SARRY™ contaminated-water treatment system

At TEPCO's Fukushima Daiichi Nuclear Power Station, which was damaged by the Great East Japan Earthquake of March 11, 2011, Toshiba has made significant contributions to the achievement of the cold shutdown condition announced on December 16, 2011. We have been offering newly developed technologies suitable for the severe and rapidly changing circumstances at the site while providing our emergency project team consisting of about 2 000 engineers for the earliest possible stabilization of the facilities there.

In particular, the development of a compact gamma camera and the minimization of site work by modularization and prefabrication of each unit of equipment have allowed site workers to work under conditions that realize significant reductions in radiation exposure. Furthermore, we developed and fabricated the SARRY™ contaminated-water treatment system within three months. The SARRY™ system has played a crucial role in cleaning and reducing the enormous volume of contaminated water at the site and contributed to stabilization of the levels of contaminated water in the turbine buildings due to its high performance and stable operation.

We are making continuous efforts to propose innovative cutting-edge technologies that we have cultivated over many years of experience in developing and constructing nuclear power plants to TEPCO, the central government, and local governments, in order to restore the damaged environment both on-site and off-site. Furthermore, we will supply nuclear power plants with the world's top level of safety based on the knowledge obtained through the Fukushima experience.

## Super-Mobility Robot for Application to Nuclear Power Plants

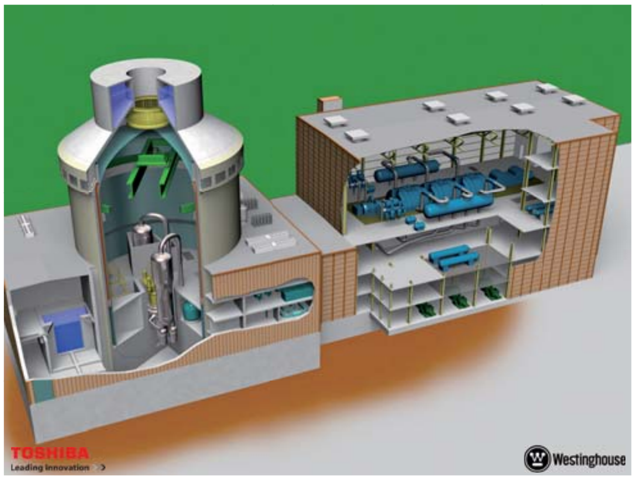

Super-mobility robot for application to nuclear power plants

Toshiba has developed a super-mobility robot for application to nuclear power plants, designed to work in harsh environments and to access high-radiation areas as a substitute for personnel.

This robot equipped with a walking mechanism and a manipulation function is capable of walking in spaces of 500 mm in width, stepping over obstacles of 500 mm in height, going up and down ladders, and moving through objects such as pipes. Thanks to these capabilities, it is useful for performing visual inspections, monitoring radiation indicators and other equipment, operating valves, drilling holes in pipes, and other critical tasks.

We are planning to apply the super-mobility robot to the restoration work at the Fukushima Daiichi Nuclear Power Station in 2012. There are also high expectations that this robot will be of use in plant equipment maintenance, fire prevention, building security, and various other fields in the near future.

## Seismic Enhancement of AP1000™




Bird's-eye view of enhanced high-seismic AP1000 PWR plant

The AP1000™ is a cutting-edge PWR that features innovative passive safety concepts utilizing the natural forces of gravity, natural circulation, and compressed gases. This plant is designed to achieve and maintain a safe shutdown condition without any operator actions or active components, such as diesel generators or pumps, in the event of an accident. This results in economic competitiveness by reducing the amount of safety-grade equipment. A total of eight plants are already under construction in China and the United States.

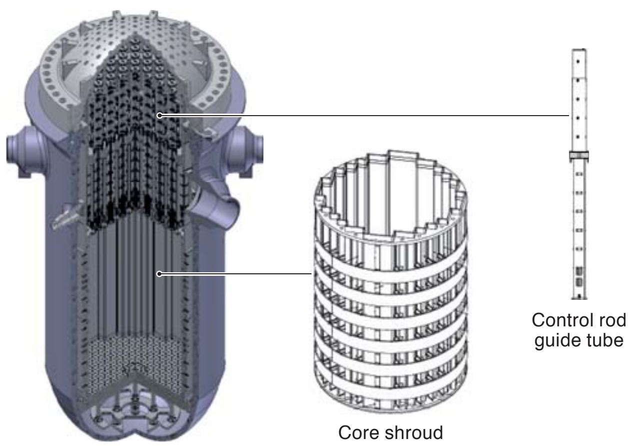
To apply the AP1000™ to earthquake-prone areas, an enhanced high-seismic AP1000 is being developed with the same inherent passive safety concepts and economic competitiveness. The building basement will be expanded to improve stability during an earthquake, and high-strength materials will be used for the buildings and structures to minimize changes to the seismic footprint. Additional support for the control rod drive mechanism and vibration damping systems for major components, such as the steam generators and the pressurizer, are also being developed for this application.

## Establishment of Manufacturing Technology for AP1000™ Reactor Vessel Internals

Toshiba has refined the manufacturing technology for the AP1000™ reactor vessel internals through the fabrication of full-scale mockups prior to the first assembly.

We fabricated full-scale mockups of both the core shroud and control rod guide tubes with complicated structural welds, which were extracted from the AP1000™ reactor vessel internals as components to be verified by evaluating the difficulty of manufacturing such components based on our prior experience in the fabrication of reactor internal components. By both analyzing the results of dimensional measurements at each step of the mockup manufacturing and optimizing the welding methods, assembly procedures, and manufacturing jigs, an improved manufacturing technology satisfying the dimensional and functional specifications was realized. We also obtained the potential to further shorten the manufacturing lead time by analyzing and improving the manufacturing process.

As a result, we have established the manufacturing technology to be used for the AP1000™ reactor vessel internals, and have started manufacturing the core barrel, which is an integral part of the reactor vessel internals, with this improved technology at Keihin Product Operations. We are planning to further expand the scope of manufacturing of the reactor vessel internals based on these activities.



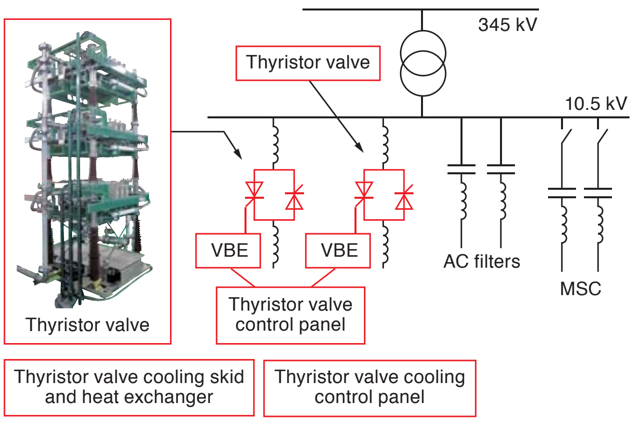

Cross-sectional structure of AP1000™ reactor vessel internals

## Completion of Factory Tests of +100/-84 MVA SVCs for Santos Dumont 2 Substation in Brazil

Factory tests of the main components manufactured in Japan for the +100 MVA to -84 MVA static var compensators (SVCs) for the Santos Dumont 2 Substation of Companhia Energética de Minas Gerais S.A. (CEMIG) have been completed, and they were shipped to Brazil in September 2011. The main components consist of thyristor valves; valve base electronics (VBE); thyristor valve cooling systems comprising a cooling skid, heat exchangers, and a cooling control panel; and a thyristor valve control panel. The SVC system will be installed in the new 345 kV/138 kV Santos Dumont 2 Substation to stabilize the 345 kV system voltage.

During the factory acceptance test in Japan, the functions of the thyristor valve control panel, which serves as the core of the SVC system, were verified by connecting a digital simulator representing an actual network system with the SVC main circuit. The tests were witnessed by CEMIG, and satisfactory performance meeting the client's requirements was confirmed.

The installation of these main components at the site started in April 2012. After the completion of unit tests, system combination tests, and field verification tests, the SVCs are scheduled to be commissioned in November 2012.




MSC: mechanically switched capacitor bank

Configuration of SVC for Santos Dumont 2 Substation, Brazil

## Completion of FTK Contract for 300 kV-240 MVAR Series Reactors of Az Zour South Substation in Kuwait

Completed 300 kV-240 MVAR series reactor

With various countries having made plans to install large-capacity power stations in recent years, the breaking current of power transmission systems has tended to increase. As the breaking current of a 300/420 kV system is generally 63 kA, gas-insulated switchgear (GIS) manufacturers have been developing and manufacturing equipment to meet such system requirements. The Ministry of Electricity & Water (MEW) of Kuwait was also planning to increase the generation capacity of the Az Zour South Power Station. As the breaking current in this plan would increase, the existing circuit breaker could not break the increased breaking current exceeding 63 kA.

Toshiba utilized its advanced system analysis technologies to carry out an analysis of the electric power system, making use of its advantage as the existing GIS supplier. As a result, it was recognized that the breaking current could be controlled if a 240 MVAR series reactor was connected to a 300 kV system, making breaking possible without modification of the existing GIS. At the same time, we examined the stability of the power system and confirmed that it would not be significantly affected. We proposed this course of action to MEW, and were awarded the contract for a full-turnkey (FTK) project including civil engineering work for the new buildings. The project was successfully completed in July 2011. This project served as a good example of our project solution capabilities fully utilizing our knowledge and experience of electric power system analysis technologies.

## 3D-Shaped Yttrium-Based High-Temperature Superconducting Coil

The size of a heavy ion accelerator ring can be reduced by applying yttrium-based high-temperature superconducting (HTS) coils to the electromagnet for the ring because of the high current density of HTS wires. As an extremely uniform magnetic field distribution is required for a heavy ion accelerator ring, it is necessary for the coil to be a complicated three-dimensional (3D) shape. Although an yttrium-based HTS wire, which is flat tape-shaped, meets the requirements, it is difficult to wind in a 3D configuration without any degradation of the superconducting property.

Toshiba has fabricated 3D-shaped yttrium-based HTS coils using a newly developed 3D coil winding machine. As a result, the critical current of the coil achieved 98.7% of the designed value, and it was confirmed that the winding machine satisfied the predetermined performance. In the future, we will apply 3D-shaped yttrium-based HTS coils to wind power generators, magnetic resonance imaging (MRI) systems, etc. as well as heavy ion accelerators.

3D-shaped yttrium-based high-temperature superconducting coil

Part of this work was supported by the Japan Science and Technology Agency (JST) under the Strategic Promotion of Innovative Research and Development Program.

## Superconducting Dipole Magnet System for SAMURAI

Toshiba has developed one of the world's largest(*) superconducting dipole magnet systems equipped with a 4 K cryocooler for the SAMURAI multiparticle spectrometer, a major experimental installation under construction at the Radioactive Isotope Beam Factory (RIBF) in the RIKEN Nishina Center for the measurement of multiparticles from radioisotope beams.

The superconducting dipole magnet system consists of a set of superconducting magnets located at the upper and lower parts of 600-metric-ton iron cores (blue parts in the figure), a vacuum duct installed between the magnets, and a rotatable base on which these are mounted.

The main feature of the system is the reduction of the heat load to 1/25 of the original design value by applying both a cryogenic temperature heat insulation support technology that can support no less than 650 tons (6.4 MN) of electromagnetic force and a conduction cooling technology. As a result, a 4 K cryocooler system with unprecedented compactness for a system of this scale was realized. This eliminates the need for a conventional large-scale refrigeration facility and achieves significant simplification of all aspects of the system, including operation and maintenance.

(*) As of March 2012 (as researched by Toshiba)

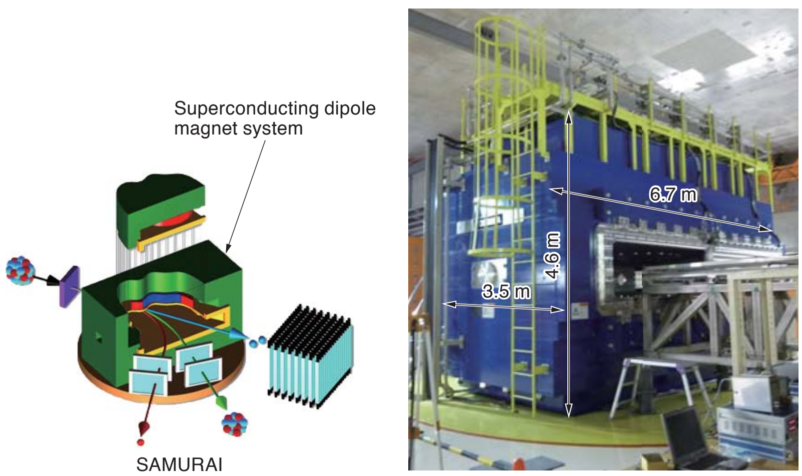



Photo courtesy of RIKEN

SAMURAI and superconducting dipole magnet system