## All Four Units of AP1000™ under Construction in China

Westinghouse has developed the AP1000™, an innovative pressurized water reactor (PWR), to the level of practical application, and four units are under construction in China for the first time in the world.

Westinghouse commenced the construction of Sanmen Unit 1, scheduled to be the world's first operating AP1000™, with the first concrete pouring in March 2009. Installation of the containment vessel (CV) from the bottom head to CV ring #4 has been completed. In addition, Westinghouse commenced the construction of Haiyang Unit 2, which is the fourth unit of the AP1000™, in June 2010. A total of four units of the AP1000™, including Sanmen Unit 2 and Haiyang Unit 1, are simultaneously under construction and all are being constructed on schedule.

Commercial operation of Sanmen Unit 1 is planned to start in November 2013, and that of Haiyang Unit 2, the fourth AP1000™, is planned for March 2015.

(a) Installation of CV bottom head at Sanmen Unit 1 (December 2009)

(c) First concrete pouring at Haiyang Unit 2 (June 2010)

(b) Installation of CV ring #4 at Sanmen Unit 1 (September 2010)

AP1000™ under construction in China

## Commencement of Commercial Operation of Maizuru Power Plant Unit 2 of The Kansai Electric Power Co., Inc.

Maizuru Power Plant Unit 2

Commercial operation of the Maizuru Power Plant Unit 2 of The Kansai Electric Power Co., Inc. started in August 2010. This plant is a coal-fired thermal power plant that has a large capacity under severe steam conditions; i.e. a rated capacity of 900 MW, a rated main steam pressure of 24.5 MPaG, a rated main steam temperature of 595°C, and a rated hot reheat temperature of 595°C. The steam turbine is a cross-compound four-flow exhaust type, and the generator is composed of primary and secondary generators of 670 MVA and 370 MVA, respectively.

High efficiency was realized in this plant by various advanced technologies such as those for attaining higher efficiency of the steam turbine by employing longer last-stage blades, for attaining higher steam temperature by using 9Cr alloy steel that can withstand high temperatures, and for attaining larger capacity by an indirectly hydrogen-cooled turbine-driven generator (with the highest capacity in the world[*]). In particular, the highest level of plant performance in the world for a coal-fired power plant was achieved, making a significant contribution to the reduction of carbon dioxide ($CO_2$) emissions.

Toshiba undertakes engineering, manufacturing, and commissioning of turbines and generators, and also supplies conventional boilers as a boiler, turbine, and generator (BTG) main contractor.

Since the Maizuru Power Plant Unit 2 was constructed during the commercial operation of Unit 1, we paid special attention to the requirements of installation in a limited area and the establishment of a commissioning schedule matching the operating schedule of Unit 1.

We will continue to contribute to stable power supplies throughout the world by applying new technologies as a BTG contractor.

(*) As of October 2009 (as researched by Toshiba)

## Start of Manufacturing at TXCS Factory in China

New office building and factory of Toshiba Xingyi Control System (Xi'an) Co., Ltd.

Construction of the factory of Toshiba Xingyi Control System (Xi'an) Co., Ltd. (TXCS) in China, which was established in July 2007, has been completed and manufacturing operations started there in July 2010.

This factory has the capability to produce five sets of large-scale distributed control systems (DCS) for thermal power stations per year. Toshiba aims to actively compete with other overseas DCS manufacturers and to enlarge its share in the Chinese market. Moreover, this factory is positioned as a base of manufacturing for overseas thermal power stations, especially those in the Southeast Asian region.

As the first project at the factory, the DCS for Unit 2 of the Shajiao B Power Station, which has two 350 MW power generating units, was manufactured and subjected to a factory acceptance test (FAT), which it successfully passed in October 2010.

TXCS is further enhancing its manufacturing capabilities in order to receive orders for whole control and information system projects, including field devices for thermal power stations from engineering, procurement, and construction (EPC) contractors.

The following is an outline of the TXCS factory.

- Location: Xi'an High-Tech Industrial Development Zone, in Xi'an, Shaanxi Province, China
- Production: DCS and related information, control, and instrumentation systems
- Site area: 12 640 $m^2$
- Building area: 9 170 $m^2$

## 3 × 209.2 MW Nam Ngum 2 Power Project in Operation in Lao People's Democratic Republic

Overview of Nam Ngum 2 Power Station

The 600 (3 × 209.2) MW Nam Ngum 2 Hydroelectric Power Project north of Vientiane in the Lao People's Democratic Republic has been successfully completed, and entered commercial operation in December 2010.

This project is one of the largest hydroelectric power projects in the Lao People's Democratic Republic, and Toshiba's turnkey capability has received high commendations from the owner as a result of this successful operation. The electrical and mechanical parts were designed, manufactured, supplied, installed, and commissioned by the Toshiba Group; namely, by Toshiba and Toshiba Plant Systems & Services Corporation.

The scope of supply and ratings are as follows.

- Turbines: 3 units, 209.2 MW-154.5 m-214.3 $min^{-1}$
- Generators: 3 units, 228 MVA-15 kV-50 Hz
- Control and protection system: 3 sets
- Powerhouse equipment: Main circuit bus, station service equipment, overhead crane, etc.

## Completion of Large Runner Assembly on Site for Gongguoqiao Hydropower Station in China


Runner manufacturing factory at site and on-site-welded runner



Hydraulic research laboratory of THPC

The Gongguoqiao Hydropower Station is a low-head, large-capacity power station under construction in Southwest China. With equipment supplied by Toshiba Hydro Power (Hangzhou) Co., Ltd. (THPC) in China, it has design ratings of 66 m head, 230 MW unit capacity, 7 m runner diameter, and 150 t runner mass.

While equipping the power station, a temporary factory was constructed near the site and furnished with the runner welding equipment, a vertical lathe, and a furnace, since the integral type runner could not be transported due to size and weight limitations. The runner crown, band, and blades were each transported separately to the site factory, and then welded together on site. Detailed welding procedures based on a mockup test evaluation and welding deformation analysis ensured that the high quality of Toshiba's standards was maintained throughout the manufacturing process.

Since its establishment in 2005, THPC has moved forward with first-rate facilities including a new coil shop, a new hydraulic research laboratory, and a large machine shop equipped to service 600 MW hydraulic equipment. As a result, THPC has been steadily receiving orders such as for the supply of 45 MW bulb turbine/generators for the Huang Feng Hydropower Station and the supply of 326.5 MW pumped-storage systems for the Qingyuan Pumped Storage Power Station.

The Toshiba Group including THPC is not only working to develop the hydroelectric power market in China, but also striving to expand its business around the world in accordance with its global manufacturing capabilities and sophisticated engineering facilities.

## Indirectly Hydrogen-Cooled Turbine-Driven Generator Awarded Various Prizes for High Efficiency and Large Capacity

670 MVA indirectly hydrogen-cooled turbine-driven generator undergoing shop test

Toshiba has developed a 670 MVA turbine generator with the world's highest level of efficiency (99.1%), as well as the world's largest capacity(*) for an indirectly hydrogen-cooled turbine-driven generator.

Since the carbon dioxide ($CO_2$) emissions of a thermal power station can be reduced by using this generator, it has been recognized as contributing to the improvement of environmental performance and the prevention of global warming.

We have been awarded the following prizes for this generator:

- Outstanding Energy-Saving Devices Award, The Japan Machinery Federation President's Prize (February 2010)
- Progress Prize, Electro-technical Promotion Award, The Institute of Electrical Engineers of Japan (May 2010)
- Electrical Science and Technology Encouragement Prize, Incentive Award of the Minister of Education, Culture, Sports, Science and Technology (November 2010).
- Iwatani Naoji Memorial Award, The Iwatani Naoji Foundation (March 2011)

(Awards are listed above in the order received.)

This generator has been installed on the primary side of the cross-compound type power generation facilities of Maizuru Power Plant Unit 2 of The Kansai Electric Power Co., Inc., which started commercial operation on August 31, 2010.

(*) As of October 2009 (as researched by Toshiba)

## Titanium 48-inch Last-Stage Blade for 60 Hz Steam Turbines of Thermal Power Plants

Low-pressure turbine rotor applying 48-inch titanium last-stage blade

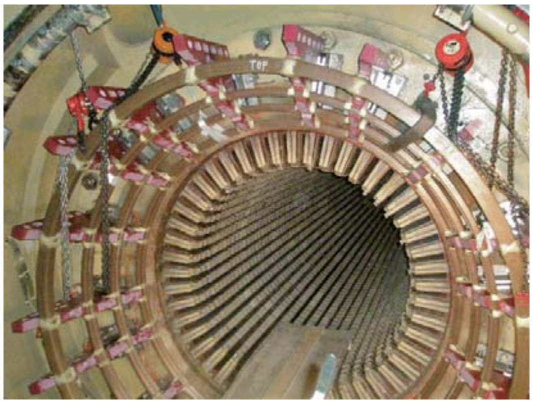
Toshiba has developed a titanium 48-inch last-stage blade to achieve high performance and compact design of steam turbines for 1 000 MW-class thermal power plants and 300 MW-class combined-cycle plants. This blade has the world's largest class exhaust annulus area and highest tip blade speed for 60 Hz steam turbines of thermal plants.

Despite the fact that this blade operates at a high Mach number, the airfoil was designed without much increase in loss. The blade configuration is characterized by curved axial fir-tree dovetail and snubber cover blade tip connections and mid-span connections. To achieve superior vibration characteristics, a continuously coupled structure was adopted for the blade connections. The blade therefore has high reliability in terms of strength and vibration.

To confirm the validity of the design, sub-scale model blades were fabricated and tested in a model steam turbine as a first step. Next, one row of actual-size blades was manufactured to confirm the quality of the forged material and machinability. These blades were then assembled on a test rotor and subjected to a rotating vibration test in a spin cell. Finally, the blades were tested under actual steam conditions in a full-scale steam turbine test facility. As a result, the aerodynamic performance and vibration characteristics of this blade under actual steam conditions were successfully verified.

It has already been decided that this titanium 48-inch last-stage blade will be applied to actual plants.

## Stator Rewinding Work Completed at Lambton Generating Station in Canada



Generator stator coil of Lambton Generating Station, Canada

Toshiba received the order for rewinding of the stator coil of the Lambton Unit 4 generator at the Lambton Generating Station in Ontario, Canada, in March 2009, and completed the rewinding work in June 2010. This was the first time that Toshiba undertook the rewinding of a generator of another original equipment manufacturer (OEM) in North America.

As preparation for this project, we investigated other OEM generators to which our rewinding technology could be applied. We then established a method for measuring the internal dimensions of other existing OEM generators using a three-dimensional (3D) laser measuring instrument and other devices, as well as an organization for rewinding work in North America by training the winders of REGENCO LLC in the United States.

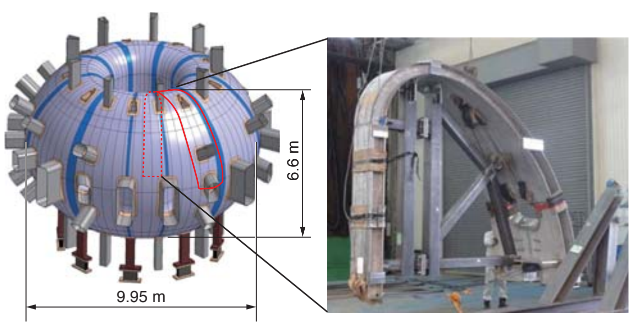
The successful completion of this work has verified that Toshiba has the capability to conduct rewinding work on other OEM generators.

## Establishment of Production Technique for Vacuum Vessel of JT-60SA Experimental Fusion Device

Toshiba is manufacturing the vacuum vessel (VV) that will comprise the main component of the JT-60SA experimental fusion device. This device is being constructed at the Naka Fusion Institute of the Japan Atomic Energy Agency (JAEA) in a collaborative project between the European Union and Japan. The purpose of the device is to perform experimental studies of the International Thermonuclear Experimental Reactor (ITER), which is under construction in France, more efficiently and to support studies on a demonstration reactor in a complementary manner. The first plasma will be produced in the device by March 2016.

The VV has a doughnut shape and a double-shell structure. The height and outer diameter of the torus are 6.6 m and 9.95 m, respectively, and its cross section is D-shaped. It is essential to suppress welding distortion in the manufacturing process. Through the manufacturing of a prototype of the upper part of the 20° sector, we have established a technique to reduce and correct welding distortions and achieved high precision to satisfy the product specifications. We are planning to deliver all 10 sectors by March 2014.

Toshiba is aiming to contribute to the international fusion project with high-level production techniques and to expand its nuclear fusion business in the future.



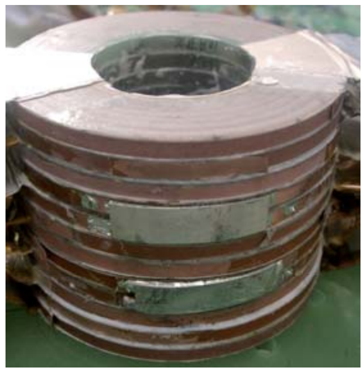

(a) Vacuum vessel    (b) Prototype of upper part of 20° sector

Sector-division line

Figure courtesy of JAEA

VV for JT-60SA and prototype of upper part of 20° sector

## Development of Yttrium-Based High-Temperature 4.7-tesla Superconducting Coil



12-layer pancake coil wound with yttrium-based high-temperature superconductors

Toshiba has developed a 12-layer pancake coil wound with yttrium-based high-temperature superconductors impregnated with epoxy resin possessing the world's highest central magnetic field of 4.7 tesla(*) for yttrium-based high-temperature superconducting coils obtained at a cooling temperature of 20 K.

The superconducting properties of the coil were improved by establishing a coil manufacturing technology in which the thermal stress applied to the yttrium-based high-temperature superconductors is reduced when the coils are cooled.

Since yttrium-based high-temperature superconductors have a high critical temperature as well as high mechanical strength and high current density, it is possible to make devices using such superconductors with reduced size and weight.

We plan to apply this technology to various superconducting devices such as a superconducting magnetic energy storage (SMES) system for voltage dip compensation and a silicon crystal puller.

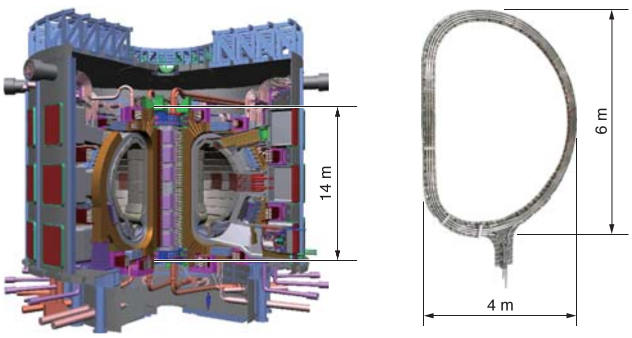
(*) As of November 2010 (as researched by Toshiba)

## Completion of Prototype Coil Windings for ITER Toroidal Field Coil

In the International Thermonuclear Experimental Reactor (ITER) project, Toshiba has developed the manufacturing technology and fabricated a prototype coil to confirm the feasibility of the toroidal field (TF) coil, which will be one of the main components of the machine. ITER's TF coil is a large structure with a width of 9 m, a height of 14 m, and a mass of 300 tons.

The manufactured prototype coil is a D-shaped coil of 4 m in width and 6 m in height using a real ITER conductor of 43.7 mm in diameter. A newly developed conductor length measurement system with a precision of 0.01% and a newly developed winding technology capable of controlling the curvature with a precision at the 1% level were employed.

The results obtained for the prototype coil have demonstrated the feasibility of manufacturing precise large superconducting coils that satisfy the very tight ITER specifications by applying the newly developed technology.




(a) ITER (b) Prototype D-shaped coil

Figure courtesy of the ITER Organization in JAEA

ITER and prototype D-shaped coil with real ITER conductor

## Next-Generation Irradiation System for Heavy Ion Cancer Therapy Facility

Heavy ion treatment room for irradiation system

Toshiba has developed a next-generation irradiation technology for treating cancers in cooperation with the National Institute of Radiological Sciences (NIRS). Using this new technology, even cancer cells that form complex shapes and move due to breathing can be shot with pinpoint accuracy by a heavy ion beam at high speed.

Unlike the present method, in which the whole cancer is shot by an expanded beam at one time, in the new technology cancer cells are irradiated so that they are completely painted out by a pencil beam with the thickness of a pencil. The new technology is therefore capable of treating complex cancer shapes and reducing the exposure of normal regions to radiation. Furthermore, the new technology achieves accurate irradiation of organs that move due to breathing such as the lungs within a few moments of full exhalation due to the system's new fast scanning device, which operates 100 times faster than the conventional device.

The new system has been undergoing verification in the therapeutic irradiation setting since May 2011.

## Technology for Recovery of Rare Metals from Ore Solution after Uranium Mining

Toshiba has developed a technology to recover useful rare metals such as dysprosium (Dy) and neodymium (Nd), which are utilized as raw materials for high-performance magnets, from the residual ore solution that until now has been disposed of following the extraction of uranium from it.

This technology was realized by applying a technology employed for the recovery of useful elements from high-level nuclear waste generated in the reprocessing of spent nuclear fuel.

Rare metals are precipitated from the ore solution by the addition of oxalic acid, and Dy and Nd metals are recovered from this precipitate using the molten-salt electrolytic deposition method.

This technology is expected to contribute to stable supplies of these rare metals.

Dy metal recovered on electrode using molten-salt electrolytic deposition