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Special Reports

Advanced Energy Technologies Cultivated by Toshiba Supporting Experimental Nuclear Fusion Projects

Toshiba's Contribution to Development of Nuclear Fusion Energy
HATAZAWA Mamoru

Toshiba's Approaches to Research and Development of Nuclear Fusion Devices
NODA Tetsuya / SHIMADA Kazuhiko / INAGAKI Junji
Toshiba has been actively participating in projects for the research and development of nuclear fusion energy with related domestic and overseas research institutions and universities since the beginning of nuclear fusion research in Japan in the 1970s, and has developed various technologies for the design and manufacturing of experimental devices in this field. Among these projects, ITER, an international project being promoted by seven member entities including Japan, and the JT-60SA (JT-60 Super Advanced) experimental tokamak type device, a joint project between Japan and Europe, are currently under construction. We have been assigned the design and manufacturing of core equipment for these projects and have been developing advanced manufacturing techniques and skills in order to fulfill the high-level specifications of ITER and JT-60SA. Based on the knowledge accumulated through these projects, we are also engaged in design studies for a demonstration nuclear fusion reactor to achieve the goal of realizing the practical utilization of nuclear fusion energy.

Efforts for Realization of Nuclear Fusion Demonstration Reactor
ASANO Shiro / TAKIWAKI Kenya / ARAKI Takao / TANIGAWA Hisashi
The ITER international project is being promoted by seven member entities to develop an experimental nuclear fusion reactor that can realize the levels of plasma temperature and density necessary for a practical device. In the DEMO next-generation demonstration reactor, which will be built after the ITER facility with the objective of achieving stable and continuous production of several hundred thousand kW of electric power, technical verification of various aspects including operation, maintenance, and radioactive waste management will be carried out toward the construction of a commercial reactor.
Toshiba has been proceeding with technical development of the DEMO reactor in cooperation with the Japan Atomic Energy Agency (JAEA). We have been concentrating our resources on the development of a tritium breeding blanket having a cylindrical shape that provides high productivity, and have confirmed that it satisfies the required conditions. In addition, we have performed thermal-hydraulic analyses for various types of accident scenarios in the DEMO fusion reactor plant and obtained useful results with respect to the maximum pressure inside the facility and changes in the temperature of individual components in the event of an accident.

Start of Manufacturing of Toroidal Field Coils for ITER Project
OHSEMOCHI Koichi / YANAGI Yutaka / ABURA Masakazu
ITER is an international project being promoted by seven member entities including Japan with the aim of demonstrating the technological and scientific feasibility of fusion energy. ITER uses toroidal field (TF) coils to produce high magnetic fields that confine the high-temperature and high-density plasma needed to generate a fusion reaction. As the TF coils, equipped with superconducting conductors, are huger than ever before, there is a strong need for extremely high-accuracy winding and welding technologies.
In response to this situation, Toshiba has developed and introduced various manufacturing technologies and equipment based on the knowledge it has accumulated through its research and development efforts in this project. After verification of manufacturability, we started manufacturing the world's largest class TF coils for ITER, including four TF coils and six TF coil structures (TFCS), in 2015, with shipments scheduled to commence in 2017.

Technologies for ITER Blanket Remote Handling System
SHIGEMATSU Soichiro / MATSUKAGE Takeshi / SHIMAMURA Mitsuaki
At the ITER Tokamak, currently under construction as an international experimental nuclear fusion research and engineering project, a blanket remote handling system (BRHS) will be used to facilitate the installation and maintenance of blanket modules, which serve as a shield against neutrons produced in the fusion reaction, by robotic devices such as manipulators. Toshiba has been engaged in the development of the ITER BRHS based on its experience accumulated through design studies and a full-scale demonstration using a mockup during the ITER engineering design activities (EDA) implemented from 1992 to 2001. We are now carrying out both the detailed design to conform with the required specifications, such as earthquake loads, etc., and the verification of elemental technologies for the ITER BRHS aimed at the manufacturing of equipment to be deployed in the vacuum vessel, with the start of series production scheduled for 2017. By making use of technologies cultivated through the development of manipulator control methods and cutting and welding tools for the blanket cooling pipes, we are making efforts to overcome various issues in collaboration with the ITER Organization and the Japan Atomic Energy Agency (JAEA).

Completion of Vacuum Vessel Sector Manufacturing and Approaches to Overall Assembly of JT-60SA
HAYAKAWA Atsuro / MIZUMAKI Shoichi / HAMADA Takashi
The JT-60SA experimental tokamak type thermonuclear fusion device is currently under construction as a joint project between Japan and the European Union.
Toshiba has been assigned the manufacturing and assembly of the vacuum vessel of this medium-scale tokamak type device. In order to meet the requirements for high-accuracy assembly of the vacuum vessel, we have established a manufacturing procedure to secure the accuracy of assembly consisting of the following three stages: (1) manufacturing of the vacuum vessel sectors at our factory, (2) welding connection of each sector, and (3) assembly at the installation site. As a result, we have completed the assembly of the vacuum vessel within the tolerance of ±10 mm. We are now continuing our efforts to design an overall assembly procedure for the components of the superconducting magnets including thermal shields, cryostat, and utility supply systems.

Refurbishment of Power Supplies and Control System to Achieve Long-Pulse Operation for JT-60SA
GOMIKAWA Kenji / KAWASHIMA Shuichi
Based on the results acquired through the development of the JT-60 break-even plasma test facility, the JT-60SA (JT-60 Super Advanced) facility uses superconducting coils to produce magnetic fields that confine the plasma by means of a longer pulse operation compared with the JT-60. In order to achieve this, integration and abolition of the existing motor generators (MGs) that accumulate energy and release it in a short time, improvement of the ratio of power received directly from the commercial electric power system, and development and refurbishment of the magnetic field coil power supplies are required.
As part of this plan, Toshiba has received orders for recombination of the AC power system and refurbishment of the existing magnetic field coil power supplies. We have already completed the recombination of the AC power system, which redistributes loads according to the accumulated energy of the MGs. These efforts are making a significant contribution to the realization of long-pulse operation for the JT-60SA facility.

Neutron Monitoring System for Nuclear Fusion Facilities
YAMAUCHI Michinori / KONO Shigehiro / ISHIZAWA Kazuya
International research and development projects aimed at realizing a nuclear fusion reactor are currently being implemented. Among these projects are ITER, which is being constructed in order to verify deuterium-tritium plasma ignition, and the Large Helical Device (LHD) and JT-60U (JT-60 Upgrade) facilities, which are being redesigned in order to pursue research on high-performance plasma through the new phase of deuterium discharge. In all cases, the measurement of neutrons in these facilities plays a major role because the neutron generation rate is proportional to the output of the nuclear fusion reactor.
The Toshiba Group has been contributing to these projects by supplying a neutron monitoring system, utilizing its long-accumulated experience as a main Japanese manufacturer of fission chambers. We have developed effective components for ITER, which can work under the extremely severe conditions of a vacuum chamber. To overcome the specific problem of a noisy environment caused by the wide variety of components in such facilities, we have also developed a signal processing unit that offers superior performance for the removal of miscellaneous noises as well as a high time resolution and a wide dynamic range, and have obtained good results.

Efforts for Development and Enhancement of Experimental Devices for Nuclear Fusion Research in Universities and Research Institutions
GOMIKAWA Kenji
In contrast to nuclear fusion devices of the tokamak type, typified by the ITER and JT-60SA (JT-60 Super Advanced) facilities, universities and research institutions in Japan are also promoting the research and development of nuclear fusion devices using unique methods to produce the magnetic field that confines the plasma. These include a mirror type device of the University of Tsukuba and the Large Helical Device (LHD) of the National Institute for Fusion Science (NIFS), one of Japan's inter-university research institutes.
Toshiba has been developing, manufacturing, and delivering such experimental devices to universities and institutes since the beginning of nuclear fusion research. Under the LHD project, NIFS has been making preparations for a deuterium experiment program to investigate the characteristics of high-temperature and high-density plasmas, as the next stage of nuclear fusion research for the realization of nuclear fusion power generation. In this program, we are contributing to the installation of a tritium production rate monitor and the enhancement of a perpendicular neutral beam injector (NBI).

Feature Articles

Application of Multi-objective Optimization Method to HDD Production Lines
ISHIHARA Yoshiyuki
In the head positioning control system of a hard disk drive (HDD), it is necessary to facilitate parameter tuning of the multi-stage notch filters taking into consideration the mechanical resonance modes of the head supporting mechanism for the realization of high accuracy and high stability. However, as conventional manual parameter tuning makes it difficult to adjust variations in the mechanical resonance characteristics of individual HDDs, the occurrence of defective products during mass production caused by unstable head positioning control is an important issue.
To overcome this problem, Toshiba has developed an autonomous parameter tuning technology for notch filters that conforms with the mechanical resonance characteristics of individual HDDs using a multi-objective optimization method. Parameters tuned in assembled HDDs are written to the flash memory of each HDD in the production line, and are read and used for head positioning control when the HDD is turned on after shipping. This technology is contributing to the improvement of yield in our HDD production lines.

Mathematical Approach to WIP Control Mechanism for Semiconductor Production Line
KUNINOBU Shigeta / YOSHIDA Takufumi
The throughput and the turnaround time (TAT), which are in a tradeoff relationship, are generally used as indexes to evaluate the production efficiency of a semiconductor production line. The adoption of a work-in-progress (WIP) control mechanism, which restricts the number of WIPs in a production line so as not to exceed the upper limit of WIP, k, has recently become common to facilitate production line operation while maintaining the appropriate throughput and TAT.
With this as a background, Toshiba has proposed $\phi(k)$ and $T(k)$ as approximations for throughput and TAT, respectively, in a semiconductor production line model, derived by a mathematical approach based on a queuing theory capable of determining an optimal k. This model takes into consideration the WIP control mechanism as well as variations in the inter-arrival times of lots and in the machine processing times. We have conducted evaluation experiments with a production line model consisting of about 20 processes using actual line data, and confirmed that the proposed approximations achieve higher calculation speed and almost the same accuracy in comparison with conventional simulation results.

Differentiation Technologies for "TZCS" Thin Client Solution with High Security
MATSUOKA Yoshio / WADA Koetsu / MATSUDA Kyohei
With the widespread dissemination of high-speed wireless networks as a social infrastructure system in recent years, small digital devices are providing users with various services effortlessly and at low cost via the network through connections to social networking service (SNS) servers. Thin client products, which can remotely display desktop images transferred from a virtual machine via the network without storing the actual data files, have mainly been used as operator terminals and for specialized applications requiring high security. From the viewpoint of security, attention is being focused on thin client products as a potential candidate for the next information technology (IT) infrastructure for enterprise use due to the replacement demand for PCs caused by the expiration of support for operating system (OS) software, changes in business configuration as a result of the broad diffusion of mobile devices with high functionality, and frequent occurrences of information leakage.
Toshiba has developed the "TZCS" thin client solution for virtual desktop infrastructure (VDI), which ensures high security for users while providing high mobility and robustness comparable to its notebook PCs for the business-to-business (B2B) market. Taking advantage of the integration of our proprietary basic input/output system (BIOS) and OS technologies, the TZCS can be used without any storage devices and offers a quick remote data deletion function as well as protection functions for a variety of setting values by applying terminal management technology.

Frontiers of Research & Development

Simultaneous Interpretation Technology Lowering Communication Barrier in Business Meetings
On-Machine Dimensional Measurement Technology Supporting Manufacturing of Large Parts