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Special Reports

Advanced Technologies Supporting Environmentally Conscious Thermal Power Plants

Fossil-Fuel Power Plants in Low-Carbon Society
HAYASHI Masataka

Advanced Technologies Supporting Highly Efficient Thermal Power Plants
MURAKAMI Toru
In the field of thermal power generation, practical realization of carbon dioxide (CO_2) capture and storage (CCS) systems as well as highly efficient thermal power plants are required to reduce greenhouse gas emissions. In addition, thermal power plants optimized to balance load fluctuations in the electricity grid caused by natural power generation facilities, such as wind and solar power installations, are also required.
In response to a broad range of market needs, Toshiba has been providing a wide variety of equipment and services through the following technological advancements: (1) technologies for highly efficient thermal power systems, (2) control technologies for flexible load changeability, (3) technologies for rehabilitation and monitoring systems, and (4) CCS technologies.

High-Efficiency Technologies for Thermal Power Plant Steam Turbines
TAKAHASHI Takeo / TAKAHASHI Toru / OKITA Nobuo
Thermal power generation has the characteristic of permitting flexible responses to fluctuations in power demand. In order to reduce carbon dioxide (CO_2) emissions by thermal power plants, enhancement of their thermal efficiency is required.
Toshiba has been engaged in the development of high-efficiency steam turbines for thermal power plants using various technologies including state-of-the-art computational analysis and test facilities such as its steam turbine development facility for the reduction of internal losses in steam turbines. Furthermore, we have been developing a 700°C-class advanced ultra-supercritical (A-USC) steam turbine with the aim of realizing higher thermal efficiency.

Dissimilar Welded Rotors for Large-Capacity High-Temperature Steam Turbines
ASAI Satoru / SAITO Kazuhiro / MURAKAMI Itaru
Toshiba has been developing a large-capacity high-temperature steam turbine to realize highly efficient, environmentally conscious power generation systems. We have also been engaged in the development of a welded rotor for steam turbines in response to the market demand for short delivery times in recent years.
We have now developed a welding method to fabricate dissimilar welded rotors, composed of modified 12% chromium (Cr) steel and chromium-molybdenum-vanadium (CrMoV) steel, for high- and intermediate-pressure (HIP) turbines. The joint strength and thermal stability of the newly developed welded rotor, as well as the applicable inspection technique, have been verified through tests. As a result, the rotor has been applied to the high-pressure (HP) turbine of Sigma Power Ariake Co., Ltd.'s Mikawa Power Plant Unit 2, where its successful performance has been confirmed under actual machine conditions.

Insulation System Realizing Environmentally Conscious Stator Coils with High Thermal Conductivity for High-Efficiency Turbine-Driven Generators
KOBAYASHI Masashi / HATANO Hiroshi / NAKAMURA Hideyuki
The recent enhancement of awareness regarding global environmental change has led to the development of high-efficiency turbine-driven generators, which are considered to be a means of reducing the environmental burden of various manufacturing processes.
Toshiba has been developing a high-efficiency, large-capacity, turbine-driven generator employing an indirectly hydrogen-cooled stator coil that has so far been used for turbine-driven generators with an intermediate capacity of up to the 400 MVA class. As a result of these efforts, we have developed a new insulation system that has made it possible to realize stator coils with high thermal conductivity. A 670 MVA indirectly hydrogen-cooled turbine-driven generator applying this insulation system has achieved 0.1% to 0.2% higher efficiency compared with conventional generators. In addition, the development of this environmentally conscious insulation system has reduced the amount of waste materials produced by and improved the working environment for the manufacturing of stator coils.

Information and Control Technology to Improve Efficiency and Operation of Thermal Power Plants
TANI Akinori / KUBO Takashi
As renewable energy resources such as wind, solar, and other natural energies are subject to natural conditions, their output power fluctuates in accordance with external factors. Thermal power generation systems are expected to compensate for such fluctuations and stabilize the grid system due to the improvement of their load response.
Toshiba has been developing new technologies to improve the load response of thermal power plants by optimally controlling the main steam pressure and temperature. Furthermore, in order to operate thermal power plants more efficiently, we have developed a new control system utilizing information and control technology that can provide various information and functions to operators, including plant performance surveillance, plant abnormal status prediction, and so on, based on the historical data of the plant.

Engineering for Rehabilitation of Thermal Power Plants in Eastern Europe
TAJIRI Junichi / TANAKA Katsuaki
Following the conclusion of its first contracts for the rehabilitation of aging thermal power plants in Eastern Europe, Toshiba has been implementing rehabilitation projects in Romania and Bulgaria. Rehabilitation of the Paroseni Thermal Power Plant in Romania has already been completed, and a rehabilitation project at the Maritsa East II Thermal Power Plant in Bulgaria, in which a total of six turbine-driven generator units are planned to be replaced, is in progress. Rehabilitation of four of these units has been completed, and work on the remaining two units is under way.
Although engineering delays caused by both lack of information on existing equipment and differences in business practices such as complicated certification systems have occurred frequently in these Eastern European projects, we have been making efforts to minimize delays in the project schedules by taking advantage of our practical experience in rehabilitation project management and engineering.

Efficient Maintenance Service for Overseas Power Plants Utilizing ICT
ISHIKAWA Tetsuro / NISHIMURA Mariko
Immediate and appropriate responses to customers' inquiries and actual problems related to power plant operations, as well as the prediction and prevention of problems by the monitoring of operations, are essential to secure the stability of commercial power generation.
As a solution to this issue, Toshiba has been offering a continuous service agreement (CSA) for overseas power plants that it has delivered. The CSA can provide immediate and appropriate responses to problems by obtaining information on the status of the power plant in question through information and communication technology (ICT) and Web-based systems. It can also detect the symptoms of some problems including rubbing, insufficiency of lubricating oil, and so on before a critical problem such as turbine damage occurs, by continuously monitoring the steam turbine vibration.

Validation Testing of Carbon Dioxide Capture Pilot Plant Using Flue Gas of Coal-Fired Thermal Power Plant
KITAMURA Hideo / EGAMI Norihide / OHASHI Yukio
Coal reserves are relatively rich and widely distributed around the world compared with other fossil fuels such as oil and liquefied natural gas (LNG). Coal therefore has advantages in terms of stable supply and low cost as a fuel for power generation. However, the carbon dioxide (CO_2) emissions per unit of electricity generated by coal are larger than those of other fossil fuels. The development of technology for separation and capture of CO_2 from the flue gas of coal-fired thermal power plants is thus required from the standpoint of global warming prevention.
Toshiba has been developing a post-combustion capture (PCC) method using chemical absorption, which is suitable for CO_2 capture from large volumes of flue gas and can be applied to not only newly constructed but also existing power plants. We constructed a 10 tons-CO_2/day-scale pilot plant at the Sigma Power Ariake Co., Ltd.'s Mikawa Power Plant in September 2009, and have been conducting test operation to verify the performance of the system using actual flue gas.

Feature Articles

Advanced Simulation Technology for Innovating Air-Assisted Paper-Feed Mechanism
NAKAMOTO Hideichi / SAWADA Tomohiro / HATTORI Shunsuke / TEZUKA Akira
Further improvements in the performance of automated paper handling machines such as printers and mail sorting machines are required by gaining a better understanding of the complex coupling behavior between air and the conveyed media. In particular, there is a need for detailed feed unit design taking air flow control into consideration for the development of an air-assisted paper-feed unit, which is a mechanical unit to pick up one sheet of paper from a bundle of papers with the assistance of wind blown on the side of the bundle. However, it is difficult to identify desirable design directions through trial-and-error experiments alone.
Toshiba and the National Institute of Advanced Industrial Science and Technology (AIST) have been engaged in joint research aimed at determining the potential application of advanced fluid-structure interaction simulation technology developed by AIST to the development of an air-assisted paper-feed unit. We have confirmed the effectiveness of such numerical simulations and obtained findings that were unobtainable in past experiments.

Antenna Technologies for Important Document Control Systems Using UHF-Band RFID
YAMADA Akiko / SHOKI Hiroki / HORI Fusao
Radio-frequency identification (RFID) systems have recently been introduced to important document control systems due to their superior efficiency in terms of document-by-document control and ability to facilitate inventories of the contents of filing cabinets. An ultrahigh-frequency (UHF)-band RFID is expected to be applicable to such document control systems because of its long read range and ability to read multiple tags. On the other hand, these advantageous characteristics can also cause several problems such as tag collision, overreaching to tags in unexpected places, and interference with other RFID reader/writer (R/W) systems. Furthermore, the tag reading performance in the case of commonly used metal cabinets is sometimes insufficient. As UHF electromagnetic signals are canceled near the metal surface of the cabinet, tags within 3 cm from the cabinet wall are frequently left unread.
Toshiba has developed a near-field R/W antenna for simultaneous tag reading in a single file box. This antenna reduces unwanted emissions and incorporates an in-phase reflector for better control of important documents in metal cabinets.

One-Chip Transceiver IC Using CMOS Technology for Millimeter-Wave Radar Applications
MITOMO Toshiya / HOSHINO Hiroaki
Demand has been increasing for commercial radar applications using 77 GHz-band millimeter waves, which offer enhanced ranging operations due to the advantages of high straight-line performance and high resolution. However, the high costs of conventional radar transceivers fabricated with compound semiconductors have been hindering the dissemination of millimeter-wave radar applications. A recent deep-submicron complementary metal-oxide semiconductor (CMOS) technology has therefore been attracting considerable attention as a solution to this issue.
Toshiba has developed the world's first one-chip transceiver IC for 77 GHz-band millimeter-wave radar using a 90 nm CMOS technology based on frequency modulated continuous wave (FMCW) radar technology. We have confirmed the effectiveness of this transceiver IC through experiments on its FMCW signal generation and ranging performance.

Japanese/Chinese/English Speech-to-Speech Translation System for Smartphones
ISAKA Takehiko / CHINO Tetsuro / NAGAE Hisayoshi
Toshiba has developed an automatic speech-to-speech translation system for smartphones that realizes all-directional interpretation between Japanese, Chinese, and English as a standalone system. This system can recognize speech accurately even in noisy environments, translate it into natural expressions, and synthesize clear speech. The typical time required for both speech recognition and machine translation is within about 3 seconds. This system will enable people in various countries to broaden their communication horizons.

Cost-Effective Ticket Issuing Machine for Distance-Based Toll Systems
TAKEI Satoshi / SUEKI Nobuyuki
With the expansion of road networks in recent years, expressway operators have been considering the introduction of distance-based toll systems. However, it is still difficult for small-scale expressway operators to introduce the ticket issuing machines required for a distance-based toll system due to their high functionality and high cost.
As a solution to this issue, Toshiba has developed a new ticket issuing machine for distance-based toll systems that can reduce the operating cost. This machine is equipped with the minimum functions necessary for urban expressways and tollways, while increasing the number of tickets that can be continuously issued, shortening ticket processing times, and offering improved environmental robustness.

Frontiers of Research & Development

Compression Noise Reduction Technology for Digital TV Broadcasting
Technology for Numerical Simulation of Micro-Organization Structures for Development of Materials