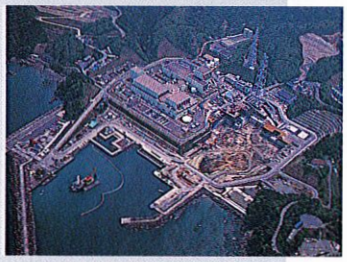
Power Systems and Industrial Equipment

Changes in society and people's lifestyles will increase long-term demand for electricity. In response to trends in demand for energy in Japan and around the world, Toshiba is working to develop technologies that meet diverse consumer needs for stable, reliable electrical supply, new energy technologies and more effective applications, and environmental protection, as well as rationalization of operations and lower costs. Toshiba is also introducing innovative equipment and systems in the fields of manufacturing, public works, and traffic and transportation.

Completion of World's First ABWR Power Plant and BWR Construction Update

The world's first advanced boiling water reactor (ABWR), Unit No. 6 of Kashiwazaki-Kariwa Nuclear Power Station (electrical output: 1,356MW), operated by The Tokyo Electric Power Co., Inc. (TEPCO) began operation in November 1996. The ABWR was developed through international cooperation incorporating proven technologies and operating experience from BWRs around the world, and offers reduced costs and improved safety, reliability and operability. The ABWR incorporates a number of improvements, such as installing the reactor coolant recirculation pump inside the reactor pressure vessel, a fine motion control rod drive mechanism, and a reinforced concrete containment vessel, as well as an optimized emergency core cooling system and a state-of-the-art control system. Plant construction was carried out by a joint venture among Toshiba, General Electric and Hitachi, with Toshiba acting as representative company. Unit No. 7 of the same facility began operation in July 1997.

Kashiwazaki-Kariwa Nuclear Power Station Unit No. 6 of The Tokyo Electric Power Co., Inc.



Onagawa Nuclear Power Station of Tohoku Electric Power Co., Inc., Unit No.3 is under construction

A number of BWR construction projects are also in progress. Construction began on Unit No. 3 (825MW, BWR5) at Tohoku Electric Power Company's Onagawa Nuclear Power Station in October 1996. In addition, Tohoku Electric Power Co. Inc.'s Unit No. 1 of Higashidohri Nuclear Power Station and Chubu Electric Power Co., Inc.'s Unit No. 5 of Hamaoka Nuclear Power Station have applied for establishment permits as part of the licensing process. Overseas, Toshiba has received an order from General Electric to supply the main equipment for the nuclear steam supply system (NSSS) in Units No. 1 and 2 of Lungmen Nuclear Power Station being constructed by Taiwan Power Co.

To promote the further expansion of ABWR construction in Asia, Toshiba and Hitachi jointly established the ABWR Promotion Organization (APO) in January 1997.

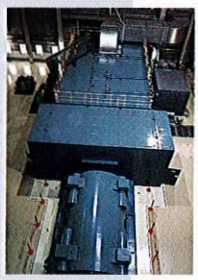
Completion of Thermal Power Plants in Japan

The first stage (7-4 stage, 350MW) combined cycle power plant at the Yokohama Thermal Power Station of The Tokyo Electric Power Co., Inc. began commercial operation in June 1996. The plant uses a new 1300°C-class 9FA advanced gas turbine, a three-drum heat recovery boiler, and a two-compartment reheating steam turbine (on a single shaft), and has a thermal efficiency in excess of the specified 48 percent.

Yokohama Group 7 and 8 power plants of The Tokyo Electric Power Co., Inc.

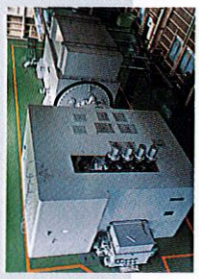
Off-loading of heat-recovery steam generator (HRSG)

In July 1996, the combined cycle power plant at Unit No. 2 of the Chita Second Thermal Power Station, operated by Chubu Electric Power Co., Inc., started commercial operation. The plant is designed for equipment repowering through a combination of the existing 700MW steam turbine and a new 154MW gas turbine (7FA).



1,300°C-class, 154MW gas turbine, Unit No. 2 of the Chita Second Termal Power Station

Two three-stage extraction condensing turbines for industrial power supply started commercial operation during 1996: the 63.8MW Unit No. 4 of the Osaka plant of Mitsui Toatsu Chemicals, Inc., in January; and the 45MW Unit No. 1 of the Kure plant of Oji Paper Co., Ltd., in October. Finally, the 30MW Unit No. 2 of the Kakkonda Geothermal Power Plant operated by Tohoku Electric Power Co., Inc. began commercial operation in March 1996.



63.8MW steam turbine and generator, Unit No. 4 of the Osaka plant of Mitsui Toatsu Chemicals, Inc.

30MW steam turbine and generator at Kakkonda Geothermal Power Station Unit No. 2

World's First Successful Commercial Operation of Double-Fed Adjustable-Speed Flywheel Generating System

The world's first successful commercial operation of a double-fed adjustable-speed flywheel generating system was achieved in August 1996 at the Chujowan Substation of The Okinawa Electric Power Co., Inc. The system is an application of adjustable-speed pumped-storage system technology, and the main equipment consists of a flywheel generator (200MJ, 26.5MVA-600min^{-1} ±15%), cycloconverter (6.55MVA) and AC excitation control equipment. The system suppresses frequency fluctuation in the power system by releasing or absorbing the electric power produced by changes in the rotating speed of the rotor and flywheel in response to load changes too sudden to be dealt with by the governor controls of previous generators.

The system on Okinawa is small and independent, with power demand varying from 1,200MW in summer to 400MW in winter. Under those conditions, sudden load changes of about 30MW often caused system frequency fluctuations to exceed the allowable limit of ±0.3Hz. It therefore became essential to develop a method to suppress these fluctuations.

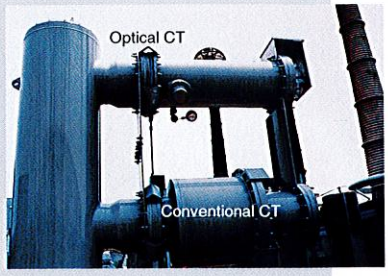
Successful commercial operation achieved suppression of the frequency fluctuation to within ±0.3Hz for a 30MW load change and verified the system's high level of effectiveness in suppressing frequency fluctuations caused by a sudden load change. In the future, the adjustable-speed flywheel generating system is expected to contribute to improving the quality of electrical power in small, independent electric power systems that experience sudden load changes.

Adjustable-speed flywheel generator

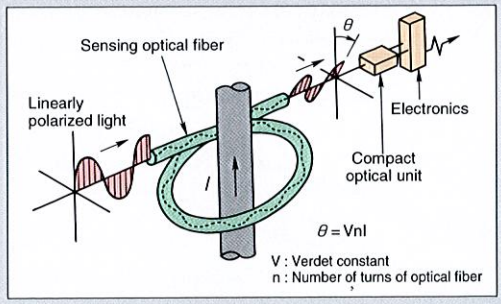
Development of Fiber Optics Current Transformer for Power Transmission Systems

Tests have confirmed the long-term reliability of the new fiber optics current transformer for power transmission systems developed by Toshiba. The current transformer applies the Faraday effect, and has been developed for optimum suitability for the 550kV gas-insulated switchgear (GIS). Specially designed fiber optics used for the Faraday sensor are attached to the periphery of the GIS tank. The system has displayed excellent results in operating tests, including switching operation accuracy under vibration conditions and ambient temperature variation from -20°C to 90°C.

The fiber optics current transformer is expected to contribute greatly to the further miniaturization of GIS.



Fiber optics current transformer



Principle of fiber optics current transformer
Current I is measured by the rotation angle of polarization plane θ based on the Faraday effect.

PC25™C 200kW Fuel Cell Power Plant Starts Commercial Operation

The PC25™C 200kW fuel cell power plant was developed jointly by Toshiba and ONSI Corp. of the United States, and the first unit was shipped in November 1995. As of February 1997, a total 17 units in Japan and 31 overseas had been delivered. In Japan, 11 units have begun operation, including three used to supply heat and electricity at Toshiba factories. Almost all the other plants used in Japan have been introduced through gas companies.

Installed with the coordination of Tokyo Gas Co., Ltd., the PC25™C at the Tokyo Water Works Bureau is the first DC power supply plant to use electrolysis to produce germicide. As concern for the global environment increases, expectations are high for the fuel cell power plant as a clean source of energy. Fuel cell power plants are completely different from previous cogeneration systems, and can be used in new applications based on their many unique characteristics, including multi-fuel acceptability and high-quality electrical output. As new applications such as use of gases produced in sewage plants as fuel continue to evolve, the diffusion of fuel cell power plants is expected to grow rapidly.

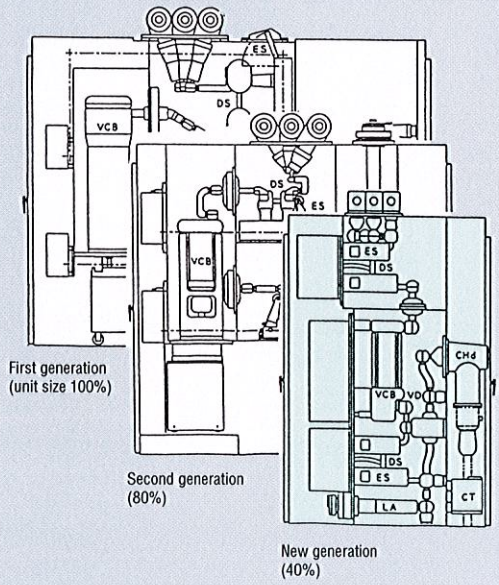
Commercial PC25™C 200kW fuel cell power plant

72/84kV C-GIS New Generation Vacuum Switchgear

Toshiba has developed a 72/84kV cubicle-type gas insulated switchgear (C-GIS) using a vacuum circuit breaker that is the smallest and lightest in the world. The new C-GIS achieves a reduction to 40 percent of the size and 60 percent of the weight of Toshiba's first generation model. In addition, an external cable bus makes on-site use of SF_6 gas unnecessary, raising reliability while reducing manufacturing time.

The circuit breaker in the new C-GIS uses a vacuum interrupter that controls the vacuum arc through application of the high current interruption principle, in which the vacuum arc is diffused uniformly to the electrode surfaces by means of the optimal magnetic field production system. Furthermore, the size of the insulation structure in the vacuum interrupter has been decreased greatly.

The insulation structure for the C-GIS employs the SF_6 gas/epoxy composite insulation principle. The metal electrodes have been set into molds made of epoxy resin with a low dielectric constant, and the electric intensity in the SF_6 gas gap has been reduced and made uniform. Both of these factors have contributed to greatly reducing the size of the C-GIS.



Successive generations of cubicle-type gas insulated switchgear

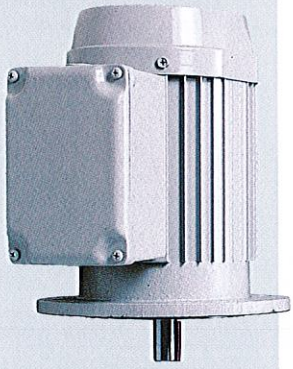
Intelligent Actuator (IA)

To provide motors for the industries of the twenty-first century, Toshiba has developed the intelligent actuator (IA) series. The IA is an entirely new concept in industrial motor design, combining the motor with an inverter to drive it. Special features of the IA series are as follows:

- The motor can be easily adjusted to the desired optimum speed;
- The high speed drive allows the motor to be made more compact;
- Identical speed can be attained worldwide regardless of power supply frequency; and
- Motor protection and automatic operation functions are built in.

The above features contribute to a compact, optimum machine design, thus increasing its performance and value. Major specifications are as follows:

- 200V class;
- 0.2 to 3.7kW;
- Totally enclosed fan-cooled type;
- Foot or flange-mounted;
- 1,800 to 7,200 rpm rated speed (2 series); and
- 1:2 speed control range.



200V, 0.75kW, 7,200rpm intelligent actuator

IGBT Converters for Railway Vehicle Applications

With its ability to withstand higher voltages and current capacities, the insulated gate bipolar transistor (IGBT) is playing an important role in the recent rapid development of semiconductor technology. Toshiba has developed both module type and press-pack type IGBTs. Press-pack IGBTs are ideal for use as high-performance railway converters because of their compactness, reliability and long-life design. Currently the 2,500V-1,000A press pack IGBT is in use and a 3,300V press-pack IGBT is also available.

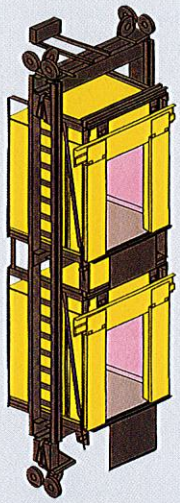
A variety of different converters equipped with IGBTs were used in rail systems in 1996. An individual-axle-control type converter used on the Odakyu Electric Railway Series 30000 provides the ability to climb hills with a 4.0 percent gradient on the mountainous Hakone Tozan Line with only one unit open. A multi-motor control type converter is mounted on the Nozomi model *shinkansen* (bullet train). The Nagoya Railroad System 3000 uses a dual-mode type converter. On this system, each of the four traction motors are driven by a separate inverter unit, which can supply auxiliary power in case of a power supply failure. All of the IGBT converters also provide quiet operation.

Odakyu Electric Railway Series 30000 express train, and IGBT individual-axle-control type VVVF inverter

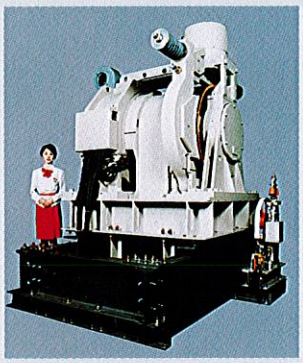
Double-Deck Elevator

To raise the carrying capacity of elevators in very tall buildings without requiring additional space, Toshiba has developed a double-deck elevator, with an upper and lower section combined in a single car. A special group supervisory system to regulate a bank of these elevators has also been developed.

The upper and lower decks of the elevator are each equipped with displays that can show images from a monitor unit in the other deck, as well as information for passengers. The group supervisory system for banks of these elevators is designed to increase carrying efficiency and convenience for passengers by taking advantage of the special characteristics of double-deck elevators. For example, when passengers going in the same direction press the elevator buttons on neighboring floors, the group supervisory system directs a single elevator to respond to the requests on both floors, thus raising operating efficiency and reducing waiting time.



Car for double-deck elevator



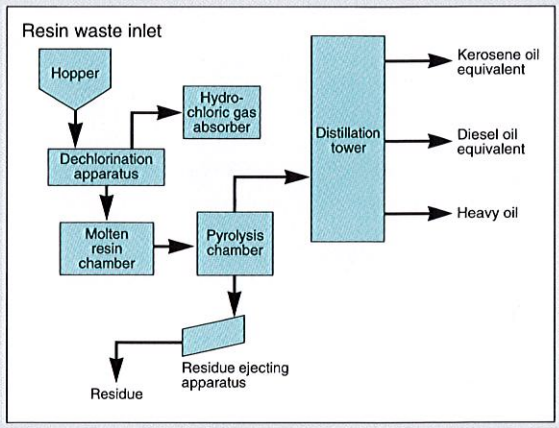
Traction machine

Pilot Plant for Oil Reclamation System from Resin Wastes Containing PVC

One issue that has become a focus of attention is the treatment of resin wastes, particularly polyvinyl chloride (PVC) for which no treatment method exists at present other than disposal in landfills. In response, Toshiba has been studying a method of oil reclamation from resin wastes containing PVC, and that research has led to the construction of a pilot plant with a production capacity of 500kg/day for demonstration purposes.

System for oil reclamation from resin wastes

The system allows continuous treatment of mixed resin wastes without separation of PVC. The heating value of the oil produced from the treatment is 11,000cal/g, equivalent of that of commercial fuel oil. Pyrolysis is used to generate carbon-rich residue with a heating value of 5,000 to 9,000cal/g, which is equivalent to that of coal, allowing the residue to also be used as fuel. Hydrochloric gas generated from the PVC is absorbed into water and collected as hydrochloric acid. Toshiba is researching ways to make effective use of this recycled acid.



Concept of system for oil reclamation from resin wastes