Kin No. 1 220-MW Thermal Power Station of The Okinawa Electric Power Company, Incorporated

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OVERVIEW: The Kin Thermal Power Station No. 1 unit began operations in February 2002. Planned and developed by The Okinawa Electric Power Company, Incorporated, this 220-MW coal-fired thermal power station has the largest generating capacity in Okinawa. The steam specifications at the power station are as follows: the main steam pressure at the turbine inlet is 16.57 MPa, the main steam temperature is 566°C, the reheat steam temperature is 566°C and the condenser vacuum is 6.67 kPa. The turbine model employs a high-medium pressure single flow turbine (SF-40) and a compact single-casing turbine design. During construction, new and conventional construction methods helped improve efficiency. As a leader in engineering, Hitachi employed a full turnkey method encompassing both civil engineering and construction to successfully complete construction of this plant.

INTRODUCTION

THE construction of the Kin Thermal Power Station, a 220-MW coal-fired thermal power facility, for The Okinawa Electric Power Company, Incorporated, began in May 1999 (see Fig. 1). Power was first received in May 2001, and the station started operating in February 2002. Hitachi, Ltd. was the main machinery manufacturer for both the No. 1 unit and for the No. 2 unit, which began operations in May 2003. Hitachi has played an engineering leadership role in this power station, was involved from the earliest stages of planning, and managed the whole project, including participating in civil engineering and construction, installing machinery and managing trial operations.

This paper describes the features of the Kin thermal power station and its technological applications.

PLANT PLANNING

Table 1 provides the main details of the power station plant and a comparison with previous power

Fig. 1—Bird's-eye View of the Kin Thermal Power Station of The Okinawa Electric Power Company, Incorporated.
In the Kin thermal power plant (generating 220 MW, the largest in Okinawa), the No. 1 unit began operations in February 2002. The No. 2 unit also started operation in May 2003.

TABLE 1. Power Plant Plan: Major Specifications and Comparison
High steam conditions and a 40-inch (about 101.6-cm) titanium long blade at the final stage achieved both higher efficiency and a smaller size than previous machine.

Item			Unit	Previous machine*	Kin Nos.1 & 2 units
Basic plan requirements	Rated output		MW	156	220
	Steam conditions		MPa	16.57	Same as left
			°C	566/538	566/566
	Operation method		—	Sliding pressure operation	Same as left
	Fuel		—	Coal burning	Same as left
	Designed seawater temperature		°C	28	26
	Unit operation		—	Middle load operation	Base load operation
Major machine specifications	Boiler	Type	—	Natural circulation boiler	Forced circulation boiler
		Steam pressure	MPa	17.26	Same as left
		Steam temperature	°C	569/541	569/569
		Boiler evaporation	t//h	520	660
	Turbine	Type	—	2-casing, 2-flow exhaust	1-casing, single flow exhaust
			—	TCDF-26	SF-40
		Steam pressure	MPa	16.57	Same as left
		Steam temperature	°C	566/538	566/566
		Exhaust vacuum	kPa	6.67	Same as left
	Generator	Type	—	3-phase AC generator	Same as left
		Capacity	MVA	184.0	259.0
		Excitation method	—	Brushless	Thyristor

* Previous machine: No. 1 unit of Gushikawa thermal power station of The Okinawa Electric Power Company, Incorporated

generators. The main features are as follows:
(1) High steam pressure/temperature and single-casing turbine

During plant development, comprehensive economic efficiency including efficiency in civil engineering and construction was required. This was achieved through high efficiency by using high steam pressure and temperature and a compact turbine unit (single-casing turbine) that functions by utilizing a final-stage 40-inch long titanium alloy blade.
(2) System configuration

The heat cycle configuration is almost equivalent to the previous power generator. The overall system configuration was simplified by eliminating the turbine bypass system and attaching circulating water pump blades, because the plant will be a base operation.

STEAM TURBINE OVERVIEW

Turbine Main Unit: Structure

Fig. 2 shows the completed SF-40 220-MW steam turbine power generation facility. The turbine unit consists of 17 stages (17 wheels): 7 high-pressure stages and 10 medium/low pressure stages. The final stage has 40-inch blades, which have a proven record at Chubu Electric Power Co., Inc., Hekinan No. 2 700-MW power station. The most significant feature of this turbine is a single-flow exhaust system, featuring the largest capacity in Japan.

Fig. 2—Inside Turbine Room.
A single flow turbine exceeding 200 MW was the first for Hitachi.

Turbine Main Unit: Features

After a careful study of turbine strength, a turbine with a two-bearing structure that shortens the turbine length as much as possible was created. As a result, the turbine main unit, which is compact and has excellent thermal performance, could be designed in a well-balanced manner. Fig. 3 shows a structural

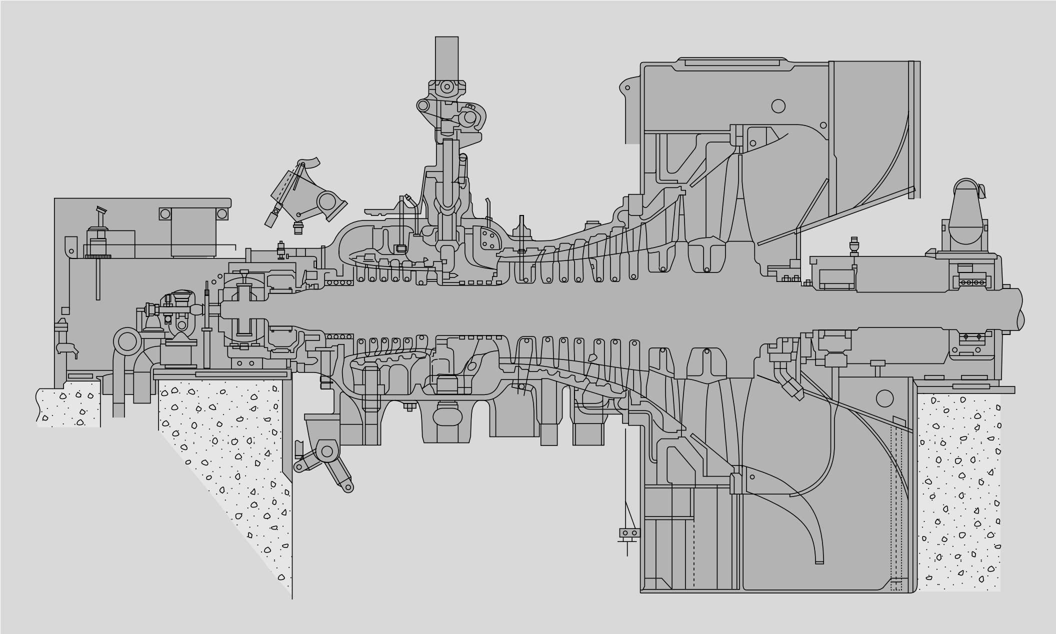

Fig. 3—Structural Cross-section of the Turbine.
Smaller size by utilizing a single-casing/single-flow exhaust turbine and two bearings.

cross-section of the turbine. Leading-edge technologies, for example, a 3D-designed blade, were used for the turbine blade and, in the final stage, a 40-inch titanium blade was utilized because of its proven record in 60-Hz machines.

PLANT SUPERVISION AND CONTROL SYSTEM

For maximum efficiency, a batched centralized supervisory operation method was employed in the plant supervision and control system. This system controls the main unit and the outdoor auxiliary facility using comprehensive display screens (CRTs: cathode-ray tubes), thus allowing the system to be operated efficiently with a small number of operators. The system has the following features:

(1) The configuration of the central control room allows for centralized supervisory operation of the Nos. 1 and 2 power stations as well as an outdoor auxiliary facility. It consists of a central control panel with six CRTs for each unit and a BTG (boiler, turbine, generator) auxiliary panel. A 70-inch LCD (liquid crystal display) screen allows plant operation data to be shared (see Fig. 4).

(2) A digital control system (auxiliary unit sequential controller, turbine speed governor, automatic voltage reactive power regulator, etc.) has been implemented as a functional distributed system in which the Hitachi Integrated Autonomic Control System (HIACS-7000) is used. The distributed computers are connected by a fast, large-capacity optical fiber (100 Mbit/s, duplex), so that the whole system has excellent responsiveness and the whole plant is effectively coordinated.

Fig. 4—Central Control Panel — Kin No.1 Thermal Power Station.
Centralized supervisory operation utilizing a compact operation panel, BTG auxiliary panel, and large display screen.

(3) A protection circuit and an interlock circuit, which conventionally consist of auxiliary relay panels, are now implemented as software and a digital controller. To achieve the same level of reliability as conventional systems in software implementation, a programmable control module with ROM (read-only memory) has been employed in the controller process I/O (input and output), so that, if the controller fails, the control module alone can perform protective functions. As a

Fig. 5—Generator Installation.
The jack and rails used for installing generators were shared when both generators were installed.

Fig. 6—Condenser Installation.
The condenser was brought in by a special dolly from the boiler side in the turbine building and installed underneath the turbine generator frame. (Photo: lower body of the condenser)

result, an auxiliary relay panel has been eliminated and electrical instrument installation has become efficient.

INSTALLATION AND CONSTRUCTION

Delivery Plan for the Power Generators and Condensers

During the delivery of the power generators and condensers to the two Kin power stations, Hitachi coordinated the development effort with related organizations to effectively design the civil engineering and construction and achieve highly coordinated and efficient work processes.

(1) Efficient machinery transport by effective delivery path and method

The previous power generator was taken into the turbine room through an opening in the turbine building wall in front of the transformer, sacrificing the transformer yard. The opening was created and protected with protective material. In the two Kin thermal power stations, a hydraulic jack was installed at the entrance in the center of the building for large machinery. The power generators for both power stations were brought in using this jack (see Fig. 5).

The previous condenser was brought into the basement of the turbine building from the circulating water pipe pit side through an opening in the turbine building wall, sacrificing the construction in the pit. In the Kin thermal power station, the condenser was brought in from the boiler side and placed underneath the turbine generator frame using a special dolly.

(2) Shared delivery facilities

For the Kin thermal power station, Hitachi provided the turbine plant machinery for both power stations. In addition to the main turbines, Hitachi also delivered the power generators and condensers; the delivery facilities used for both power stations were shared. When bringing in the power generators, the jack and rails were also shared and used after the power generators were brought into the turbine building. When the condensers were brought in, the delivery facilities, up to and underneath the turbine generator frame, were also shared. This sharing contributed to the overall efficiency of delivery (see Fig. 6).

(3) Advantages

(a) Work load leveling

Since the Kin thermal power station is in Okinawa prefecture, the most southern part of Japan, the efficiency of installation work can be greatly affected by weather condition such as typhoons. For this reason, most movement of power generators was done indoors, which helped to level out the work load resulting in a smoother running schedule and cost savings. When a power generator or condenser was brought in, high efficiency of multidirectional installation was achieved without sacrificing the transformer yard for the power generator and without sacrificing the circulating water pipe pit for the condenser.

(b) Streamlining and improving the implementation tasks

The installation of the power generators was done mainly indoors (conventionally it is done outdoors). This means that no scaffolding was required and there was effective and versatile use of a ceiling crane; there was no need to protect the turbine building or make restorations. Installation was streamlined and construction tasks proceeded smoothly. Coordination for the installation of the power generator among civil engineering and construction was also significantly simplified, resulting in an improved and safe work environment. Carrying by hand was eliminated, ensuring better work flow. Since there was no opening in the building, there was no need to protect the building. This led to effective quality control.

CONCLUSIONS

This paper described the major features of the Kin No. 1 Thermal Power Station belonging to The Okinawa Electric Power Company, Incorporated. The No. 2 power station also started operation in May 2003. In the development of the Nos. 1 and 2 units, Hitachi, Ltd. maintained its engineering leadership in the project and made every effort to successfully inaugurate the power station. Hitachi will continue to search for better technologies that will improve the development of power stations and continue to apply those to future thermal power stations.

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