H-25 Gas Turbines for PetroChina's Gas Processing Plant in Indonesia

Hiroo Tsuruta
Shunichi Hirose
Nobuyuki Shinohara

OVERVIEW: The importance of energy including natural gas is universal, and worldwide demand will only continue to escalate in the years ahead. Areas experiencing growing demand for energy have inevitably expanded as industry has evolved in various regions around the globe, and new oil and natural gas fields continue to be developed. Recently, a natural gas field was discovered in the Betara District in the Jambi Province, eastern central Sumatra in Indonesia, and the Betara Complex Development Project, managed chiefly by PetroChina International Jabung Limited, was built to exploit this resource. A key facility of the project is the Betara Gas Processing Plant for which CHIYODA CORPORATION and Chiyoda International Indonesia were brought in to provide engineering, procurement, and construction (EPC), and Hitachi was commissioned to supply H-25 gas turbines as the power supply for the plant. Because the project site is so remote from Indonesia's power grid, the power system for the plant is implemented as an isolated system that is not connected to any other power system.

INTRODUCTION

THE Betara Gas Processing Plant, operating by PetroChina International Jabung, was developed on the island of Sumatra, Indonesia, to produce sales gas from gas fields in the vicinity for delivery to Singapore. Construction work began on the plant in 2003, and the generators went into service in June 2005. Combining the collective resources of CHIYODA CORPORATION and its affiliate Chiyoda International Indonesia (both entities are included in subsequent references to CHIYODA CORPORATION) and Hitachi in plant engineering, the Betara Gas

Fig. 1—Overview of Betara Gas Processing Plant.
The complex was built by PetroChina International Jabung Limited to remove liquid from gas (vapor-liquid separation) and refine the gas from nearby gas wells. Hitachi's H-25 gas turbine was chosen as the power generator for the Betara Gas Processing Plant.

Processing Plant—the key facility of the Betara Complex Development Project—was completed using Hitachi's H-25 gas turbines that are renowned for their robustness and reliability. Here we give an overview of the Betara Gas Processing Plant, highlighting the key role of Hitachi's H-25 gas turbines used to generate power for the plant.

OVERVIEW AND UNIQUE ASPECTS OF BETARA GAS PROCERSSING PLANT PROJECT

The Betara Gas Processing Plant is built on a site that was carved from the jungle in the province of Jambi on Sumatra. The infrastructure of roads could not support overland delivery into the site, so the plant assemblies and equipment were brought up the river. The equipment was first gathered in Singapore, then moved by barge across the strait and up the Betara River, and finally off-loaded and moved overland to the construction site. Fig. 2 shows a map of the project site on Sumatra and the water transport route from Singapore.

Equipment at the plant includes sales gas compressors, propane gas compressors, and a number of other large-scale compressors. The mainstream approach up until recently has been to use mechanical drive gas turbines for these compressors. The disadvantages of using gas turbines are that they require periodic maintenance and operate at high temperature, which means that spare parts must be kept on hand and replaced on a fairly regular basis. Particularly in the case of mechanical drive gas turbines, different gas turbines are required for each kind of equipment that needs to be driven, and this greatly increases the number of spare parts that have to be kept on hand.

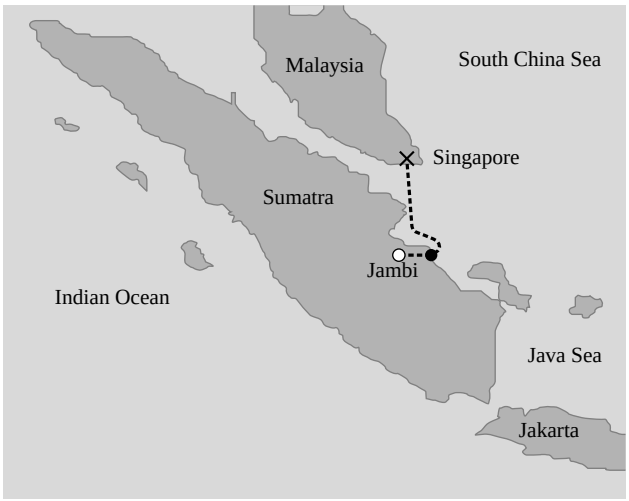

Fig. 2—Location of Betara Gas Processsing Plant and Barge Route to Site.
Equipment was delivered by barge from Singapore to Jambi, up the Betara River, and off-loaded at the site.

Indeed the client initially proposed exactly this approach of deploying several smaller turbine generators at the Betara Gas Processing Plant to separately drive the several compressors at the plant. CHIYODA CORPORATION and Hitachi proposed changing this aspect of the plan and just using a few larger H-25 gas turbines to drive the motors of all the compressors. A feasibility assessment revealed that using just a few H-25 gas turbine generators has significant advantages—simpler operation and plant layout, less maintenance and need for fewer spare parts, and lower costs—so in the end this approach was adopted.

System Overview

The Betara Gas Processing Plant is in the middle of the jungle far from the power grid, so power has to be generated on site by operating an isolated power system referred to as an "island operation." Schematic diagrams of the plant's equipment and electrical systems are shown in Figs. 3 and 4, respectively.

Gas and liquid are received at the plant by pipeline from several dozen gas wells in the vicinity, and the plant separates liquid from the gas stream and refines the gas. The refined gas is sent by pipeline for use as city gas or fuel gas for generating power and the separated hydrocarbon liquid is sent to another nearby plant that is part of the project where it is separated and refined as LPG (liquefied petroleum gas) for shipment.

Most of the power load goes to drive the compressors, and typically two H-25 gas turbines operated in parallel provide about 60% of the load each. There are also two satellite plants, NEB-10 and GEMAH-6, that are located 5 and 15 km distance from the Betara Gas Processing Plant, and after natural gas from nearby gas wells undergoes simple vapor-liquid separation at atmospheric pressure at these satellite sites, the pressure is raised by associated compressors, and the gas is shipped to the Betara Gas Processing Plant. Output from the H-25 gas turbines is transmitted to both the NEB-10 and GEMAH-6 plants.

The Indonesian power system uses 50 Hz, but the plant was designed for 60 Hz to ensure that the pumps and other equipment operate fast enough, and also reduce the size and cost of equipment.

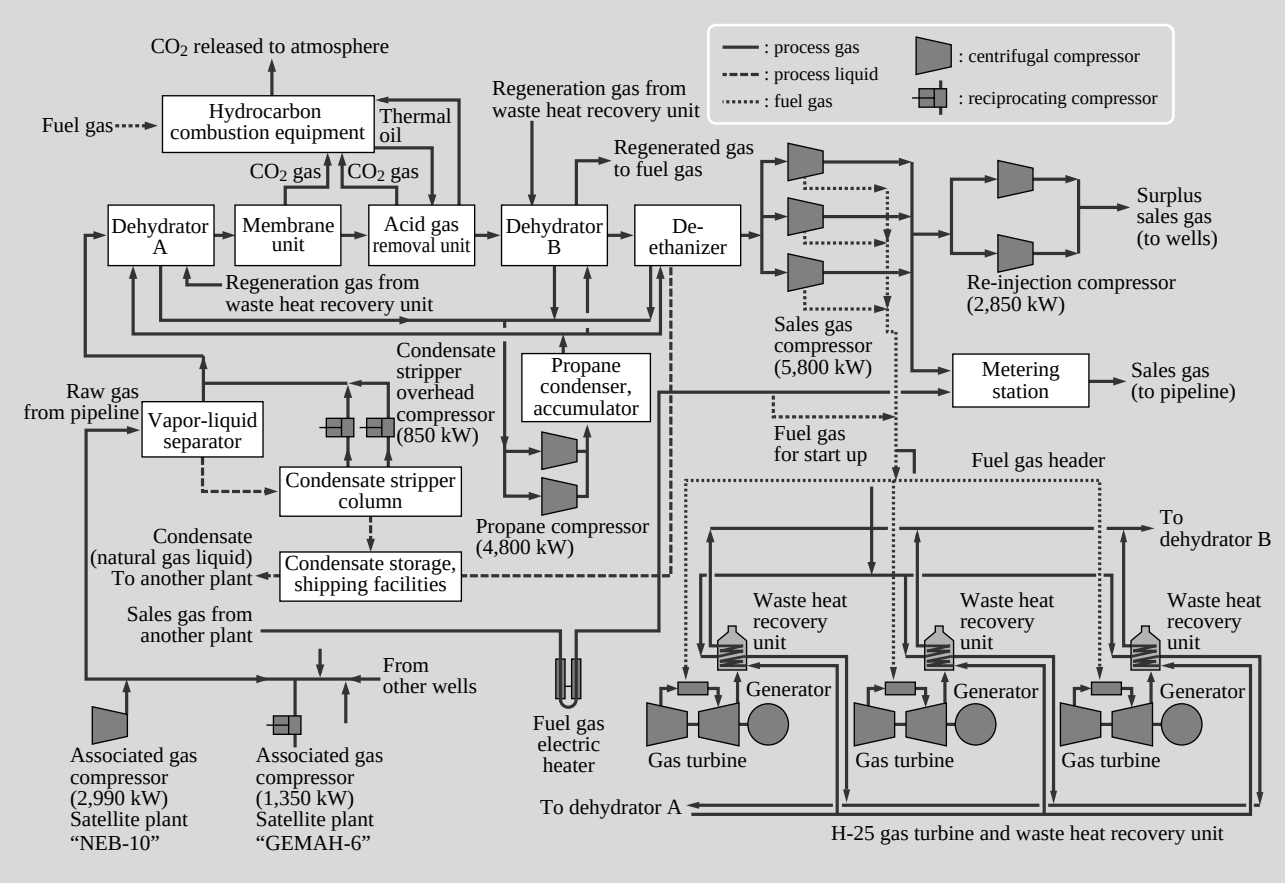

Fig. 3—Schematic of Equipment and Systems at Betara Gas Processing Plant. Sales gas is delivered out by pipeline, while surplus gas is pumped underground.

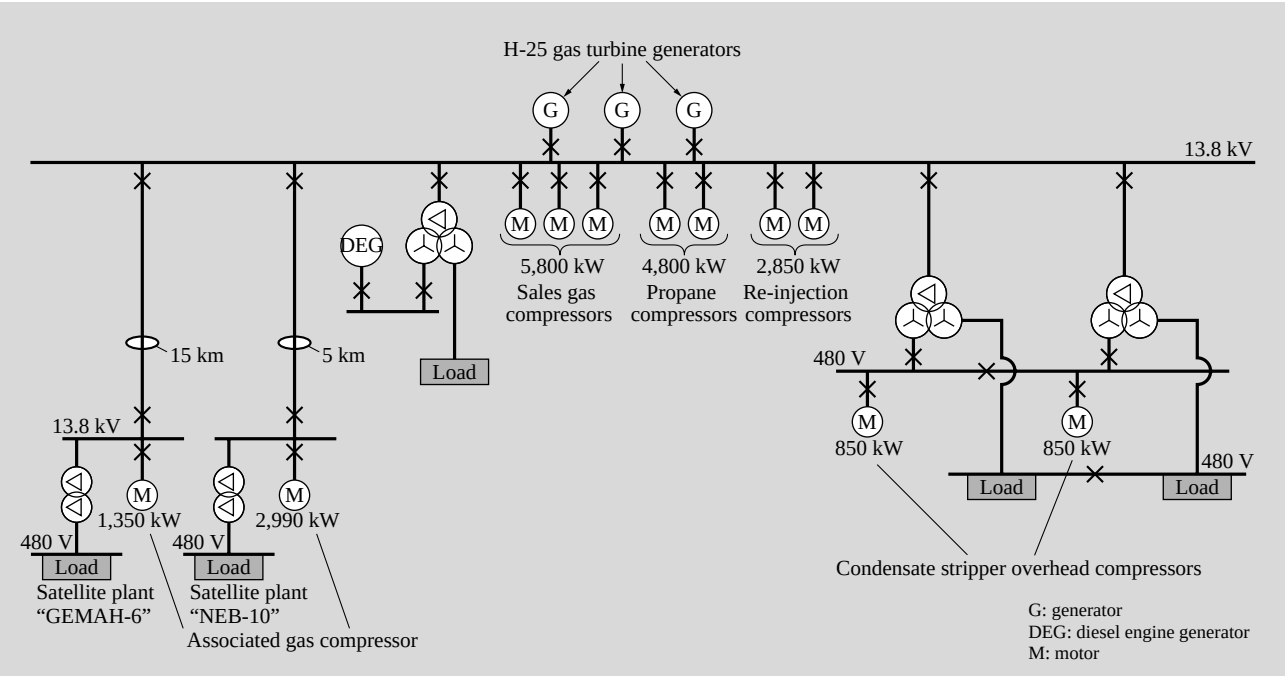

Fig. 4—Schematic of Electrical System at Betara Gas Processing Plant. The sales gas compressor includes 5,800-kW motor-driven equipment, and multiple motors are started by full-voltage.

TABLE 1. Equipment Specifications
The H-25 gas turbine is supplied by Hitachi, and the waste heat recovery unit is supplied by CHIYODA CORPORATION.

	Parameter	Specification
Gas turbine	Model	H-25 (heavy duty type)
	Power output	23,300 kW
	Rated revolution speed	7,275 min^{-1}
	Fuel	Natural gas
Generator	Type	Open air cooled
	Capacity	29,130 kVA
	Rated rpm	3,600 min^{-1}
	Excitation	Permanent magnet brushless
Reduction gearbox	Type	High-speed parallel longitudinal axis
	Transmitted power	31,000 kW
Waste heat recovery unit	Type	Cylindrical vertical standalone
	Use	Heating process gas (2 systems)
	Heat recovery capacity	1.2 Mcal/h + 2.2 Mcal/h

TABLE 2. Main Drive Motors for Compressors
Compressors were supplied by Hitachi.

For driving	Unit	Rating	Site
Sales gas compressor	3	5,800 kW	Betara
Re-injection compressor	2	2,850 kW	
Propane compressor	2	4,800 kW	
Condensate stripper overhead compressor	2	850 kW	
Associated gas compressor	1	2,990 kW	NEB-10 satellite plant
Associated gas compressor	1	1,350 kW	GEMAH-6 satellite plant

Fig. 5—5,800-kW Motor-driven Gas Compressor.
Photo of sales gas compressor installed at the Betara Gas Processing Plant.

Equipment Overview

There is an installed base of more than fifty H-25 gas turbines in service throughout the world that have a combined operating history of over a million hours, so the reliability and robustness of the H-25 is well attested. Three H-25 gas turbines were started up in quick succession for trial runs within a short period of time, and currently all three are running smoothly. Specifications of the H-25 gas turbines and other equipment are summarized in Table 1, while the specifications of the main compressors driven by the turbines are listed in Table 2. In addition to the H-25 gas turbines, Hitachi is also responsible for supplying the principle motor-driven compressors for the project. Fig. 5 shows a photo of the sales gas compressor, one of the motor-driven compressors installed at the Betara site.

Large-motors Startup Procedures: Investigation and Findings

Before the H-25 gas turbines can be started up, the lubricating oil system and other auxiliary equipment must be started up. A DEG (diesel engine generator) was brought to the site specifically to start these auxiliary systems. Essentially the startup procedure is as follows: After the DEG is started and the auxiliary equipment is up and running, the DEG and one of the H-25 gas turbines are synchronized. After the DEG and H-25 gas turbine are running in parallel, the DEG is shut off. Then the second turbine is started and synchronized with the first turbine that is already running, and finally the motor-driven compressors are

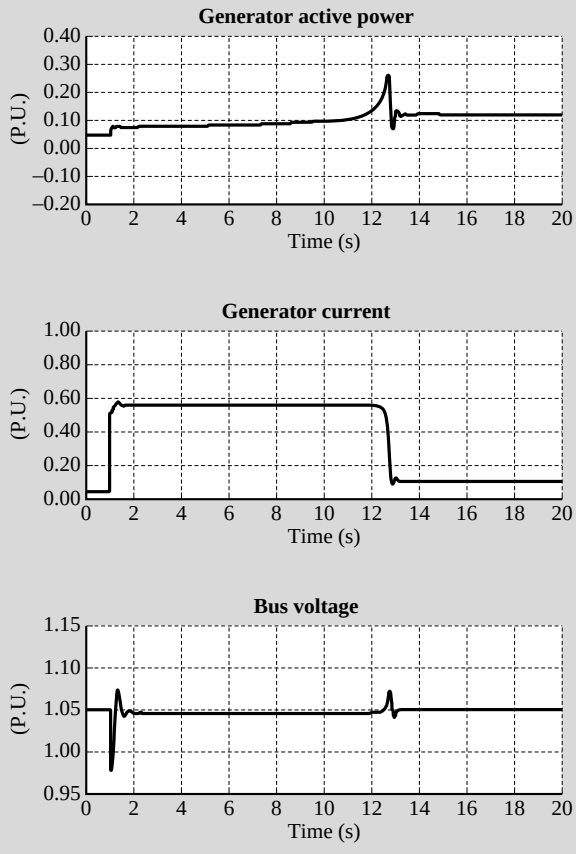

Fig. 6—5,800-kW Gas Compressor Drive Motor Start-up Analysis Results.
Results confirm that during start-up, voltage fluctuations and other variables are well within the permitted range.

started up.

The largest load equipment at the plant is the 5,800-kW motor-driven sales gas compressor, so by showing that we could start this motor, we effectively demonstrated that the other smaller load motor-driven compressors could also be readily started. We analyzed the startup behavior of the 5,800-kW sales gas compressor drive motor, and the results are shown in Fig. 6. The voltage fluctuations and other variables exhibited when starting the motor were exactly what we predicted, and no problems occurred.

CONCLUSIONS

This paper describes motor-driven compressors and H-25 gas turbines that Hitachi supplied as the main power source for driving several large compressors at the Betara Gas Processing Plant, which is part of the Betara Complex Development Project operated by PetroChina International Jabung on the island of Sumatra in Indonesia. CHIYODA CORPORATION and Hitachi efficiently concluded a series of trial runs within a remarkably short period of time, and the systems are now in service and performing smoothly. In the isolated system conditions that prevail at the site, we employed a full-voltage startup procedure, and the 5,800-kW motor-driven sales gas compressor and other equipment started up smoothly without any problems. Encouraged by these results, we plan to adopt these procedures on a wider scale to improve the efficiency and operations at a wide range of other project sites.

ABOUT THE AUTHORS

Hiroo Tsuruta
Joined CHIYODA CORPORATION in 1970, and now works at the Mechanical Technology of Engineering Unit. He is currently in charge of rotating machinery and packaged mechanical equipment. Mr. Tsuruta is a member of Turbomachinery Society of Japan.

Shunichi Hirose
Joined Hitachi, Ltd. in 1970, and now works at the Overseas Thermal Power Plant Project Management Department of the Thermal Power Systems Division, the Power Systems. He is currently engaged in project management of gas turbine generating plants.
Mr. Hirose is a member of The Institute of Electrical Engineers of Japan (IEEJ).

Nobuyuki Shinohara
Joined Hitachi, Ltd. in 2003, and now works at the Gas Turbine Design Section, the Turbine Plant Design Department, the Thermal Power Systems Division, the Power Systems. He is currently engaged in the basic design of gas turbines. Mr. Shinohara is a member of GTSJ.