Gas turbine cogeneration system for supercomputer " K"

We have introduced a 6 MW class gas turbine cogeneration system, as part of the electrical facilities for the "K" at the RIKEN Advanced Institute for Computational Science. It is our first experience to apply a cogeneration system to protect power supplies at a data-processing center. In this article, we report the features of this combined heat and power.

Preface

The "K" supercomputer was ranked No. 1 amongst the world's top 500 supercomputers in June and November 2011. We delivered a combined heat and power (CHP), consisting of two 6 MW class gas turbines, as part of the electrical facility for the "K."

The CHP introduced into the "K" facility not only serves the purpose of reducing contracted demand by means of peak shaving and energy-saving but also protects the power supply to the supercomputer. This is the first time that we have applied a CHP for the purpose of protecting the power supply of a data-processing center.

In this article, we report our contribution to the power supply of the "K" via the power supply protection system for the "K" and the energy-saving measure.

Fig. 1 Appearance of CHP unit

1 Overview of the CHP unit

Figure 1 shows the appearance of the CHP unit. It is made up of two 6 MW class gas turbines and two heat recovery steam generators (HRSG), with city gas 13A used as the fuel. The generator is connected to important loads such as the hard disk device of the "K" and laboratory loads, being operated constantly with utility power supply in a system interconnection configuration. These loads are protected against service interruptions and instantaneous voltage drops. In addition, gas turbine exhaust gas is used to produce chilled water for the computer by means of a steam absorption chiller.

2 Features

(1) Power supply protection system

The system of measures that protect the "K" facilities against service interruptions and instantaneous voltage drops (called "measures against instantaneous voltage drop" in the following) is aimed at the protection of important domains such as large-scale storage units that store the results of computation and research buildings for which the protection of research data is needed.

A commonly practiced measure against instantaneous voltage drop for facilities such as a data-processing center is a storage-battery-based UPS unit. In the case of this facility, however, the power requirement for the important domains to be covered was estimated to be 6,500 kW, therefore a storage-battery-based UPS facility posed problems in an increase in initial costs, the need to acquire an installation site, and an increase in the maintenance expenses. To protect file servers, which are important devices, from instantaneous voltage drops, it is necessary

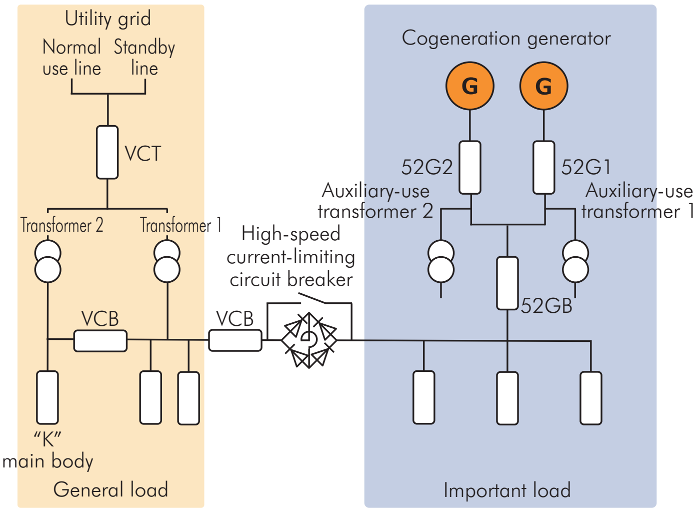

Fig. 2 Schematic diagram of protective measures against instantaneous voltage drops

to maintain the voltage of the generator bus within 80% should an instantaneous voltage drop occur and to complete cut-off from the power system within 20 ms. In response to this necessity, a system of measures against an instantaneous voltage drop incorporating a high-speed current-limiting circuit breaker was devised. Fig. 2 shows the diagram of the system configuration.

In comparison with existing measures, this system allows important units such as file servers to be protected while containing the installation and maintenance expenses for the backup power supply and reducing the installation space.

(2) Introduction of energy-saving technology for an eco-supercomputer facility

One of concepts for the facilities of the "K" supercomputer is an "eco-supercomputer." Kawasaki's CHP uses a power generation system consisting of gas turbines and steam absorption chillers that runs on gas turbine exhaust gas, thus contributing to a reduction in environmental load from the computer system and facilities in the building in which the supercomputer is installed. Fig. 3 shows the flow from the heat source.

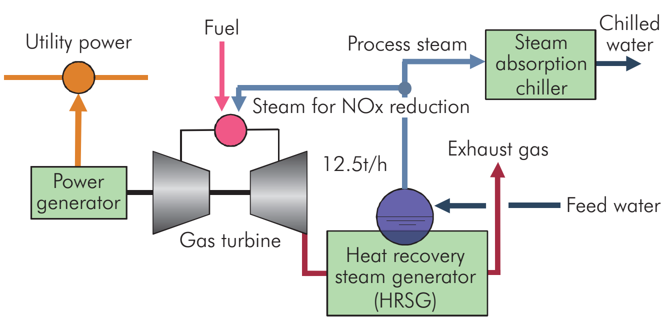

Fig. 3 Facility flow of CHP

(3) Operating track record

(i) Operating track record

The CHP has a power generation efficiency of approx. 30%, a heat recovery efficiency of approx. 45%, and an overall efficiency of approx. 75%, thus operating efficiently in compliance with computer loading.

(ii) Power Usage Efficiency

Power Usage Efficiency (PUE) is a criterion by which to assess the energy conservation capability of an entire computer processing center.

$$PUE = \frac{\text{Energy consumption in entire building}}{\text{Energy consumption of computer}}$$

This definition shows that the closer to 1 that PUE is, the smaller the electricity consumed by the building facilities, excluding the computer. In other words, the better the energy conservation of the facility is.

The "PUE target values to be attained in 2011," made public by the U.S. Environment Protection Agency, are 1.7 for the standard value, 1.3 for the best value to be attained, and 1.2 for epoch-making technology.

According to the track record obtained with the "K" supercomputer to date, the system has operated at a value of approx. 1.3, the best value to be attained, because the CHP has been running very efficiently.

Postscript

Kawasaki's CHP introduced into the facilities of the "K" has proven that it adds, to the advantages of existing CHPs, new advantages such as the elimination of expenses for the installation of backup power supplies and a reduction in installation space. With these points evaluated highly, the electrical facilities for the "K" were awarded an Institute of Electrical Installation Engineers of Japan Promotion Prize (for facilities, technical fields.) (The prize was jointly awarded to the RIKEN Advanced Institute for Computer Science, Nikken Sekkei Ltd., Kinden Corporation, Kyudenko Corporation, and Sanki Engineering Co., Ltd.)

As a final note, the authors sincerely thank the RIKEN Advanced Institute for Computer Science and those who provided us with cooperation in a variety of ways in the task of delivering this facility.

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