Basic Technology Subjects

Energy Engineering Research Laboratory

Brief Overview

The Energy Engineering Research Laboratory is aiming to achieve security, as well as construct power and energy supply and demand systems, through the R&D of clean and high efficiency thermal power generation technologies and advanced heat utilization systems.

Achievements by Research Theme

High Efficiency Power Generation

To secure reliability and decrease the operation and maintenance costs of thermal power plants, the rationalization of maintenance and management for the boiler tube and the gas turbine hot gas path parts, as well as the evaluation technology of applicability of non-conventional liquid fuel to the thermal power plant are under development. In order to improve efficiency and reduce carbon emissions, we aim to support the smooth introduction of IGCC commercial plants and evaluate a next-generation coal-based thermal power plant system.

- Miniature sample creep tests and metal temperature analysis of actual boiler tubes have been performed to accumulate reference data for the reasonable judgment of the chemical cleaning interval. It was discovered that the chemical cleaning interval could be extended through forecasting the damaged condition of the boiler tube based on the actual operation data of the thermal power plant boiler.
- The nondestructive method that identifies the delamination of thermal barrier coating on hot gas path parts developed by CRIEPI was examined to find appropriate test conditions. The result of this examination revealed the reasonable test condition as a function of top coat thickness and consequently the method could identify the delamination of the actual parts clearly. (M13007).
- The operating data of Nakoso Unit 10, which was an IGCC demonstration plant and has been in commercial operation since FY2013, were analyzed in order to predict the gasification performance of the candidate coal. We extended our knowledge about plant performance and suitability to investigate coal types for IGCC, and contributed to the stable commercial operation of the IGCC plant.
- Gasification tests using the 3t/d coal research gasifier and reaction analyses were conducted for investigating oxygen-CO_2 blown gasification characteristics in the high efficiency IGCC system with CO_2 capture which CRIEPI proposed as a future option for low-carbon emission technology. The result showed that the increase in CO_2 concentration in the gasifying agent contributed to improvement in carbon conversion efficiency (M13005).

Advanced Fuel Utilization

In order to diversify energy resources and improve the environmental friendliness of coal-fired power plants, the Energy Engineering Research Laboratory is developing combustion enhancement methods for low combustibility coal, evaluation methods and countermeasures for spontaneous ignition of solid fuels, trace element measurement methods, brown coal dewatering method and manufacturing methods for fly ash solidification material.

- For the spontaneous combustion of coal and biomass, we investigated recent accidents, preventing methods and monitoring methods. The results indicated that the spontaneous combustion during indoor fuel storage occurred more often than during outdoor fuel storage and the monitoring system using an odor sensor would be effective for use with indoor fuel storage, especially silo storage.
- For the effective use of coal fly ash (FA), we examined a manufacturing method that enables mass-production of FA-shell solidification materials at low cost. We found that FA solidification material without addition of the cement for earthworks, could be produced using a method of concrete placement with vibration (M13304).
- The measurement method for gaseous boron in a combustion flue gas was tested for a simulated coal gasification gas. This result indicated that the method was applicable to a coal gasification gas.

Heat Pump and Thermal Storage

For developing high-efficiency heat pumps and expanding their application areas, we search and evaluate innovative technologies. To assist in proposing energy-saving solutions to customers, we develop simulation tools for analyzing energy consumption.

- Regarding the proposed frost-free heat pump, we evaluated the potential of the practical system based on experimental results of the solid desiccant coated heat exchanger. In cold climates, at -7℃ and 80% relative humidity, the system could achieve 3.0 COP. It could also achieve non-frost operation for more than 40 minutes which was the same as the defrost interval of the current air heat source heat pump system.

Energy Conversion Engineering

Basic technologies that relate to the evaluation of thermal efficiency and fuel cells, and environmental analysis, etc., will be developed to improve operability and thermal efficiency of the thermal power plants and geothermal power plants.

- An efficiency improvement of existing gas turbine combined cycle, GTCC, repowered in combination with state-of-the-art Solid Oxide Fuel Cells (SOFCs) was examined. The efficiency of a 1250℃ class GTCC rose from 53% to 69% in low heating value, LHV, whereas the efficiency of a 1500℃ class GTCC went up from 59% to 71% in LHV in response to an increase in capacity of SOFCs. (M13003)
- Transient voltage response of SOFC (Solid Oxide Fuel Cell) to instantaneous variation of load (up to 1 sec) was evaluated using several bench-scale cells to build a model representing voltage response. The output control of the SOFC system based on this response would be effective measures to balance fluctuations in generation from renewable sources such as solar and wind power. (M13002)
- X-ray absorption fine structure (XAFS) was applied to the determination of chemical form of trace mercury in complex mixtures such as coal ash and sludge by using SPring-8. The result showed that there is a possibility to estimate the chemical form of mercury from slight structural changes in X-ray absorption edge. (M13004)

Innovative Numerical Simulation Technology

Comprehensive numerical simulation tool is being developed by integrating multi-scale and multi-physical numerical schemes and models in order to solve issues taking place in thermal power generation plants by accurately evaluating performance and optimizing the operating conditions of thermal equipment, such as pulverized coal combustion boilers, coal gasifiers, and gas turbines.

- The detailed flame structure where devolatilization from pulverized coal particles, soot and luminous flame formation were taking place was clarified using laser diagnostics. In order to predict such phenomena, a numerical method that enabled computation of large elementary reaction mechanism concerning tar polymerization and decomposition within a practical computational cost was developed.
- The chemical analysis of SCR catalyst showed that the deposition of ash particles on the catalyst surface was one of the major mechanisms suppressing DeNOx catalytic reactions in the DeNOx SCR system in a coal-fired power plant. A numerical estimation method of ash particle deposition on the catalyst surface was also developed to predict such phenomenon.

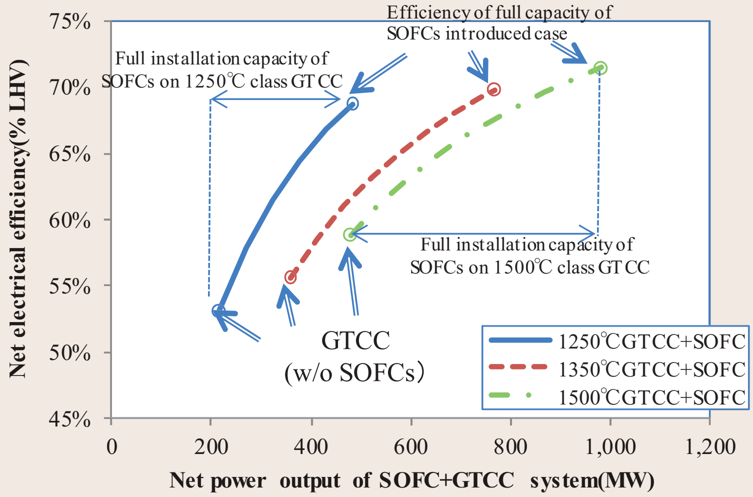

Fig. 1: Efficiency improvement of existing GTCC repowered by SOFCs

The maximum capacity of installed SOFCs is regulated by the air flow rate from the compressor of GTCC. The installable capacity of SOFCs is 250 MW while the corresponding efficiency improvement is 16% for 1250℃ class GTCC case. For the 1500℃ GTCC case, the installable capacity of SOFCs is 460 MW, while the corresponding efficiency improvement is 12%. Higher efficiency improvement by the installation of SOFCs is obtained in 1250℃ class GTCC case.