Energy Engineering Research Laboratory

Brief Overview

Aiming to establish high efficient power generation and demand systems, the Energy Engineering Research Laboratory (EERL) is engaged in the development of energy conversion, storage and utilization technology, environmental impact reduction technology, and biomass utilization technology, etc. The EERL is also engaged in relevant technology research on systems and equipment, facility diagnostics, and plant operation and maintenance.

Achievements by Research Theme

High Efficiency Power Generation

【Objectives】

The evaluation and maintenance technology for the hot gas path parts of gas turbines (GT) and combustion technology for new type liquid fuels are developed to advance the further efficiency increase and improvement of operability of thermal power plants.

【Principal Results】

・To develop a Non-Destructive Examination (NDE) technique for heat resistance degradation of thermal barrier coatings (TBC) on gas turbine blades, a new evaluation system using a temperature measurement and a numerical analysis has been developed aimed at temperature changes in laser heated TBC surfaces (Fig. 1). Using this system, appropriate ranges of measurement conditions were demonstrated and measurement accuracy was verified [M09007].

・To advance the crack propagation prediction method for gas turbine first stage nozzle vane, temperature estimation method based on steady-state conjugate heat transfer analysis was developed. Temperature distribution estimated here was found to be useful in the understanding of the crack propagation mechanism [M09005].

Advanced Fuel Utilization

【Objectives】

For the diversification of fuels applied to coal fired power plants, some basic research related to the upgrading of low grade fuels, and the sampling and analysis of trace elements applied to coal gasification gases and coal combustion flue gases were conducted. New applications of the catalytic decomposition of volatile organic compounds are also under development.

【Principal Results】

・Extraction technology using DME was found to have various applications such as upgrading of low grade fuels containing moisture and/or oil, oil recovery from alga, and remediation of contaminated soil.

・To establish measurement methods for gaseous boron and selenium, which are useful in improving the quality of environmental protection performance of thermal power plants, the interferences during sampling were specified.

・The catalytic decomposition of volatile organic compounds using ceria catalyst was applied to deodorization, and was found to be effective to decompose major odors such as mercaptan and acetaldehyde.

Energy Conversion Engineering

【Objectives】

Development of system analysis, heat pump/heat storage, fuel cell and innovative basic technologies, aimed at the realization of popularization/expanding of energy saving technology from the demand side and super-high efficiency power generating systems.

【Principal Results】

- Improvement of the Energy Chain Evaluation Program (ECEP) for analyze and evaluation of energy demand and supply systems and equipment based on energy load data in demand side.
- Development of analysis method for energy efficiency degradation factors at thermal and gas combined power plants with EnergyWin, which is our software for analysis of static thermal characteristics in power generation plants [M09013].
- Development of basic technology and know-how on cathodes for higher performance and cost reduction of the Molten Carbonate Fuel Cell (MCFC). Improvement of degradation factor analysis and development of common performance evaluation method on the Polymer Electrolyte Fuel Cell (PEFC) and the Solid Oxide Fuel Cell (SOFC).

Numerical Analysis of Turbulent Heat Transfer and Reacting Flows

【Objectives】

In order to theoretically estimate and optimize performance of thermal power generation plants, advanced numerical analysis technology is developed. This technology is established by combining various numerical analysis technologies and developing models of turbulent heat transfer and chemical reactions on equipments (e.g., pulverized coal combustion boilers, gasifiers and gas turbines) at thermal power generation plants.

【Principal Results】

- Turbulence models that can accurately predict heat transfer characteristics around gas turbine blades were installed to the developing code. From the comparison to the experimental results, the turbulence models were found to be reliable for the simulation of gas turbine thermal flow fields.
- A multi-phase combustion model which can accurately estimate radiative heat transfer among the solid, liquid and gaseous phase was developed and the validity of the model was investigated by performing direct numerical simulation (DNS).
- The effects of inner flow structure on de-NOx reaction on the catalyst wall were investigated by performing large eddy simulation (LES). The results contribute to the establishment of prediction method for degradation characteristics of de-NOx catalyst in thermal power generation plants.

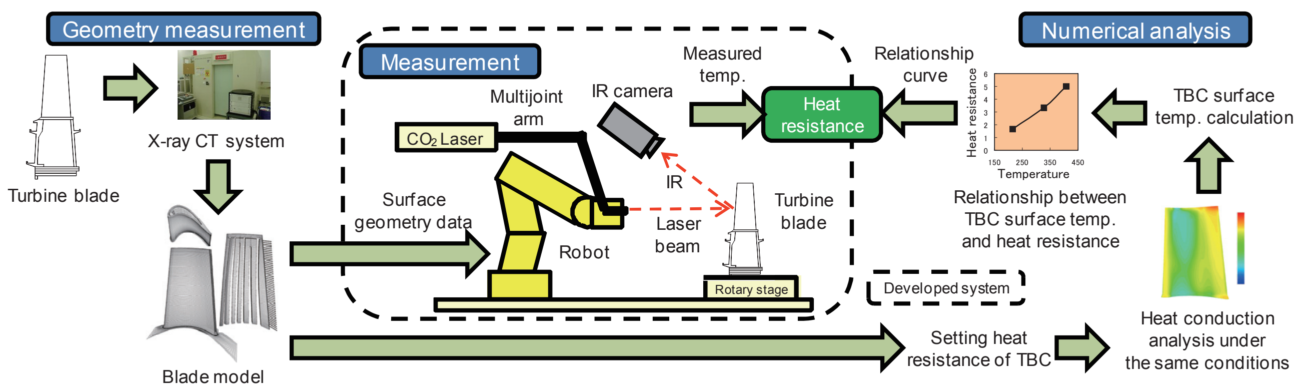

Fig. 1 Configuration of the NDE system for heat resistance of TBCs on gas turbine blades

A TBC heat resistance is decided using the TBC surface temperature when the blade is heated using a laser beam under the same heating conditions and a relationship curve that is calculated by a numerical analysis. Based on the results, the temperature distribution on the blade base metal can be estimated, and the remaining life assessment of the blade can be performed.