Advanced Power Generation

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Research Objective

The researchers are pursuing activities that will lead to a breakthrough in advanced coal generation and applications of key technologies. There are three categories within this research topic:

Integrated coal gasification combined cycle (IGCC)

- Build a process model for the whole IGCC plant and its optimization process
- Provide an engineering design model for the whole IGCC plant
- Optimize the dynamic control system for the whole IGCC plant
- Obtain the gasification technologies for the IGCC

Advanced ultra supercritical (USC) power generation

- Conduct research on combustion and heat transfer characteristics of large-capacity and high-parameter boilers
- Study the combustion and heat transfer characteristics of super 700°C USC boilers
- Establish a prediction model for ash deposition, and provide quantitative data for fine particle removal and ash deposition prevention

Efficiency improvement and carbon reduction for in-service power plants

- Obtain detailed data related to increasing efficiency and carbon reduction for different boiler types, loads, and coal types for in-service power plants
- Evaluate the retrofitting technologies and obtain the technological roadmap for increasing efficiency and pollutant emission reduction
- Obtain the retrofitting and operation experience of key technologies

Technical Approach

Researchers are pursuing a variety of activities related to the IGCC. The team will conduct a coal-gasifier process simulation, integrate the gasifier and IGCC process design, conduct a study on the integrated process optimization of the IGCC system, produce a study on the dynamic control optimization of the IGCC system, and conduct a gasification technology evaluation and research for IGCC.

Advanced USC power generation activities include pursuing furnace combustion and heat transfer of a 1,000 MW USC boiler and a super 700°C USC boiler; investigating the coupling characteristics between the furnace and the pipe of the USC boiler; and evaluating combustion, fouling, and slagging issues related to USC boilers.

Regarding efficiency improvement and carbon reduction for in-service power plants, the team will conduct analysis of the potential for efficiency improvement and carbon reduction; evaluate technologies of in-service power plants; and conduct an engineering demonstration for key technologies, such as an advanced low-NO_x burner and boiler materials for USC.

Recent Progress

Researchers studied the coal combustion characteristics in the different scales of reactors, such as TGA, wire mesh, and down-fired combustors, which will help to develop the CBK char combustion model. The team also conducted a technical evaluation of pyrolytical char from lignite in the power plant.

Soot concentration around a single coal particle was measured by the laser-induced incandescent and multi-elemental diffusion flame burner under different conditions, such as variations in combustion temperature, resident time, coal types, and oxygen concentration. This data can help to develop the soot formation, oxidation model, and thermal characteristics during these processes.

The formation mechanisms of fine particle and deposition mechanisms were studied in the down-fired combustor, and researchers noted that the differences in ash deposition are due to differences in aerodynamics more so than physical or chemical differences in the ash, particularly for the practical self-sustained coal combustor. The results provide the experimental foundation for the ash deposition prediction and prevention model based on the particle aerodynamics mechanism.

Expected Outcomes

IGCC activities will lead to the generation of a complete IGCC system calculation model with sensible heat recycling, a universal IGCC power plant design method and technology, and a software copyright of the IGCC system design.

The research team's efforts in advanced USC power generation will produce a thermal calculation method of large-capacity and high-parameter boilers, a general large-capacity boiler thermal calculation program module, a calculation method of furnace combustion and heat transfer for super 700°C USC boilers, heat transfer coupling characteristics between the furnace and the pipe of USC boilers, and a prediction model of ash fouling and slagging in USC boilers.

The flame shape of coal combustion in different O_2 concentrations