Nagoya University
Graduated School of Engineering
PROF. NORINAGA'S LABORATORY

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Introduction

In our laboratory, we conduct research on High-efficiency energy/material conversion of carbon resources such as biomass conversion, separation/recovery and effective use of CO2 based on reaction and separation engineering. Currently, we are a team of 28 people including 8 staff (Professor: Koyo Norinaga, Research Associate Professor: Hiroshi Machida, 7 Project Associate Professors, 1 Postdoctoral Researcher and 4 secretaries) and 21 students（7 PhD students, 10 MS students, 3 Undergraduate students and 1 Research student). In addition to being in charge of education in the Departments of Materials Engineering and Chemical Systems Engineering, we serve as the Future Society Creation Organization, which was established to promote industrial collaboration, and are also involved in the planning and management of various (on-campus/Intercampus research/international/industry-academia) collaboration projects.

Research summary

ENERGY-SAVING CO2 SEPARATION AND RECOVERY

CO2 separation and recovery by the chemical absorption method using an amine solution has been industrialized, but it is an energy-intensive process.Our laboratory found an amine-ether mixed aqueous solution that separates the liquid-liquid phase into a concentrated CO2 phase and a dilute phase during the CO2 capturing process. This promotes CO2 absorption and regeneration and significantly reduces the energy required for separation and recovery. Aiming for further energy saving, we are also working on elucidation of CO2 absorption/regeneration mechanism using in-situ spectroscopic analysis and new absorbent solution development by molecular simulation. Besides, we propose a "CO2 separation/recovery/utilization integrated process" that simulates CO2 regeneration using hydrogen as a stripping gas and utilizes the obtained CO2/hydrogen mixed gas as a direct raw material for CO2 conversion processes such as methanation and methanol synthesis. We also carry out continuous tests and energy evaluations using laboratory plants to develop various technologies for practical use in collaboration with machine manufacturers.

COKE FOR IRON MAKING

The resource amount of coking coal that forms lump coke is limited, and it is essential to develop a technology for producing coke to make iron from inexpensive coal materials. We are collaborated with blast furnace manufacturers to develop a technology for producing high-grade coke from low-grade raw materials by interpreting the dry distillation/carbonization reaction mechanism of solid carbon fuel and new reaction operations.

CERAMIC-COMPOSITE

Engines equipped with ceramic composites (CMC) on the stationary blades and the moving blades directly downstream of the burner are being implemented in consumer aircraft. Mass production technology with price competitiveness and quality control is indispensable for the general-purpose commercialization of CMC. We want to contribute to developing mass-production technology for Sic-based composite materials through numerical simulation. Regarding the production of CMC by the chemical vapor-phase infiltration method, we are working with the manufacturer to develop a unique simulation technology that considers the non-stationarity associated with chemical reactions, mass transfer, and impregnation.

METHANATION

We believe that the so-called Power to Fuel, which is derived from renewable energy or contains methanation derived from CO2-free hydrogen and CO2, will become more critical in the era of mass introduction of solar and wind power. There has been no large-scale demonstration of the methanation process so far. We want to contribute to the speeding up of scale-up by using reaction rate modeling and computational fluid dynamics. To design a catalyst-fixed bed reactor for Methanation (Exothermic Process) that realizes the optimum temperature distribution, we have developed a methanation reactor numerical analysis code that considers the reaction, heat transfer and flow on an open-source basis.We are working with catalyst and plant manufacturers, resource development companies, and national research institutes to commercialize the process.

THERMOCHEMICAL CONVERSION OF SOLID CARBON RESOURCES

Combined cycle power generation via solid carbon resource gasification enables highly efficient power generation compared to a combustion boiler power generation.We aim to improve the gasification efficiency by modeling the chemical reactions in the gasification furnace at the molecular and radical levels, predicting the reaction characteristics of tar, soot, sulfur, and nitrogen-containing compounds. We are also promoting collaboration with top-class researchers in Japan and abroad. We want to visualize the inside of a furnace and predict gasification characteristics by calculating the detailed chemical reaction model's integrated analysis, heat transfer in the furnace, and fluid calculation.