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Advanced Material Analysis Using Synchrotron Radiation and its Application for R&D Activities in Thermal Power Plants

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Abstract

X-ray analysis is a non-destructive tool for identifying the chemical composition, crystal structure, and physical properties of materials. SPring-8 (Super Photon Ring – 8 giga electron volts), which was constructed in Hyogo Prefecture, Japan, is one of the largest synchrotron radiation facility which delivers powerful synchrotron radiation. This synchrotron radiation includes an X-ray region. X-ray generated by SPring-8 is characterized by useful features such as high brightness, high directionality and wavelength tunability. These features can provide us valuable analyses which cannot be performed with a conventional X-ray tube.

The Kansai Electric Power Co., INC. has been applying SPring-8 to our researches in several fields such as fuel cell, lithium ion battery, catalyst, and so on. This paper introduces a couple of studies about material analysis for thermal power plants.

Gas turbine components, such as blades and nozzles, are exposed to high temperature combustion gas during operation. Since these conditions cause material degradation, an accurate damage assessment method is required. Generally, degree of damages in turbine blades caused by a high stress under high temperature during operation is evaluated by a metallographic observation and mechanical examinations of specimens cut from discarded blades. However, these methods cannot directly evaluate the damages accumulated during operation. Accumulation of damages essentially increases dislocations in the crystal lattice. We applied synchrotron radiation X-ray diffraction at SPring-8 for evaluating the dislocation density in specimens of Ni-based superalloy before and after creep tests. We observed the relation between the remaining life and the accumulated damages.

It has been a significant issue to capture CO_2 emitted from thermal power plants. One promising method is a chemical absorption system which is based on a reversible chemical reaction between CO_2 and an aqueous amine solution. In this method, one of the problems to be solved is to develop a more efficient solution which shows a high absorption capacity, a high absorption rate and a small thermal energy for regeneration. In order to design a new solution, it is necessary to analyze the hydration structure of chemical species bound with CO_2. We applied high energy X-ray scattering at SPring-8 to the analysis of a monoethanolamine aqueous solution, and succeeded in an observation of hydrogen bonds formed between absorbed CO_2 molecule and neighboring water molecules.

The detailed results will be discussed in the session.