Basic Technology Subjects

Nuclear Technology Research Laboratory

Brief Overview

The Nuclear Technology Research Laboratory aims at positively contributing to the solving/alleviation of energy and global environmental problems by developing nuclear technologies, including base technologies to support the safety and stable operation of LWRs as well as recovery from the accident at the Fukushima Daiichi nuclear power plant, so that the use of nuclear energy is accepted by society in a positive manner.

Achievements by Research Theme

Reactor Systems Safety Technology

To enhance safety and support stable operation of light water reactors, the reliability improvement of technologies related to the nuclear reactor system safety, such as, accident prevention, mitigation, emergency management, and preservation for high reliable operation have become important based on the experience of the Fukushima Daiichi nuclear plant accident.We aim to construct those fundamental technologies in connection with the field of thermal-hydraulics and risk assessment.

- We have been sophisticating TRACE code which was developed by the Nuclear Regulatory Commission (NRC) and has been used for safety regulations in the USA as a part of collaborative research with NRC. We suppressed numerical divergence and enhanced convergence of pressure at a liquid phase interface by implementing the liquid compressibility in the numerical solver.
- We have developed a new sensor called a "sub-channel void sensor" to acquire a cross-sectional distribution of two-phase flow in a fuel rod bundle. Based on experimental data, we validated the prediction error of the existing models to sophisticate the thermal-hydraulic analysis code for nuclear reactors.
- Common cause failure (CCF) analysis has an essential role in probabilistic risk assessment (PRA) for nuclear power plants (NPPs). Malfunction records of electrical and instrumentation devices in Japanese NPPs were investigated to find the CCFs and estimate the CCF parameters, which represent the existence ratio of CCFs to the whole failures, for use in PRA. The CCF analysis for the mechanical devices was already carried out last fiscal year. (L12004)
- For an evaluation of vibration fatigue of piping and components due to acoustic fluctuations caused at piping branches in wet steam conditions of an actual plant, wet steam experiments were conducted to clarify the effects of the steam wetness on fluctuations, and it was discovered that the amplitude of fluctuations decreased in proportion to steam wetness.

Nuclear Fuel and Reactor Core

Nuclear fuel and the reactor core are the heart of a nuclear power plant. In order to contribute to the enhancement of their safety, CRIEPI has been promoting the clarification of degradation mechanism of fuel cladding tube, the understanding of fuel performance under accident conditions, and the sophistication of reactor core analysis technology. The assessment of molten fuel characteristics and the development of subcriticality measurement technology are also being pursued for contributing to decommissioning of Fukushima Daiichi nuclear power plants.

- In order to confirm the integrity of fuel cladding when seawater is supplied to a spent fuel pool for emergency cooling, cladding tube specimens were immersed in artificial seawater. The test results indicated that no remarkable corrosion occurred in the specimens even in extreme seawater temperature of 80 to 85℃ and three times higher seawater ingredient concentration than natural seawater. This resistance to corrosion was due to a precipitation layer formed from seawater ingredients on the specimen surface. (L12001)
- Neutron was irradiated to a subcritical assembly simulating a mixture of nuclear fuel and steel, which forms as a result of a core meltdown, and the energy spectrum of gamma-ray emitted from the assembly was measured. The numerical analysis based on the gamma-ray spectrum measurement result was able to determine the ratio of nuclear fuel to steel in the mixture. This indicates that the subcriticality measurement technology under development by CRIEPI is applicable to molten fuel.

Nuclear Fuel Cycle

The necessary technical developments for the early stages of commercial operation of the Rokkasho reprocessing plant were carried out. Basic data for stable operation and safety improvement was also obtained. To maintain our world-top ranking for the developmental level of our FBR fuel cycle technologies we engage in collaborative studies with other institutes in Japan and/or foreign countries. By applying these technologies, prevention technologies for radioactive contamination in a severe accident were also developed.

- The so called "Yellow phase"*1, which sometimes forms in the glass metler was examined comprehensively with attention to the basic physical property, dissolution behavior in the final repository and the diffusion and dissolution behavior into the glass. The obtained results are utilized in the developing activities for next generation glass melters.
- In order to evaluate the applicability of pyro process technologies, which were originally developed for FBR metal fuel cycles, to the treatment technologies for defected fuel generated in core meltdowns, the electroreduction tests using the simulated defected fuel containing U and Pu or the defected fuel generated in the TMI (Three Mile Island Nuclear Power Plant) accident were carried out. It was revealed that the uranium in the defected fuel can be converted to metal*2. Based on the obtained knowledge, we will continue to research the application of pyro technology to defected oxidized fuels.
- CRIEPI continued the operation support for the contaminated-water treatment system in Fukushima Daiichi Nuclear Power Plant and proposed effective operation conditions for cases in which salt concentration is reduced in the contaminated water.

Human Factors Research

In order to contribute to building an organization that exhibits good performance without any human error during both normal operation and emergencies, we will develop measures toward preventing human error and fostering a safety culture by bringing out the features of individuals, teams, and organizations.

- We developed a questionnaire instrument to assess the idealized image of effective power plant operator teams in three different levels of emergencies. This instrument makes it possible to share the ideal images of good team work, necessary for efficient training, among the concerned people (L12005).
- We found that extending the diversity of subjects' knowledge regarding causal factors (ex. unclear operation manual) through a 10-minute lecture on the factors has a beneficial effect on improving one's ability to detect unsafe acts. This suggests that a simple lecture on causal factors before the start of a shift improves workers'(especially inexperienced ones) ability to detect unsafe acts (L12006).

*1 Salt phase containing a high amount of Mo or S, which is separate to the glass phase.
*2 In collaboration with Japan Aeronautical Engineer's Association (JAEA) or Institute for Transuranium Elements (ITU,EC)

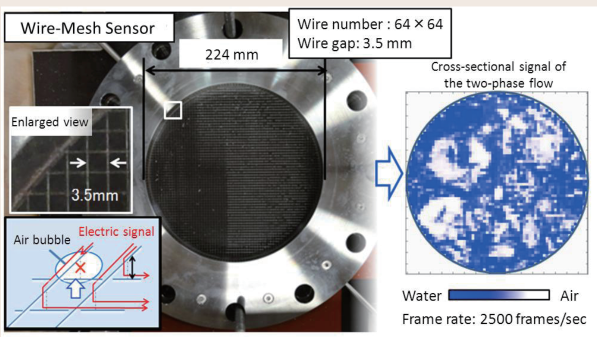

Fig. 1: Schematics of the Wire-Mesh Sensor (WMS)

WMS consists of a pair of parallel wire layers located at the cross-section of a pipe. The WMS measures the cross-sectional void distributions based on local conductivity. CRIEPI's WMS is 224 mm in internal diameter, consists of 64 × 64 parallel wires (3200 measuring points) and can measure the two-phase flow at high speed (2500 fps). Moreover, two sets of WMSs are installed to measure bubble velocity. Slope depends on the aging temperature.

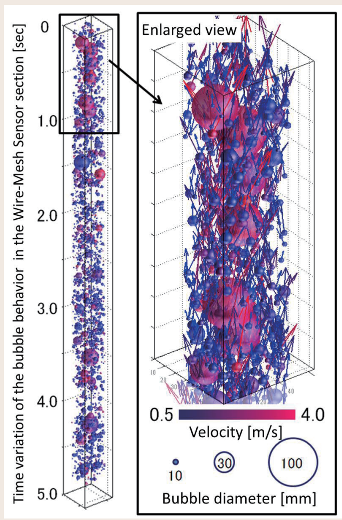

Fig. 2: Visualization of bubble behavior

Three-dimensional bubble velocity is determined by the tracing bubble. The circle size indicates bubble size and the arrow (color) indicates bubble behavior (velocity).