RD-096

High Temperature Gas Cooled Reactor Regulation Development – Operation & Maintenance Perspective

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Demands for better safety, security, safeguard and economic aspects have led to the emergence of innovative nuclear reactor designs. One of the new designs is High Temperature Gas Cooled Reactor (HTGR). HTGR and including all of Generation IV nuclear reactors have a safety paradigm that is completely different from current nuclear reactor technology. Since most of the nowadays commercial Nuclear Power Plants (NPPs) operating in the world are based on water coolant reactor technology, the development of HTGR makes the current regulations will no longer applicable. Regulation is already known has a strong correlation with operation & maintenance optimisation that make the preparation of the new regulation become very important. As the part of that purpose, this study is conducted in order to prepare the more flexible regulatory framework for operation & maintenance activities but without overriding the safety aspects. The safety functions of HTGR are investigated by adopting a graded approach and examine the importance of each function. The regularly operating systems having a high safety importance are identified, and the reliability models and frequency of inspection of these systems are discussed. Furthermore, a detailed reliability model of a regular system in an existing light water reactor is prepared to conduct a numerical demonstration on the application of risk information for operation & maintenance. This study indicates that new perspective of regulation has to be developed for the future operation of HTGR.

Keywords: nuclear, power, HTGR, Generation IV, maintenance, operation, regulation

RD-097

Developing Trilingual Vocabulary List for the Analysis of the Four Capabilities of Resilience: A Case Study Based on Fukushima Daiichi Nuclear Accident

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The Fukushima Daiichi accident was caused by natural forces, but it exposed certain weaknesses in Japan's safety regulatory framework and accident management practices, especially lack of resilience. To prevent another severe accident, the existing public documents (National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission, Investigation Committee on the Accident at Fukushima Nuclear Power Stations of Tokyo Electric Power Company, Yoshida Reports, etc.) of the Fukushima Daiichi accident have been studied in detail by experts and researchers. Some of them analyzed those documents to learn lessons to improve resilience capabilities. However, those public documents are not easy for systematic analysis because those documents are written by variety of authors without any common reference framework.

The aim of this study is to develop a trilingual vocabulary set of the four capabilities of resilience (learning, anticipating, monitoring, and responding) proposed by Erik Hollnagel. It will support researchers and practitioners to extract useful information from accident reporting documents to improve resilience capabilities of the related organizations and stakeholders. It is a supporting tool for resilience-based disaster management.

The proposed vocabulary set was verified by using IBM SPSS Text Analytics for Surveys software and Fukushima Daiichi Nuclear Accidents reports as example text. As a result, the proposed vocabulary set is composed of six categories. Four of them is based on Hollnagel's original capability categories. And two categories, positive and negative, are added by the author to improve effectiveness of the text analysis. The proposed vocabulary set will save time for learning lessons from literatures. It can be used not only for nuclear accident case but also for a wide range of disaster management case.

RD-098

Galet – Geant4 Based Application Templet for Primers

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Geant4[1] is a Monte Carlo simulation toolkit to simulate interaction of particles with matter. It covers physics of particle interactions ranging from a few eV to TeV, so that it is widely used in various science field such as high energy physics, nuclear physics, space and medicine. Because of the wide requirements, Geant4 has been designed on the software methodologies and distributed as a toolkit, i.e. a series of class libraries. The application development requires enough expertise for software developments, but it is not easy for the primers to respond it.

For the purpose of supporting the primers to develop their own Geant4 applications, the Geant4 application templet (Galet) program was been proposed, which is a skeleton program for integrating an in-house Geant4 application with minimal effort. Geant4 has many virtual classes to be mandatory implemented in application development, while Galet provides many of the concrete classes, which have been designed to be versatile and shared among various applications. In the minimum implementation, Galet offers application developers to implement only three classes that are relevant to the geometry construction and the histogramming of simulation results.

The usage of Galet has been tested on educational and research projects. Authors have been organizing the KOSEN-KEK internship since 2016, which is partly supported by KEK as a Cooperative and Supporting Program for Researches and Educations in Universities. Until 2018, total 18 students experienced a Galet program for NaI(Tl) detector. In researches, Galet has been utilized as a framework for simulating a high purity germanium detector[2], a liquid scintillation counter[3], beta-ray induced X-ray analysis[4] and DNA damages. In conclusion, Galet is an efficient framework for developing various Geant4 applications.

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RD-099

Structural Integrity Evaluation of Reactor Pressure Vessels Using Probabilistic Fracture Mechanics Code

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Abstract

Evaluation of reactor pressure vessel (RPV) integrity is important for long term operation of nuclear power plants. It is known that RPV become brittle under neutron irradiation. The objective of this research is to understand the relationship between changing of fracture probability and fracture toughness under several transients.

The assessment has been performed by using probabilistic fracture mechanics (PFM) analysis code PASCAL (PFM Analysis of Structural Components in Aging LWR). The conditional probability of crack initiation (CPI) and conditional probability of fracture (CPF) have been evaluated considering the change of related nil ductility transition temperature(RT_{NDT}). The results show that for large break loss-of-coolant accident (LB LOCA), CPI and CPF significantly changed with the value of RT_{NDT} are 70^0C and 30^0C, respectively.

Keywords: RPV, probabilistic fracture mechanics, conditional probability of crack initiation, conditional probability of fracture.

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RD-100

Radiation Damage in Concrete for Nuclear Facilities: Degradation Mechanism

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Concrete is a mixture of cement paste and rock-forming aggregates, is used in construction of radiation shielding or bearing structures of nuclear reactors. Being exposed to high radiation dose, the aggregates swells and leads to formation of cracking in concrete due to the swelling induced by amorphization of minerals in aggregates. The amorphization process occurs only in some typical minerals of aggregates. Among the rock-forming minerals, α-quartz is the most sensitive to neutron radiation. However, the research in this field is very limited, mainly conducted by Russia in the 1970s and 1980s because their reactors are small size, concrete will be exposed to higher dose than other types of reactors. Radiation damage process is not well understood yet and there is not a unified approach to the predictive assessment of irradiated concrete. Our project aims to investigate the radiation behaviour of various common minerals containing in aggregates and their contribution to the degradation of concrete members subject to radiation. This paper provides a review on the mechanism consideration of radiation degradation of concrete.

RD-101

Development of Measurement System for Thermal and Electrical Conductivities in Warm Dense Matter Toward Physical Properties in Fusion Materials

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Warm dense matter (WDM) state was generated with pulsed-energy to the matter. Physical properties of WDM are important information for a design of fuel pellet layer in the inertial confinement fusion [1]. A thermal conductivity of WDM is also one of the key parameters of the design. The thermal conductivity in WDM was estimated by a semi-empirical approach based on Wiedemann-Franz law [2]. However, Lorenz number for WDM using quantum molecular dynamics was not explained in the low-density region of WDM [3]. To understand physical properties of a WDM, Lorenz number should be measured from both conductivities of WDM.

In our previous studies, we have developed the generating method of WDM using a pulsed-power discharge with isochoric heating by a quasi-rigid capillary tube [4]. Moreover, we have developed a method to measure the thermal conductivity of WDM [5]. The thermal conductivity are estimated by measuring time-evolution of heat flux from the WDM to the capillary. The electrical conductivity is estimated based on the shape of the WDM and the voltage-current waveforms. However, this measurement system had a problem that is unable to define the shape of WDM or a current leaking from the sample.

In this study, we had developed the confinement system of WDM with defined the shape and without current leaking from the sample. To evaluate the confinement condition, we were observed the shape of the WDM and leaking current by using a fast framing camera system and voltage-current probes, respectively. From this experiment, we had estimated the resistance and electrical conductivity of the WDM. Also, we had evaluated the Lorenz number of the WDM from this electrical conductivity, and the thermal conductivity which was obtained by previous study.

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RD-102

Flyer Acceleration by Electro-Thermal Gun Toward Warm Dense Matter Generation for Inertial Confinement Fusion with Fast Ignition

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In an inertial confinement fusion scheme with a fast ignition method [1], a guiding corn is required for heating a fuel core using fast electrons generated by irradiation of a heating laser. A diamond-like-carbon (DLC) cone, which is an insulator material, is one of the candidates for guiding corn materials. The characteristics of DLC depend on the fabrication process and on the composition ratio of carbon to hydrogen. However, the guiding corn material will pass through a warm dense matter (WDM) state by the intense laser irradiation. The WDM state is a complex regime, and the properties of DLC in the WDM state must be evaluated. A flyer acceleration and impact method (FIM) was proposed to obtain the material properties of insulator materials in the WDM state [2] with the pulsed-power generator ETIGO-II [3]. In the FIM using an electro-thermal gun, the flyer is accelerated by thermal pressure of ablated plasma. The accelerated flyer collides to a sample, and the sample is heated by the kinetic energy of flyer. Therefore, the reachable temperature of sample depends on the flyer speed.

In this study, the FIM by the electro-thermal gun driven by ETIGO-II was demonstrated. The flyer speed was estimated with the time-of-flight taken by a shadow graph image and a pulse period of laser backlight. Current and voltage waveforms applied to the electro-thermal gun were measured. As a result, the highest speed of flyer was 580 m/s with 1 cm^2 and 20 μm thickness of the Ti flyer. In this case, the peak current on the cathode of electro-thermal gun was 180 kA, and the applied voltage to the cathode of electro-thermal gun was 800 kV. In addition, it was observed that the flyer speed was constant during the flight. Therefore, the flyer speed depends on the initial speed. The higher pressure of ablation plasma is required to obtain the higher speed of flyer.

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RD-103

Effect of Alcohol Addition on Lithium Isotope Separation Using Cation Exchange Resin

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Lithium has two isotopes, i.e. lithium-6 and litihium-7. The lithium-6 is used as the parent material of tritium which is fuel for fusion reactor. The lithium-7 is used as the pH control chemical for primary coolant in PWR. For the use of these lithium isotopes, the isotope enrichment is necessary. We have been carrying out studies on the lithium isotope fractionation by chromatography using a cation exchange resin.

In the present work, in order to investigate the optimum conditions for isotope fractionation, we investigated the influence of the alcohol addition to mobile phase on the isotope fractionation coefficient in the lithium cation exchange.

This work is performed with the support and under the auspices of the NIFS Collaboration Research program (NIFS17KOBA031).

RD-104

Experimental and Numerical Studies on Reduction of Hydrogen Concentration in a Sealed Container with PAR for Storing Fuel Debris Safely

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As for the decommissioning of Fukushima Dai-ichi nuclear power plant (1F), long-term waste storage containers with high safety and integrity are requested to store radioactive materials such as fuel debris, zeolite slurry with Cesium, etc. for a long period of time.

Since hydrogen is generated by radiolysis of water, it is important to keep the concentration of hydrogen gas below the explosion limit in order to ensure the safety of the container. Then, it was considered to reduce the hydrogen concentration by using the passive autocatalytic recombiner (PAR) which is installed in the container. By the effect of PAR, hydrogen is combined with oxygen in the air which exists in the container, and steam is generated. That is, the hydrogen concentration can be reduced by PAR.

Then, a small-scale sealed container which simply simulates the shape and dimensions of a long-term waste storage container was constructed to confirm experimentally in which the sealed container with PAR is effective to reduce the hydrogen concentration. In addition, numerical analyses were carried out to predict the hydrogen and behavior in the sealed container with PAR.

From the preliminary experiments, the effectiveness of PAR for reduction of the hydrogen concentration was confirmed. Moreover, it was also confirmed from the numerical analyses that the position of PAR installed in the sealed container influences on the bonding reaction between hydrogen and oxygen. This paper describes both results of the preliminary experiments and numerical analyses.

RD-105

Experimental Study on Chemical Behavior of FP in High Temperature Region of BWR Under a Severe Accident Condition

- Component Analysis of Reaction Products Between Boron Vapor Species and Stainless Steel -

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In BWR, Boron-Carbide (B_4C) which is the control rod material melts at the severe accident and B is released to the inside of the reactor core. It has been pointed out that B affects the behavior of Cesium (Cs), such as chemically reacting with Cs. It is also important to clarify the characteristics of B for evaluating the transport behavior and accumulated distribution of Cs. It is found that the B vapor species chemically reacts with stainless steel (SS) in the high temperature region and there is a high possibility to be fixed from the results of the experiment on the transition behavior of B under the temperature condition at severe accident.

The objective of the present study is to clarify the temperature conditions where the chemical reaction of B vapor species and SS occurs. For this reason, experiments were conducted to react B vapor species with SS at various temperatures.

Experiments were conducted using the experimental apparatus for simulating fission product (FP) release behavior, TeRRa (**Te**st bench for FP **R**elease and t**Ra**nsport). In argon gas and vapor atmosphere, B_2O_3 was evaporated at a maximum temperature of 1,150 K and the retention time of 210 minutes. The evaporated B was reacted with the SS304 specimen with the dimensions of 10 mm in length, 10 mm in width and 1mm in thickness placed in each temperature region of the flow path with a temperature gradient from 800 to 1,200 K. Using the scanning electron microscope, the structure observation of the deposits on the surface and the cross section of the test piece was carried out. Component analyses of deposits on the test piece surface were performed by X-ray diffraction (XRD) and X-ray photoelectron spectroscopy (XPS).

From the present study, in the temperature range higher than at least 940 K, the SS surface and B chemically reacted and a stable Fe-B-O compound was produced. As a result, B might be firmly fixed to the surface of the SS.

RD-106

Development of a Numerical Analysis Method for Optimizing Cutting Technology of Fuel Debris by Laser Irradiation

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In decommissioning of the Fukushima-Daiichi Nuclear Power Plant, it is being considered that fuel debris which is accumulated at the bottom of the pressure vessel is picked up from the side of the pressure vessel to the outside and it is stored in a storage container. In that process, the removed fuel debris is finely cut so that it can be inserted in the inside of the storage container. This cutting is carried out by laser technique. That is, by high power laser irradiation, the removed fuel debris is cut into several pieces. Then, it is inserted into the storage container for each piece. In this case, in order to cut the fuel debris efficiently, it is necessary that the laser power and the sweeping speed are adjusted optimally. Therefore, in the present study, in order to optimally subdivide the removed fuel debris by laser irradiation, development of a numerical analysis method was performed. This paper describes the results of the preliminary simulations on the fuel debris cutting by the laser irradiation technique.

RD-107

Numerical Study on Core Degradation Behavior with TRAC and MCCI Behavior with MELCOR at Fukushima Dai-ichi Nuclear Reactor Accident

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As a part of the research on the accident at the Fukushima Dai-ichi nuclear power plant (1F), both behaviors of core degradation and molten core concrete interaction (MCCI) are numerically considered for the unit 1 of 1F. Thermal hydraulic behavior in the reactor during the core degradation was estimated using TRAC-BF1 code [1]. TRAC-BF1 is the nuclear code developed by Idaho National engineering Laboratory (INL) for the purpose of estimating transition behavior of BWR. On the other hand, melting behavior of concrete at MCCI was predicted using MELCOR code [2]. MELCOR is the nuclear code developed by Sandia National Laboratory (SNL) for the purpose of predicting complicated phenomena at a severe accident.

From the present numerical study, it was found that the core degradation can be avoided by activating the reactor core Isolation cooling Condenser (IC) installed in the unit 1 of 1F at an early stage of the severe accident. Moreover, it was predicted that the layer of the concrete corroded by MCCI is 20-30 cm.

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RD-108

Generation of Color Centers in NaCl Irradiated by Pulsed Intense Relativistic Electron Beams at Low Temperature

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1. Introduction

Radiation damage research in alkalis halides has long history and still draws attentions of researchers. Among the alkaloid halides, radiation induced point defects in NaCl yield a yellow-brown color, which are called color centers.

Recently, experimental data of color centers in NaCl are required because of geological remote sensing of planetary satellites. NaCl may exist on the surface of Europe which is the second satellite of Jupiter. However NaCl is transparent, and the optical measurement is difficult. On the other hand, Jupiter has a large magnetosphere, in which a high dose rate is expected. Hand and Carlson thought that the radiation included color centers can be detected by color filters from a probe. They proposed a hypothesis that the brown ribbons on Europa are of irradiated NaCl[1]. It is also known that the magnetic field of a planet is fluctuated. From these, we thought that NaCl could be detected if we know the time evolution of the dose rate and the color change of NaCl. Therefore, irradiation experiment of NaCl with pulsed intense relativistic electron beam (PIREB) capable of high dose irradiation in a short time is performed. In this experiment, in order to reproduce the temperature of the Europa surface, an experimental apparatus which can be cooled with liquid nitrogen was designed and tested.

2. Experimental

A PIREB accelerator, “ETIGO-III”, was used for the production of the color centers in NaCl. The PIREB with a kinetic energy of up to 2 MeV was generated using a field-emission electron-beam diode, in which a hollow cathode and a ring anode were placed in the first acceleration cell, and then accelerated by the voltage of 2MeV in the second cell.

NaCl single crystals were used as the targets and were 10×10×12 mm^3 in size. In order to reproduce the temperature of the Europa surface, targets were set inside a dewar filled with liquid nitrogen. The targets were irradiated by PIREB at 4 MeV.

Optical absorption of NaCl crystals after the PIREB irradiation was measured with an S type spectrometer. A Xe lamp and optical fibers were used to introduce incident and absorbed lights to the spectrometer.

3. Results

Figure 1 shows NaCl crystals set in a dewar, before and after the PIREB irradiation. Brownish color after the PIREB irradiation was seen. In the absorbance measurement using the S-type spectrometer, a peak of F-center was observed around 460 nm.

From these results, it can be said that the lattice defects in the NaCl single crystal irradiated with the electron beam even at low temperature equivalent to that of Europa, are introduced.

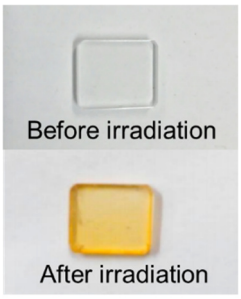

Fig.1 NaCl crystals

4. Conclusion

At low temperature equivalent to that of Europa, lattice defects occurred in the NaCl single crystal irradiated with the pulsed electron beam were observed by optical spectroscopy.

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RD-109

Study on Interaction Between Laser Ablation Plasma and Magnetic Field at Solenoid Fringe

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A laser ion source with applying solenoidal magnetic field has been expected for the driver of heavy ion inertial fusion [1]. The laser ion source with applying solenoidal magnetic field can supply a high current ion beam because of suppressing plasma expansion by the magnetic field. Previous experiments have been indicated that the ion current density increased with the solenoid magnetic field [2]. It is considered that electrons in the plasma are guided along the lines of magnetic force at solenoid fringe, and ions expansion are suppressed by the electric field generated between electrons and ions. However, it is not clear the guiding effect of the solenoidal field without fringe, that is a uniform longitudinal magnetic field, on a laser ablation plasma. The purpose of this study is to investigate the difference in behavior of the laser ablation plasma in solenoidal magnetic field with and without solenoid fringe.

In this experiment, the laser ablation plasma was generated by irradiating a copper target in a vacuum chamber with an Nd:YAG laser with a wavelength of 532 nm. The pulse width and the intensity were 16~18 ns and 10^9 W/cm^2, respectively. A solenoid with a diameter of 90 mm and a length of 220 mm was located at 30 mm from the target surface. A uniform longitudinal magnetic field was composed of the solenoid and an additional coil. The additional coil was located at 5 mm from the target in the opposite direction drifting plasma. The magnetic field of 20 mT was applied to the laser ablation plasma. The ion current density was measured as a function of plasma transport distance with a multi-Faraday cup, which was composed of four Faraday cups with apertures 1.5 mm spaced 7 mm apart. The magnetic pressure was over the plasma pressure in the measured region.

From the results, the uniform longitudinal magnetic field enhanced the ion current density as same as solenoid fringe field. On the other hand, the solenoid fringe field enhanced the ion current density compared with the uniform longitudinal magnetic field. It indicates that the solenoid fringe is more effective to suppress the plasma expansion than the uniform longitudinal magnetic field.

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RD-110

Dose Dependence on Inactivation of Aquatic Microorganism Egg in Water by Pulsed Intense Relativistic Electron Beam

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Influences on aquatic ecosystems due to aquatic microorganisms of alien species has been reported throughout the world. In previous studies, inactivation of zooplankton (Artemia Salina) and those eggs irradiated by a pulsed-intense-relativistic electron beam (PIREB) have been demonstrated[1,2,3]. Not only PIREB irradiation but also decomposition products such as OH radicals and aqueous electrons generated by PIREB irradiation in water are the main reason to inactivate the planktons. In this study, the inactivation of eggs of aquatic microorganisms in water was investigated with the various doses in the PIREB irradiation.

We used an induction accelerator “ETIGO-III”[4] to generate the PIREB. In this experiment, the PIREB irradiation was performed under the condition of acceleration voltage of 4 MV. The eggs of Artemia Salina were placed at the depths of 5.0 mm and 7.5 mm from the aqueous surface in the penetration direction of PIREB, and the radial positions were 30 mm from the center. The eggs were placed on three positions at each depth, and were set at about 100 at each position. The hatchability was defined as (number of samples incubated / total number of eggs) × 100%. Cellulose triacetate (CTA) film dosimeter "FTR-125" [5] was used for measurement of absorbed dose.

Similar to the PIREB irradiated eggs in the atmosphere, the hatchability of eggs in water irradiated with PIREB decreased with the increase of absorbed dose. In addition, it was confirmed that the hatchability of eggs in water irradiated with PIREB decreased in comparison with one in the atmosphere.

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RD-111

Development of Hydrogen Recombiners Using Porous Geopolymer

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In decommissioning of Fukushima Daiichi Nuclear Power Station, radioactive wastes with water are generated and stored in the site. Radiolysis of water in the wastes generates hydrogen. The control of the generated hydrogen is important in stable storage of the radioactive wastes. To control the hydrogen risk, a recombination catalyst which is stable over a long period of time is required. To meet this demand, porous inorganic material: geopolymer with Pt nanoparticles was proposed. Geopolymer has been named by Davidovits in 1991 [1] and is a class of polymeric materials. In this study, we investigated the supporting method of platinum nanoparticle on porous geopolymer for preparing the hydrogen recombination catalyst.

The catalyst was prepared by the following procedure. Powder of metakaoline and microsilica was mixed in a solution of potassium silicate and potassium hydroxide. Then silicon powder was added and poured in a mold. The mold was kept at 70 [^{o}C] to form porous geopolymer. The porous geopolymer was immersed in a platinum nitrate solution of each concentration, pulled up from the solution after 5 [min]. Then the porous geopolymer was heated in an electric furnace at a temperature between 300 and 500 [^{o}C] for 3 hours at atmospheric pressure. The prepared samples were characterized in scanning and transmission electron microscopy with energy dispersive X-ray analysis (SEM and TEM).

Results of EDS observations, peaks of platinum were detected. Figure 1 shows particles of platinum in a lattice image. Lattice with an interplanar distance of 2.36 [nm] is seen, which is close to that of the (111) plane in Pt(0.227 [nm]). The size of the particles was 2-3 nm, and it was confirmed that many nanoparticles existed in the sample. From these results it was expected that the prepared porous geopolymer has a hydrogen recombining capability.

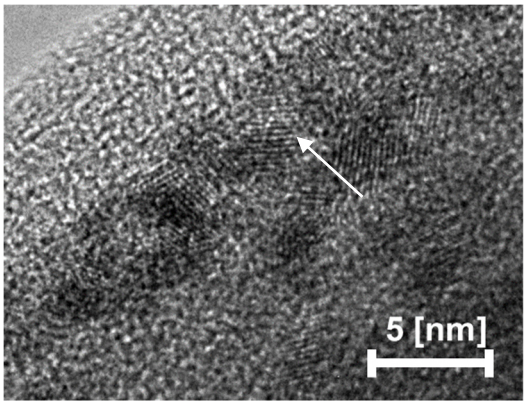

Fig. 1 TEM lattice image
A platinum particle is pointed by an arrow.

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RD-112

Development of Pulsed Diagonal MHD Accelerator Using RF Plasma Toward Low Pressure Operation

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A magnetohydrodynamic (MHD) accelerator, which can obtain large thrust with high current and responds to various missions in outer space, is expected as a next generation propulsion system. [1,2] The MHD accelerator obtains a propulsion force from the Lorentz force, which is obtained by vector product between Faraday current and magnetic field. In previous studies, we demonstrated a diagonal pulsed MHD accelerator using a model rocket engine. However, the model rocket engine has some problems such as a short operating time, an individual difference, and low conductivity of the combustion gas. To solve these problems, we develop an experimental system of the diagonal pulsed MHD accelerator using RF plasma.

The MHD accelerator consists of an RF power source, a vacuum pump, an electromagnet, an RC discharge circuit for generating pulse current, and an MHD channel with a diagonal electrode. The RF power supply provided 100 W oscillating with 13.56 MHz. To generate the RF plasma, the chamber was a pressure of 1-2 Pa with introducing Ar gas. The resistance of the generated plasma was 0.3 ohms as a time constant of pulse discharge waveform. The electromagnet was fabricated to provide a uniform magnetic field of 0.2 T to the diagonal electrode. The MHD channel was 130 mm in a length and 50 mm in a diameter. Segmented electrodes were set as four pairs along the MHD channel, and its distance was 20 mm. Diagonal angle was 22 degrees. We measured the discharge current at the upstream and the downstream of MHD channel by a current transformer. From the observation results, the discharge current waveform at the upstream was equal to one measured at the downstream. The peak discharge current and the width are 1.1 kA and 5.1 μs. To clarify the plasma parameters at the downstream of the MHD accelerator, the generated plasma potential was observed by a Langmuir probe, which was installed into 200 mm and 300 mm at the downstream of the MHD accelerator. As a result of the measurement, the plasma potentials of the two places were same, which were 1.1 kV during the pulse discharge.

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RD-113

Effects of Thermal Ageing and Irradiation on Nano Hardness of Duplex Stainless Steel

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Duplex stainless steels (DSSs) composed of both austenite and ferrite phases have good characters, and are widely used in many industries [1]. It is known that the main cause of degradation of these materials is hardening in ferrite phase by Spinodal decomposition and/or G-phase precipitation [2]. These microstructural changes are caused by both thermal ageing and irradiation. Depending on the purposes and areas, different types of DSSs with different ferrite concentration has been selected. Therefore, the degradation prediction of DSSs is different in areas.

In this study, to develop more universal degradation model for DSSs, the effects of thermal ageing and irradiation on microscopic hardness in both ferrite and austenite in various DSSs following thermal ageing or irradiation is carefully examined using nano-indentation technique.

SCS16A DSSs with various ferrite fractions — these materials were used in primary coolant pipe of nuclear power plants — were thermally aged at 400 ºC up to 2400 hours to obtain the degradated samples. Indentation hardness was measured according to ISO-14577-1 with the maximum load of 5 mN, and was converted to Vickers hardness.

As shown in Fig. 1, the microscopic hardness in ferrite was generally increased, though the one in austenite was not much change by thermal ageing. By the comparison between microscopic and macroscopic hardness, the model describing the relationship between microscopic changes and whole material has been expected.

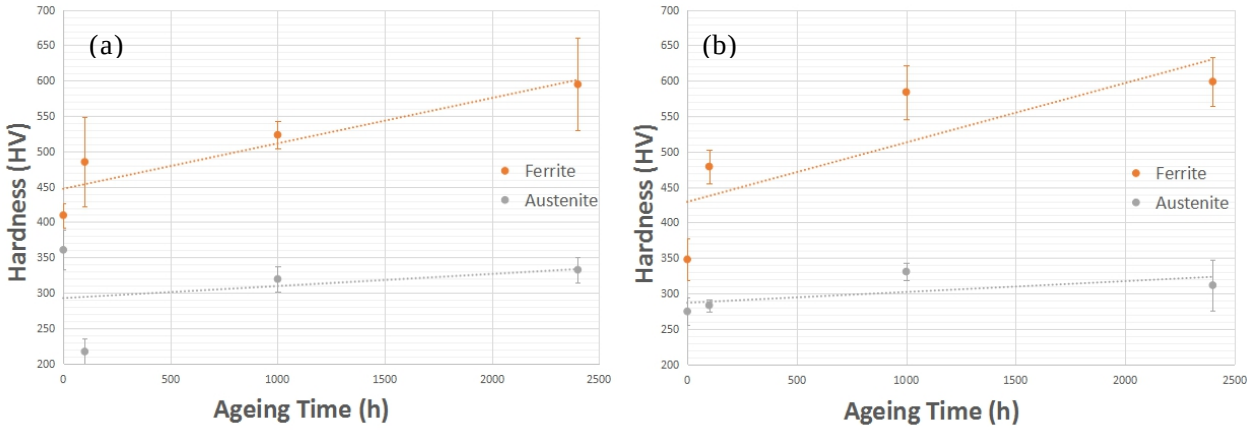

Fig. 1 Microscopic hardness in SCS16A DSSs: (a) Ferrite 29.3 %; (b) Ferrite 18.2 %

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RD-114

Education and Research on Nuclear Applications at Hanoi University of Science and Technology

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In recent years, the nuclear applications in industries are increased every year in Vietnam. Especially, the applications in medicine play an important role such as medical imaging and radiotherapy. There is a necessary for training professional people for these purposes. In the role of a leading university in Vietnam, the orientation of education and research on nuclear engineering program at Hanoi University of Science and Technology (HUST) were always met the need of the economy. Therefore, a new education and research program on nuclear applications, including medical physics, is developing at School of Nuclear Engineering and Environmental Physics (SNEEP), HUST. For education, new curriculums for undergraduate and graduate programs were constructed, consisted of 12 courses for medical physics. For research, many projects were established such as construction of radiation detector using parallel plate ionization chamber, handle multichannel analyzer, construction of industrial cone beam CT, and some other projects. However, in the hope of giving the best conditions for our students, one of the main efforts of SNEEP is that inviting experts and experienced professors from co-operated Universities (foreigner and domestic) for giving lectures and being advisors in research projects. The closed collaborations are expected to bring new breakthroughs in our research and training.

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Development of Discriminant Analysis Method on Failure Modes Relating to Damage / Fracture Modes of Functional Materials Using Support Vector Machine

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This study aims at developing a discriminant analyses method on failure modes relating to damage or fracture modes of functional materials using support vector machine. Product accidents due to damage / fracture of materials has been increasing. Such the damage/ fracture modes of materials as failure causes are often attributed to engineering changes in materials (types of materials, properties, production methods, supplier etc.). To the worse, the engineering changes in materials are sometimes intentionally conducted during manufacturing processes without noticing it to final manufacturers. Such the changes in materials should be strictly handled for product safety. We then developed a design deviation method to predict failure modes relating to damage/ fracture of materials by the changes in design / environmental conditions of products. The proposed design deviation method is composed of three steps; 1. Determination of deviation patterns in design / environmental variables in design specification, 2. Association of the deviation patterns in the design / environmental variables with the ones in stress-strength model (SSM) of materials using a prescribed association table, 3. Determination of damage / fracture modes caused by the deviation patterns in SSM, which can result in failure modes of functional parts. A case study for predicting damage / fracture modes in a laser treatment equipment demonstrated that a group using the proposed design deviation method could predict significantly much number of damage / fracture modes compared with the ones predicted by the groups using the conventional failure mode analyses methods, such as Failure Mode and Effects Analyses (FMEA) or Design Review Based on Failure Modes (DRBFM). We additionally developed a discriminant analyses method using SVM on validating failure modes relating to damage or fracture modes of materials. The discriminant analyses method could provide high discrimination rate from 77 % to 100 % for the damage / fracture modes in the cases study of a laser treatment equipment. Consequently, the proposed design deviation method and the discriminant method using SVM is effective to predict damage/fracture modes of materials regardless of experiences or knowledge of practitioners.