The utilization of the research reactors and associated facilities to support the innovative power reactor and related fuel cycle

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Abstract

Considering stable energy supply and the response to greenhouse effect of "CO_2", the nuclear power generation plays an important role and will continue to account for its present level of around 30% of Japan's total electricity beyond 2030.

To meet this request, the light water reactors (LWRs) are utilized at near term including the replacement of improved one. Furthermore it is expected to introduce fast breeder reactors (FBRs) on a commercial basis from around 2050.

To extend the lifetime of LWRs and introduce the FBRs, the experimental resolution for the ageing degradation of materials under neutron environment, upgrading the fuel performance and new materials development are so important issues. To satisfy this requirement, the effort for research and development (R&D) of fuels and materials under neutron environment is essential. This rely on facility infrastructure such as research reactors, post-irradiation examination facility and so on.

In Oarai Research and Development Center, there are some research reactors and post-irradiation examination facilities to investigate the fuels and materials for the fission and fusion reactor. That is, the research reactors are the Japan Material Test Reactor (JMTR) and the High Temperature Test Reactor (HTTR) as the thermal neutron irradiation field and the Japan Experimental Fast Reactor "JOYO" as the fast neutron irradiation field. In addition, there are four post-irradiation examination (PIE) facilities and a fuel specimen fabrication facility.

Thus, it is possible not only to fabricate the fuel specimens, examine the fuels and materials after irradiation, but also to treat and storage the radioactive waste. Besides, the research center of universities for the irradiation behavior of materials is located in the same site. Hence, Oarai Research and Development Center is able to support the research of irradiation behavior for reactor materials and upgrading the reactor fuels, effectively and efficiently.

1. Introduction

Over 30% of electricity in Japan was produced by the existing power reactor "LWR". Nuclear power has an advantage to reduce the emission of greenhouse gas "CO_2". In near future, the LWR are utilized to produce the electricity and it is planned to extend the lifetime to go up the economic efficiency and availability. To meet this technical request, the experimental resolution for the ageing degradation of materials under neutron environment and upgrading the fuel performance are so important issues.

From the viewpoint of energy resource and the reduction of environmental burdens, the innovative nuclear reactor systems are investigated in the worldwide, such as generation IV systems and INPRO (International Project on Innovative Nuclear Reactors and Fuel Cycles). In Japan, the demonstration fast breeder reactor is expected to start the operation around 2025. As one of the key technology for the realization of the fast breeder reactor system, it is important to improve the fuel performance and to develop the new materials. For this purpose, it is necessary to investigate the fuel behavior to make clear the fuel stability limit and safety margins.

The construction site of ITER was fixed at Cadarache in France last year. The effort toward the realization of fusion reactor has been done. One of the key issues to realize the reactor is to develop the materials used in severe environment. The basic research and application study of irradiation behavior for the candidate materials are conducted in worldwide.

The research reactor (RR) plays the role to figure out the degradation of materials and fuel performance, include the development of new materials. The preferability for the research of fuel performance using the research reactor should be collocated with the fuel fabrication facility for the irradiation test, post-irradiation examination facility, and so on.

In Oarai Research and Development Center (ORDC), there are three research reactors, post-irradiation examination facilities and test fuel fabrication facility to investigate the fuels and materials for innovative fission reactor and fusion Reactor.

2. The role of ORDC for irradiation research for fission and fusion reactor

The demonstration FBR will be expected to construct around 2025, and to commercialize around 2050. Until FBR cycle will come into practical use, LWRs will play so important role for electrical power generation in Japan. For this purpose it is necessary to extend the life time of power reactor. Besides, it is important to upgrade the fuel performance to go up the economic efficiency. For extending the life time of existing reactor, the understanding for the ageing effect of reactor materials under neutron environment and the optimization of fuel cycle are essential. For improving the fuel performance, it is necessary to develop the new materials and make clear the fuel behavior at high burnup including the transient condition. At present, the Zirconium alloy is used as fuel cladding, but it is difficult for this alloy to use at high burnup beyond about 60,000MWd/t. So, the effort for the development of new materials is under way.

For Generation IV system, especially FBR, fuels and materials are put into more severe environment than existing reactor. The core materials have to survive the sever condition. That is, high temperature and high fast neutron flux environment. The research to new fuels and materials is mandatory for FBR systems.

The fundamental materials research to support the development of these high performance fuels has been progressed also. Of course, these products are able to apply to fusion materials research.

The role of ORDC is to support the following items as mentioned above.

- Realization the FBR and related fuel cycle
- Extension the life time of existing plants and replacement the existing plants
- Fundamental study for irradiation effects
- Research and development for the fusion materials

That is, the role of ORDC is to provide the research field for irradiation study to meet the R&D needs for fission and fusion reactors.

3. Facilities description

There are three RRs in ORDC. that is, Japan Material Test Reactor(JMTR) and High Temperature Test Reactor(HTTR) for thermal neutron irradiation field, Japan Experimental Fast Reactor "JOYO" for fast neutron irradiation field. Four post-irradiation examination facilities are located near the RRs. These are JMTR hot laboratory (JMTR-HL), Fuel Monitoring Facility (FMF), Alpha Gamma Facility (AGF) and Materials Monitoring Facility(MMF). Plutonium Fuel Research Facility (PFRF) for test fuel fabrication and the evaluation of thermo-mechanical properties of fuels is in ORDC also.

3.1 Research reactors and irradiation technology

3.1.1 .JMTR

The JMTR is light water moderated and cooled tank type reactor [1].

The JMTR went critical in March 1968 and reached full power of 50MW thermal in January 1970. The JMTR is testing reactor dedicated to utilize for the irradiation test of materials and fuels on fission and fusion reactor. It is possible to perform the power ramping test for the fuels to study fuel integrity and safety margins.

The core of the JMTR is a cylindrical shape with 1.56m in diameter and 0.75m high, it consists of 24 standard fuel elements, five control rods with fuel followers, reflectors and H-shaped beryllium frame. The core is cooled by water at about 1.5MPa. The core inlet and outlet temperature are 49 degree and about 56 degree Celsius. Uranium-silicide is used as core fuel, its enrichment of uranium-235 is about 20% wt. The maximum power density is 425 MW/m^3.

The JMTR was operated at thermal power of 50MW by six operation cycles a year, with about 30 days a cycle. At full power operation, maximum neutron flux is about 4×10^{18} n/m^2 s for thermal neutron and about 4×10^{18} n/m^2 s for fast neutron, respectively.

The JMTR provides a wide variety of irradiation vehicle such as the capsule irradiation vehicle, the shroud irradiation vehicle, the hydraulic irradiation vehicle, etc. About 60 irradiation holes are available in the reactor core, and one third of irradiation holes can be used for instrumented capsules. It is possible for the capsule to adjust the neutron flux by the changing the loading hole. Adequate specimen's temperature during irradiation is achieved by selecting suitable irradiation holes as well as capsule design according to the irradiation purpose.

Temperature of all specimens in the capsule is controlled at the constant by the saturated boiling phenomena in the pressurized water. This capsule is used for the IASCC (irradiation assisted stress corrosion cracking) irradiation study.

Irradiation damage of material depends not only on the irradiation dose but also neutron flux and the temperature of the specimen under irradiation. Hence, Irradiation temperature control vehicle and Neutron fluence control capsule are provided to the customer. Furthermore, there are boiling water capsule (BOCA) to perform the power ramping test for BWR fuel, the hydraulic rabbit irradiation vehicle to perform the short term irradiation and so on. The example of the vehicle is shown in Figure 1.

JMTR was shut down at August 2006 to refurbish. The sophisticated irradiation vehicles will be developed at the same time. After refurbished and put the new vehicles into core, the reactor is expected to restart in 2011.

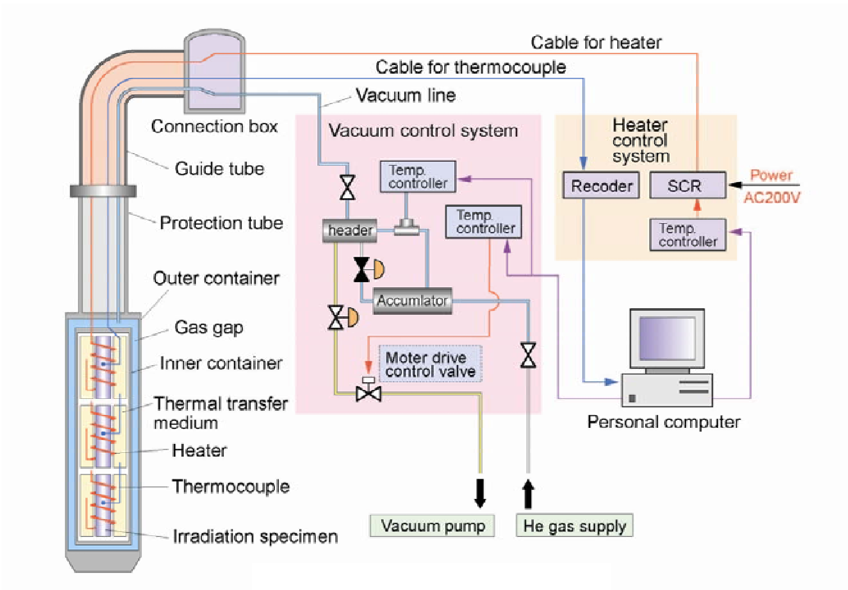

Figure 1 Irradiation vehicle for Temperature control

3.1.2. JOYO

The JOYO is a sodium-cooled fast reactor with mixed oxide (MOX) fuel. Initial criticality was attained on April 1977 with the MK-I breeder core. This core was operated at 50MWt and 75MWt. The basic characteristics of FBR were studied through the MK-I core operation.

After that, the core was modified to irradiation test bed, so-called MK-II core, and reached to first criticality in November 1982. The MK-II core with the design output of 100MWt was operated till June 2000 as the irradiation bed. To conduct the irradiation test efficiently, the core was upgraded to MK-III core with 140MWt. MK-III core went critical in July 2003. The core is divided into two regions to flatten the neutron flux distribution. The driver fuel Plutonium content is about 16% for inner core and 21% for outer core and Uraniumu-235 enrichment is 18%.

The reactor vessel is made of stainless steel with dimensions of 3.6m in inner diameter, 10m in height, and 25mm in thickness. The core is a cylindrical shape with 0.8m in diameter and 0.5m high, it contains a maximum of 85 fuel subassemblies, six control rods, reflectors and shielding subassemblies. The core inlet and outlet temperature are 350 degree and about 500 degree Celsius, respectively.

The JOYO was operated at thermal power of 140MW by five operation cycles a year, with about 60 days a cycle. At full power operation, maximum neutron flux is maximum 5.7×10^{19} n/m^2 s for total neutron and 4.0×10^{19} n/m^2 s for fast neutron, respectively.

There are two kinds of irradiation vehicles for irradiation of fuels and materials. That is, the un-instrumented irradiation test assembly and instrumented test assembly. The former are three kinds of test assemblies (Figure 2) and used the irradiation of several types of specimens, such as fuel bundle, fuel pins, fuel segments, physical-mechanical test specimens of materials and so on. Type-B irradiation test subassembly is used for irradiation of fuels and materials on early development stage. One of Type-B subassemblies is capsule type, which is used the irradiation test for the new fuels with less-information for physical-mechanical properties. The latter have on-line monitor to obtain irradiation data, such as FP gas pressure and temperature. Furthermore, the material testing rig with temperature control has been developed to evaluate the creep property under neutron irradiation.

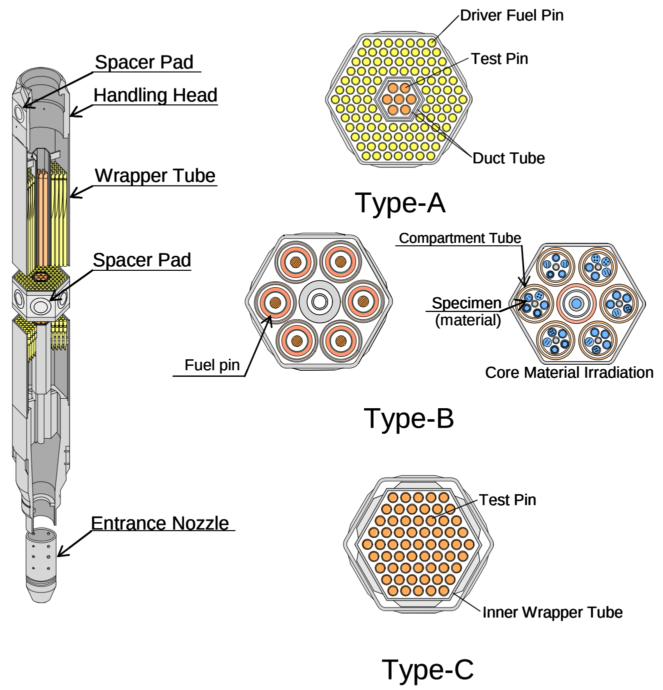

Figure 2 Irradiation test subassemblies of JOYO

3.1.3. HTTR

The HTTR is a graphite-moderated, helium gas cooled high temperature test reactor with maximum power of 30MWt. The reactor outlet temperature is set at 950 degree Celsius for high temperature test operation and inlet temperature is 395 degree Celsius. The prismatic fuel elements of hexagonal graphite blocks are used as the driver fuel. The fuel is UO_2 with the enrichment of Uranium 235 of about 6% average. It's shape is the particle covered with graphite and silicon carbide, so-called TRISO. The number of the fuel particles is as many as 14,000 particles in a fuel compact and amount o totally 109 in HTTR core.

The first criticality was attained on November 1998. This reactor is operated to establish the high temperature gas cooled reactor system technological basis in Japan.

At full power operation, maximum neutron flux is about 2×10^{17} n/m^2 s for thermal neutron and about 7×10^{17} n/m^2 s for fast neutron, respectively.

The irradiation equipment for low dose rate in-pile creep test of standard size stainless steel specimens has been developed [2]. This equipment is put into replaceable reflector region right next to the permanent reflector. Target irradiation temperatures are 550 and 600℃ for the in-pile creep test.

3.1.4. Characterization of irradiation field

The neutron flux dosimeters for JMTR used are iron (Fe-54(n,p)Mn-54 reaction) for the fast neutron flux, and cobalt (1%Co in Al; Co-59(n,γ)Co-60 reaction) for the thermal neutron flux. For the thermal neutron flux, Ti metal contained 1% Co and/or V metal contained 1% Co are occasionally used as dosimeter.

For JOYO, a dosimeter set containing of Fe, Sc, Co, Cu, Ti, Ni. Nb, Np-237, U-235 and U-238 which have reactions in different neutron energy ranges are used. The helium accumulation fluence monitor (HAFM) was used for fast reactor dosimeter to backup the activation and fission foils. The HAFM method is a technique to determine the helium production rate in materials by measuring the number of helium atoms, which were produced by helium production reaction such as the (n,α) reaction. Boron and beryllium are used as the monitor material of HAFM. This dosimeter sets are put into several locations in the irradiation vehicle to assure the reliability and accuracy of the neutron flux calculation. The accuracy of the reaction rate measurement is within 3%. The neutron spectrum at each dosimeter position is adjusted by the measured reaction rate using "NEUPAC", a J-log type spectrum unfolding cod package [3].

MCNP was used to evaluate the neutron flux at each fuel pin and specimen within the irradiation vehicles. In the MCNP calculation, whose core geometry was simulated using exact three-dimensional modeling. The compositions of each core subassembly and neutron source distribution calculated by core management code were used as the same way for DORT. JENDL-3.2 and/or ENDF/B-V cross section library were used.

The neutron spectrum for three reactors is shown in Figure 3. The fast neutron flux of JMTR is one-ten of JOYO.

The gamma heating rate is, which is so important to design the irradiation vehicle, evaluated due to measure gamma dose by calorimeters and/or thermo-luminescent dosimeters in the JMTR. Generally, the irradiation temperature of specimens is measured by thermocouples on JMTR irradiation experiment. In case of JOYO, γ-heating rate is evaluated by calculation verified by instrumented irradiation vehicle, Because of the difficulty to set the irradiation vehicle. Hence, the temperature monitors, such as thermal expansion differential (TED) monitor, silicon carbide monitor and melt wires, are used.

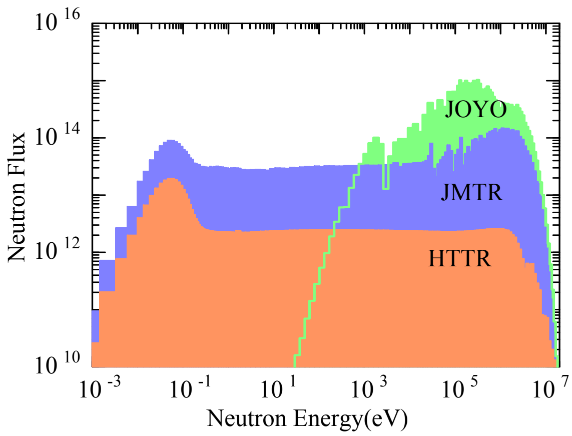

Figure 3 Neutron spectrum for JOYO, JMTR and HTTR

3.2 Post-irradiation facilities and other facility

The role of the post-irradiation examination facilities in ORDC is to carry out the post-irradiation examination (PIE) for the fuels and materials irradiated in "JOYO", JMTR and other reactors include the power reactor for the reveal the irradiation degradation of materials and the development of high performance fuels.

The outline of post-irradiation examination facilities is as follows [4, 5].

3.2.1. JMTR Hot Laboratory (JMTR-HL)

This facility building is annexed to the reactor building (JMTR). Both building are connected through a canal for transportation of irradiated capsules and specimens. The non-destructive test, such as visual inspection, Gamma scanning, X-ray radiography and eddy current test and so on, are carried out in hot cells. The destructive test, such as mechanical test, physical properties measurement and metallurgy, are also conducted. Furthermore, to meet the user’s requirement, the re-irradiation technology was developed and provided to users, which was consisted of re-assembling technique of irradiation vehicles, re-fabrication technique of specimens and advanced re-instrumentation technology for irradiated fuel rod attached a FP gas pressure gauge and a thermocouples. These are powerful technologies for better understanding of materials behavior under irradiation.

The specimens tested in this facility are fuels and materials for fission reactor and fusion reactor include commercial reactor.

3.2.2. Fuel Monitoring Facility (FMF)

The FMF is constructed to examine the fast reactor fuels and materials. The PIE for fuels and materials irradiated in JOYO is conducted, and the PIE for fuels and materials of the prototype fast breeder reactor "MONJU" is also carried out. In this Facility, non-destructive tests, such as visual inspection, profilometry, FP gas collection, gamma scanning, X-ray radiography, X-ray computer tomography (X-ray CT) and so on, are conducted. The X-ray CT is most powerful tool for PIEs. The image of fuel subassembly by this apparatus is shown in Figure 4[6]. The central void can be observed, clearly. The optical microscope inspection, the X-ray-prove microanalysis and scanning electron microscope examination are also carried out. Furthermore, the dismantling of fuel subassembly and cutting of the fuel pins to segments are done. After that, fuel segments and materials are transferred to another hot laboratory to conduct the PIE.

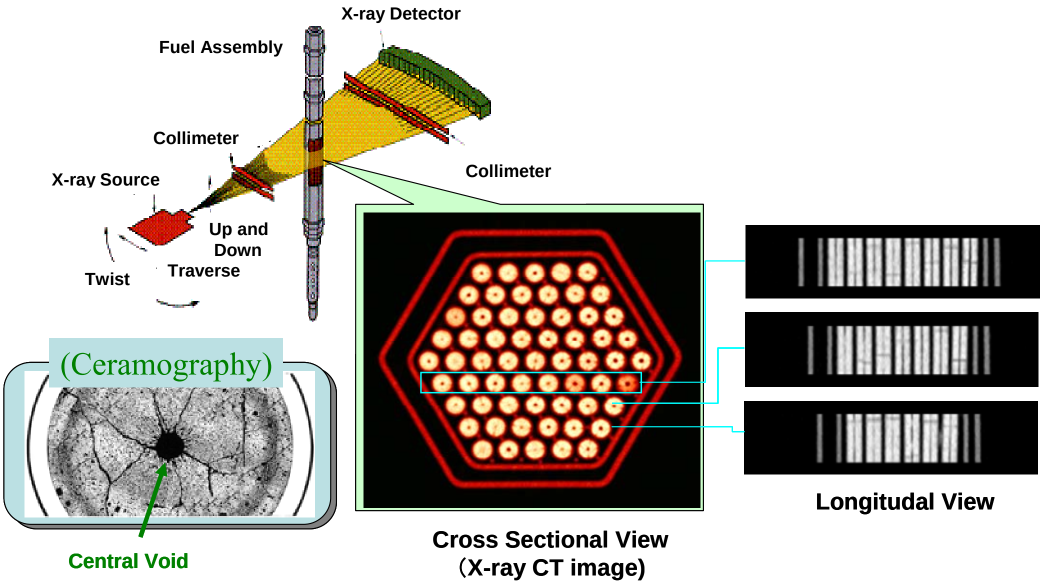

Figure 4 Image of JOYO test subassembly taken by X-ray CT apparatus
(Maximum Neutron Dose of 2.2×10^{27}n/m^2)

The examination cell is α-γ sealed type. The cell for X-ray radiography and X-ray CT are β-γ type. The atmosphere of examination cell is maintained as high purity nitrogen with H_2O and O_2 being less than 200ppm. The cell for the metallographic examination is also nitrogen atmosphere with H_2O and O_2 being less than 500ppm.

This facility has the function of reassembling of irradiation vehicle for re-irradiation in JOYO to understand the materials behavior more accurately.

3.2.3 Alpha Gamma Facility (AGF)

The main roles of this facility are to evaluate the fuel burn-up, physical property, chemical composition of trans-uranium nuclides in MOX fuel and so forth. The inner box-type cell is a characteristic in this facility, in which stainless steel movable boxes to make air tight are installed in radiation shielding such as concrete, lead, etc.

The research program to reduce the burden of geological disposal by separating long-life nuclide such as Neptunium, Americium and Curium (Minor Actinides: MAs) in spent fuels is underway. As part of this program, the MA burning experiments are also carried out. The MA containing fuels have high radioactivity, so it is necessary to fabricate the fuel by remote-handling. Therefore, it was planed to install the fuel fabrication apparatus into the hot cell in AGF. Installation of MA containing fuel fabrication apparatus was completed in 1998.The fabrication test for MOX fuel containing Am of 5% was progressed since February 2001 [7]. The short time irradiation for AGF made fuel pins in MK-III core of JOYO was completed and the post-irradiation examination is underway.

3.2.4 Materials Monitoring Facility (MMF)

The main role of this facility is to evaluate the irradiation effect for mechanical properties, physical properties, microstructural changes of reactor materials. The facility is divided into two areas, MMF-1 and MMF-2. The MMF-1 has six concrete cells and two lead cells. The one of the concrete cells is α-γ sealed type, the other are β-γ type. In the α-γ sealed type cell, the mechanical tests such as transient burst test, tensile test, etc, are conducted for fast reactor cladding materials. In the β-γ type cells, Mechanical test for structural material and metallurgy are mainly conducted. The physical properties measurement apparatus and transmission electron microscope (FE-TEM) are set in the laboratories.

The MMF-2 has four concrete cells and one iron cell. One concrete cell is divided into two parts by stainless steel wall. The half of this cell and one concrete cell are α-γ sealed type lined with stainless steel and another's are β-γ type. It is possible for two α-γ type cells to change the atmosphere of air to nitrogen. In the α-γ type cell, fuels are removed from the segmented fuel pin, and specimen preparation for mechanical test is done in the atmosphere of nitrogen. In β-γ type cell, dimensional and density measurement are performed to evaluate the swelling behavior for core materials, and mechanical test is also done for the structural materials. In the laboratory, transmission electron microscope with accelerate voltage of 400keV is provided to evaluate the microstructural evolution of irradiated core materials.

3.2.5. Plutonium Fuel research facility (PFRF)

The role of this facility is to research and development for advanced fuels such as nitride fuel, metal fuel, inert matrix fuel (ceramics with actinide oxide) and so on. The PFRF has 25 glove boxes with air atmosphere and 11 glove boxes with argon gas atmosphere (impurity levels oxygen and moisture: 1-3 ppm). In this facility, the research for fuel fabrication technology and physical and chemical property measurement such as thermal diffusivity, lattice parameter, gaseous contents, etc, is carried out to develop the advanced fuel. A small amount of Np and Am are treated to figure out the influence of MA to the physical properties of MA contained fuel.

4. Research activity using the RRs and related facilities in ORDC

The irradiation studies for the materials and fuels for existing LWR, innovative fission reactors and fusion reactor are performed by utilizing the RRs and related facilities (RR complex) in ORDC. The fundamental study is also performed in cooperative with the university researchers.

4.1. Irradiation study for LWR

For the life extension of LWR, the key issues for the fuels and materials are materials degradation under irradiation and integrity of fuel at higher burnup. The research activity for LWR is focused to make clear these issues.

Irradiation assisted stress corrosion cracking (IASCC) caused by the simultaneous effects of irradiation, stress and high temperature water environment is one of the critical concerns of structural material for LWR. To figure out this mechanism, in-pile and out-pile SCC test are carried out in high temperature water using irradiated materials. In-situ tests for the study of IASCC mechanism are underway in JMTR. These tests consist of the crack initiation test and crack propagation test, using compact tension specimens and uni-axial constant load specimens pre-irradiated. For the out-pile test, the saturated temperature capsule (SATCAP) is developed to irradiate the materials in the high temperature and high pressure water environment. After irradiation in SATCAP, IASCC tests in the high temperature and high pressure water environment are done in the JMTR-HL

To investigate the safety margin of the fuel, the re-capsule work including re-instrumentation for the fuel segments of BWR spent fuel is conducted in the JMTR-HL. This capsule is put into JMTR core and the power ramping test is conducted.

4.2. Irradiation study for FBR

The key issue is to develop the high performance fuel. Hence, new fuel cladding materials are developed and the evaluation tests are underway. One of key issues is irradiation degradation of materials at high dose and/or burnup. The irradiation is continued to reach the target burnup and /or neutron dose with interim examination once a year. Consequently, the remote technique for dismantling, assembling and reloading to JOYO was developed. This technique was applied to material reload technology to shorten the term-around for university researchers.

Up to now, a lot of irradiation vehicles suitable to the user's need are developed. JAEA keep up efforts of development for sophisticated irradiation vehicle. Recently, many users require the in-situ experiment to understand the irradiation effects more detail. The JMTR concentrate his efforts the development of irradiation vehicles for in-situ experiments. In case of JOYO, it is so difficult to perform the in-situ experiment, because of air-tight structure of his reactor vessel. The instrument irradiation vehicles are developed and already provide the irradiation experiments. The understanding of in-pile creep properties of fuel cladding for the fast reactor is so important. Tagging gas enclosure system is developed. The pressurized cladding tubes with tagging gas are irradiated in instrumented irradiation vehicle called the Materials Testing Rig with Temperature Control (Figure 5) in JOYO. The temperature and gas leak are monitored on-line.

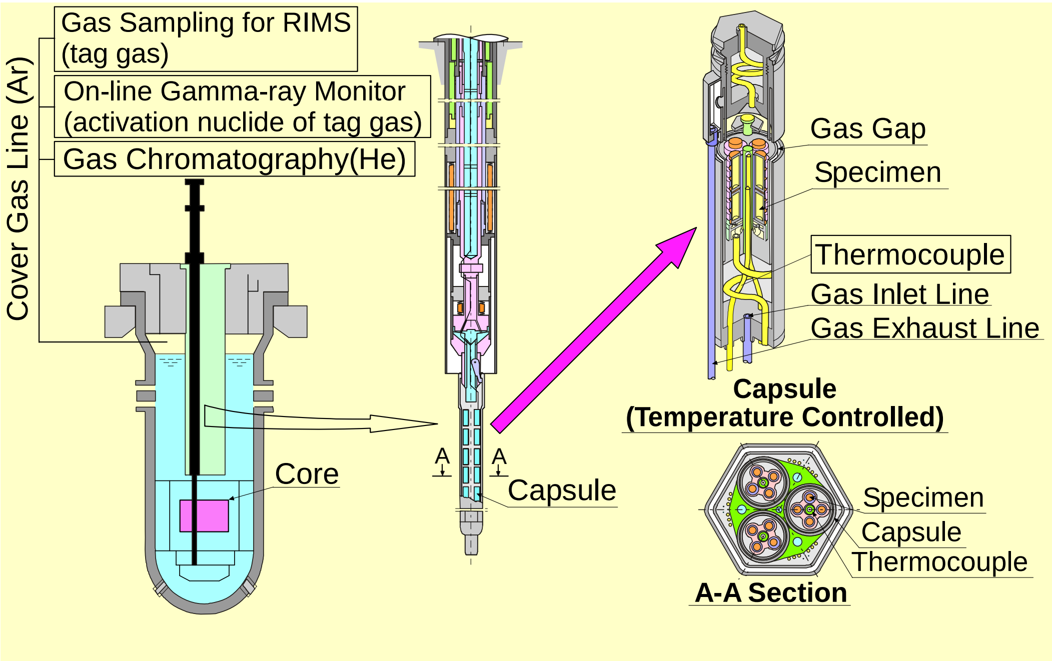

Figure 5 Materials Testing Rig with Temperature Control

One of the key issues to realize the FBR cycle is nonproliferation. So, the research and development for minor actinide (MA) containing fuel are conducted in ORDC energetically.

The remote fabrication technology for Americium (Am) containing MOX (Am-MOX) fuel has been developed in AGF. The apparatus for characterization of AGF made Am-MOX fuel are set into this facility. Am-MOX fuel pellets are irradiated in JOYO and the micro-structural observation to confirm the redistribution of Am is underway. The radio-chemical analysis for

MA-MOX fuels and MA irradiated in JOYO has been conducted also [8]. The chemical analysis revealed that a large amount of Np-237 and Am-241 are decreased by transmutation to Pu-238. As regards the research of MA transmutation under irradiation, the JAEA collaborates to Oarai branch of IMR, which has actinide laboratory [9]. From the point of view of non proliferation, the transmutation study for Np-237 to Pu-238 is also conducted [10].

4.3. Other irradiation study including the fundamental research

From the point of view of the fundamental research in Oarai branch of IMR, There are many requirements for irradiation, especially, temperature control, neutron control and in-situ experiment. These techniques to meet the user requirement are already developed and provide to the universities user. One of the examples is the neutron fluence control capsule shown in Figure 6.

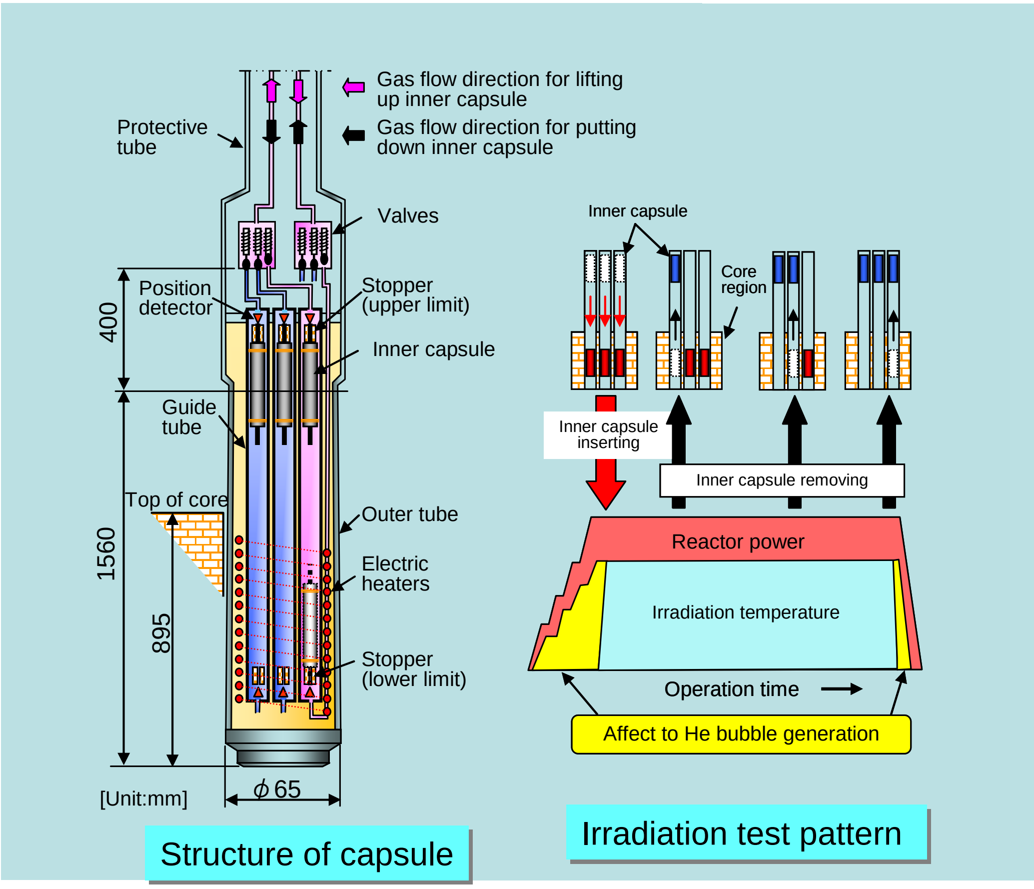

Figure 6 Neutron Fluence control Vehicle

This capsule has several small inner tubes containing specimens. These small tubes are lifted from and inserted to the irradiation position in the core at any time by pneumatic control using helium gas. By using this one, it is possible to avoid the influence of thermal and neutronic variations during start-up and shut-down of the reactor. Such test is contributing to the study of the damage mechanism.

Generation IV reactor systems are examined worldwide. One of these systems is Very High Temperature Reactor (VHTR). This system is investigated in ORDC also. The key issue is the development of high temperature materials and high performance coated particle fuels. The research and development of ZrC coating material and graphite as structural materials used to HTTR is carried out [11]. It is investigated to irradiate these materials in JOYO up to higher dose. Irradiation experiment showed the fuel fabricated in Japan is excellent performance.

Furthermore, fundamental materials research including fusion materials is in progress with collaboration to the Oarai branch of IMR, Tohoku University.

5. Future perspective

As mentioned above, there are three research reactors (RRs), four hot laboratories and a plutonium fuel research facility in ORDC. Besides, the research center of the university is in same area, which has two hot laboratories. This center is the Oarai branch of the Institute of Metal research in Tohoku University [12]. Several thousand universities persons visit to this Center to research the fission and fusion reactor materials irradiated in JMTR, JOYO and overseas reactors (see figure 7). Furthermore, there is a hot laboratory to test the surveillance specimens and high burnup fuels of LWR, which belong to private company [13]. The materials irradiated in RR can be delivered to these facilities quickly and provided the prompt implementation of examinations. After PIE, radioactive wastes are produced. These wastes are reduced it's volume and stored in the storage facilities until repository, which are located at same site.

JAEA has another research reactor (JRR-3) and hot laboratories (fuel examination facility and materials examination facility) in Tokai site, which is about twenty km apart from Oarai site [14, 15]. In addition, another two hot laboratories of private company are sited in Tokai area to test the PWR's fuels and materials [16].

Thus, there are all kinds of facilities (RR complex) in Oarai site to offer the irradiation studies. The JMTR has been utilized by other organization, but the JOYO has been used to the research of irradiation studies to complete the fast breeder reactor fuels, mainly.

Under this background, JAEA investigate to establish a comprehensive framework for advanced reactor irradiation studies in Oarai area. Of course, JAEA takes account of the Oarai branch of IMR as one of the RR complex.

It is required to establish user-friendly technology as well as software to improve the availability of RR complex. So as to realize this, the JAEA makes an effort to

- shorten the term around (duration from the specimen preparation to get the irradiated specimen)

- suit for the technical requirement of researchers
- set irradiation fee at an affordable level
- support the needs of software, such as simple irradiation procedure and technological support system to use easily

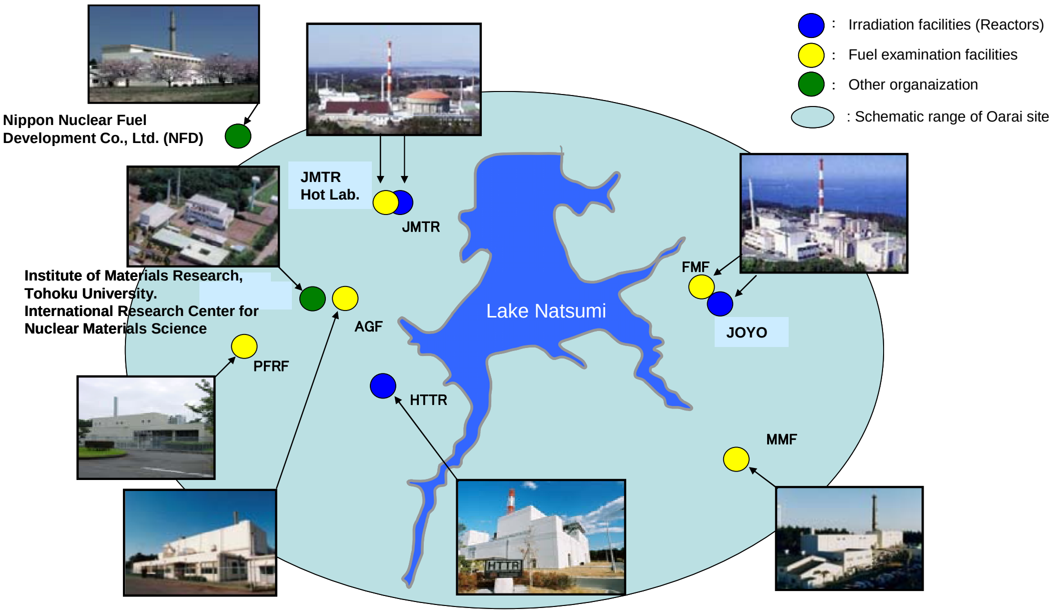

Figure 7 Irradiation and related PIE facilities in Oarai site (Research reactors complex)

The large-scale facilities such as RRs are closed year by year in Japan as well as overseas. Hence, JAEA established the system that RRs complex in ORDC are provided to external users. The utilization category is defined according to objectives of use and advertisement pattern. The facility utilization is divided into a quota for R&D and a quota for non R&D. In case of use for R&D, either a general or preferential quota for use as inter-university research is provided. The general quota is divided into a quota for disclosure and a quota for closed of R&D results. The fee of facility use is different depending on the way of utilization. As described above, the JAEA is put in a lot of work not only to upgrade irradiation technique including PIE technique but also to make facilities universally user-friendly.

On the other hand, the investigation to provide the field for training of new generation is in progress. Some university student visited to ORDC to research fuels and materials behavior under irradiation and chemical process of irradiated fuels. The training the younger generation is one of the mission of the JAEA.

6. Summary

In Oarai Research and Development Center, there are three research reactors (JMTR, JOYO and HTTR) and related facilities to investigate the fuels and materials for the fission and fusion reactor. The fundamental studies are also carried out under close collaboration with Oarai branch of IMR "International Research Center for Nuclear Material Science".

It is possible not only to fabricate the fuel specimens, examine the fuels and materials after irradiation, but also to treat and storage the radioactive waste. Hence, Oarai Research and Development Center is able to support the research of irradiation behavior for reactor materials and upgrading the reactor fuels, effectively and efficiently.

The facilities utilizing system for external users have been established to improve the applicability to external users. Now, JAEA seeks to establish it as an international center of excellence for irradiation study r related research issues.

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