Positive Achievements and Future of University Cooperative Utilization of Irradiation Test Reactor

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1. Outline of Irradiation Experimental Facility

The Irradiation Experimental Facility affiliated to Institute for Materials Research (IMR), Tohoku University was installed in June 1969, with the object of cooperative use of universities and colleges in Japan for basic research on nuclear fuels and reactor materials by using the Japan Materials Testing Reactor (JMTR) of Japan Atomic Energy Institute (JAERI) as a cooperative body. The facility is in a favored cite located in the neighborhood of both the JMTR and JOYO, the fast experimental reactor of the Oarai Engineering Center of Power Reactor and Nuclear Fuel Development Corporation (PNC) and has a hot laboratory with various kinds of test machines and equipment for post-irradiation examination. An actinides experiment installation was budged for 4-year plan in 1987 as our long-cherished desire, and its experiment building was completed 3 years later. An actinides experiment was started from the year of 1989, a laboratory of radiochemistry of metals was moved from the Sendai district to the Oarai district because of its full-scale research, a laboratory of alpha-ray emitters was installed as a detached office of the facility in the Sendai district, and the full-scale research of actinides is in full operation. The facility fulfills its function as not only in Japan but also as the only university cooperative utilization facility in the world.

At present, the facility is provided with laboratories of irradiation research on nuclear materials and radiochemistry of metals of IMR, both the clerical works and researchers efficiently perform manipulation instructions or the like of radioactive materials and experimental installations for the cooperative utilization.

The facility site rents the most suitable place adjacent to the JMTR from the JAERI. The leased land has 12,161 m^2, and the building with a total area of 5,340 m^2 consists of the research building of 989 m^2, the hot laboratory building of 852 m^2, the material irradiation research building of 216 m^2 and the actinides experiment building of 2,287 m^2. In addition, the cooperative utilization lodgings and the Tohoku University faculty lodging houses exist in Oarai Town and Onuki Town.

Facility management is carried out by a cooperative utilization committee, a facility management committee and the professor meeting of IMR, Tohoku University. Safety

management of irradiation is performed by the support of the Tohoku University Atomic Science and Engineering Committee, health consultation doctors or the like in addition to the facility employees.

The organization of the facility and the research laboratories consists of a cooperative utilization department, a research department, a service department, an administrative office and the laboratory of alpha-ray emitters, and the cooperative utilization and research activities are performed by 24 employees and 9 part-time workers (including the lodgings).

2. Positive achievement of cooperative utilization

Many researchers and postgraduate students from each university and college from Hokkaido to Kyushu come to the facility and engage in research as cooperative utilization researchers. The yearly utilization researchers reach about 1500 man-day. The ratio of material researchers to that of actinides ones is 2:1 and the actinides researchers show a yearly increase.

The research objectives of the cooperative utilization researchers placed stress on the basic problems such as light water reactors and fast breeder reactors and the related irradiation damage basic processes at the beginning of the establishment. However, at present, importance is attached to nuclear fusion reactor material irradiation research and nuclear fusion material development basic research.

Materials for research include amorphous material, oxide superconductivity material, silicon carbide or the like in addition to a variety of metals such as ferritic steel, vanadium alloy, molybdenum alloy and tungsten alloy.

Microstructures of these materials and the influence of neutron irradiation on their mechanical and physical properties are examined, solution of the irradiation damage mechanism is performed, and basic research for new material development based on the knowledge obtained is carried out. The cooperative utilization of actinides is carried out from the year of 1989. The research of actinides includes the physical properties such as the magnetic and electric properties and the superconductivity characteristics of actinides compounds and solid chemical research.

A neutron field attaches importance to cooperative utilization research laying stress on irradiation of the JMTR. A Japan-USA science cooperation undertaking was started from the year of 1982, and in the facility the initiative in the world has been taken in many JMTRs irradiation capsule technology developments by full-scale cooperation with Oarai Research Establishment of the JAERI. A number of nuclear reactor material development basic researches and international research of irradiation damage basic processes are actively performed by the cooperative utilization researchers by using the capsules. They are limited to miniaturized specimens from the year of 1984 and also utilized in the JOYO.

In addition, nuclear fusion material research gets in its stride from the year of 1980, and irradiation research such as irradiation damage behavior of 14 MeV neutron by means of the intense neutron source RTNS-II in USA as a part of Japan-USA cooperative undertaking from the year of 1982, and heavy neutron irradiation behavior in FFTF/MOTA from 1987 and dynamic behavior complex and varying environment (JUPITER program) from 1995 is actively performed in the Facility.

3. Positive achievement of cooperative utilization research in the Facility

The Facility is served to a nuclear reactor heavy irradiation cooperative utilization research for universities and colleges of the whole country. The researchers of the universities and colleges come to the Facility and perform research. Facility researchers support their research, contrive smoothness of the cooperative utilization research and carry out individual research activities.

Research, technology development and future plan in which I am currently engaged in the Facility are as follows:

[1] Advanced nuclear material development basic research and study of neutron irradiation damage

(1) Low activation nuclear fusion structural material development

1) Oxidation-resistant and irradiation-resistant vanadium alloy

Cooperative research: Faculty of Engineering, Tohoku University

Professor, Katsunori Abe

Research Assoc., Tamaki Shibayama

Graduate Student, Ichiro Yamagata

2) High toughness and high purity ferrite steel

Cooperative research: IMR, Tohoku University

Assoc. Professor, Akihiko Kimura

Graduate Student, Takuya Nagasaka

(2) Practical nuclear fusion material development by use of laser

Technology Assist., Hiroshi Shigeuchi

(Quasi Amorphous Alloy)

Fe-Cr $(Y(C_2H_7O_2)_3)$

W (Organic ZrTi compound)

Cu (Organic AlZr compound)

SiC fiber - SiC (Organic SiC compound)

Irradiation-resistant semiconductor material development for SiC fiber direct power generation

Research Assoc., Tamaki Shibayama

Undergraduate Student, Norio Taki

(3) Nuclear fusion reactor high heat flux material development

Cu (Organic Al_2O_3)

Mo-TiC TiC dispersion grain boundary strengthened material

W-TiC TiC dispersion grain boundary strengthened material

Assoc. Professor, Hiroaki Kurishita

(4) Irradiation-resistant insulating ceramic material development

In-situ measurement in nuclear reactor

Assoc. Professor, Mikio Shikama

(5) New material development by irradiation defect control and nuclear transmutation

Semiconductor material development for radiation direct conversion

(Si, SiC, and actinides compound)

(6) Acceleration irradiation of light water reactor pressure vessel

Central Research Institute of Electric Power Industry

Associate Vice President, Takeo Onchi and Kenji Doi

Toshiba Corporation

Koji Fukuya and Fumihisa Kano

[2] Functionality material development of actinides

(1) Direct power generation and hydrogen production by actinides

Research Assoc., Takuya Yamamoto

(2) Solid nuclear fusion by actinides

Research Assoc., Kenji Konashi

Part-time Instructor, Makoto Teshigawara

(3) New compound and functionality material development by high purity actinides

New compound and functionality material composed of U, Th and Np

Research Assoc., Takuya Yamamoto

[3] Nuclear reactor irradiation capsule development

Assoc. Professor, Mikio Shikama

Research Assoc., Minoru Narui

(1) Precision temperature control capsule

(2) Temperature variation control capsule

(3) Neutron spectrum constant and precision temperature control capsule

(4) Neutron flux and fluence dependence measuring capsule

(5) In-situ resistivity and optical property measuring capsule

[4] Development of post-irradiation test technology

Assoc. Professor, Hiroaki Kurishita

Research Assoc., Minoru Narui

(1) Remote operation impact Charpy test machine

(2) Remote operation miniature-specimen toughness test machine

(3) Remote operation indentation test machine

(4) Remote operation tensile and creep test machine

[5] Nuclear reactor irradiation test technology

(1) JMTR shroud irradiation installation

Rough estimate demand JAERI, Oarai Research Establishment

(2) JOYO complete temperature control capsule

Rough estimate demand

(3) HTTR shroud irradiation installation

Rough estimate demand

[6] International cooperation receiving place

Science Technology Japan and USA Cooperation Undertaking-

Receiving of post-irradiation test pieces and post-irradiation test

(1) RTNS-II and EBR-2

(2) FFTF and FBR-2

(3) HFIR and ATR

[7] Nuclear fusion material center plan

Setting of fusion technology research mechanism

4. Future plan of the Facility and future of nuclear research

The facility has fulfilled its function as the only university heavy irradiation research center in Japan since the establishment of the year of 1969. But, the Facility is not in a state to be satisfied as a research center by high energy and quite heavy irradiation specimens such as nuclear fusion. Furthermore the material post-irradiation test installation is deteriorated, and in the sub-committee of Reactors and Engineering, the Nuclear Fusion Research Liaison Committee of Science Council of Japan, it is proposed that it need be urgently kept in working order because of further promotion of fusion materials development.

Hereafter a very important point of research by the use of the Facility is nuclear fusion reactor materials research and material development basic research, RI utilization and actinides

research such as a conventional light water reactor, a fast breeder reactor and a high temperature gas-cooled reactor are integrated with the utilization of JMTR, JOYO and HTTR and a plan for performing promotion of research is being discussed.

Setting of an intense neutron source is requested by nuclear fusion material researchers because of basic solution of nuclear fusion material and irradiation behavior related to facility repairs, a rough estimate demand is limited from the budget scale, the number of personnel, or the like as the Facility affiliated to IMR, Tohoku University. It is under consideration that the Nuclear Fusion Science Laboratory will demand a rough estimate as its main body, which performs cooperative activities management and post-irradiation tests will be carried out in the Facility.

It is a policy of the Council of Nuclear Fusion that nuclear fusion material development is performed by the Science and Technology Agency, finally by the Ministry of International Trade and Industry, and universities and colleges are positioned for performing the basic research.

In regard to the practical nuclear fusion material, material enduring a severe fusion condition does not exist in the world at present, and thus nuclear fusion reactor material development requires a new creative conception in parallel to plasma technology toward realization of a nuclear fusion reactor as queen technology.

At present the USA takes the lead in low activation nuclear fusion material, in the Facility a group of the late Professor Seiji Yajima performed its basic research and conceived it, the SiC fiber/SiC composite material based on SiC fiber nicaron industrized in Japan Carbon Ltd. are being vigorously discussed. The nuclear fusion reactor manufactured by the material is being designed in the USA and Japan (JAERI). Furthermore, development of the Y_2O_3 dispersed quasi-amorphous ferritic steel by laser, in which irradiation defects have not been observed after high temperature and heavy irradiation of 400℃/560 dpa, germinating development basic research of SiC fiber production by ECR sputtering and irradiation-resistant SiC fiber/SiC composite material by laser are being performed.

5. Direction of nuclear research of the twentieth century

We will see the twenty-first century in after a few years.

The twentieth century was the golden age of science. The age of science simultaneously indicates that of material, also the age of processing of statistics and probability, and the age when a heart is obedient thereto, also an individual obey it. A means for obtaining happiness due to a number of scientific outcomes was provided, but on the contrary, it is feared that ruin of the heart, the earth environment pollution, global warming or the like will lead to danger of collapse of mankind as it is.

Particularly, in nuclear power generation technology having concentrated on the best of

big science and technology and a field of medical science for directly treating life of a man, they reach a limit of scientific technology due to statistics and probability conception. We fear that only scientific technology prospers without any consideration as it is.

In order that we may live in the twenty-first century as the happiest century, we would like to propose "individual science based on the dignity of human life".

Human life is divided into source life and organism life. The former is independently treated in philosophy and religion, and the latter is actively handled in science. However, the true nature is one, conversation of science, and philosophy and religion is realized, and a role of science is made clear as the age of the heart (consideration).

Creativity of Japan is requested on the responsibility as an economic big power from the world, and we must recognize that creation activity is in the scope of activity of the source life.

Nuclear development is impossible in enlargement of further utilization from the limit of fossil fuel, prevention of the earth warming and environment pollution or the like, and it is clear that mankind must depend on atomic power as necessary consequence. The subject is how safe it is, and whether an individual can receive it in peace of mind.