2.1 PRESENT STATUS AND FUTURE PLAN OF JMTR PROJECT

Hiroshi Kawamura, Motoji Niimi, Masahiro Ishihara, Masataka Miyazawa, Naohiko Hori and Yoshiharu Nagao

Neutron Irradiation and Testing Reactor Center, Japan Atomic Energy Agency
4002 Narita-cho, Oarai-machi, Ibaraki-ken 311-1393, Japan
kawamura.hiroshi@jaea.go.jp, niimi.motoji@jaea.go.jp, ishihara.masahiro@jaea.go.jp, miyazawa.masataka@jaea.go.jp, hori.naohiko@jaea.go.jp and nagao.yoshiharu@jaea.go.jp

ABSTRACT

The Japan Materials Testing Reactor (JMTR) of Japan Atomic Energy Agency (JAEA) is a light water cooling tank typed reactor with first criticality in March 1968. The JMTR has been applied to fuel/material irradiation examinations for LWRs, HTGR, fusion reactor and RI production. Owing to the connection between the JMTR and hot laboratory by a canal, easy re-irradiation tests can conduct with safety and quick transportation of irradiated samples. The JMTR operation was stopped in August 2006 in order to conduct its refurbishment. The reactor facilities will be refurbished during four years from the beginning of FY 2007, and necessary examination and work are carrying out on schedule. The renewed JMTR will be started from FY 2011, and be operated for a period of about 20 years (until around FY 2030). The usability improvement of the JMTR, e.g. higher reactor available factor, shortening turnaround time to get irradiation results, attractive irradiation cost, business confidence, is also discussing as the preparations for re-operation.

INTRODUCTION

The JMTR of JAEA is a light water cooling tank typed reactor. The JMTR has been used for fuel and material irradiation studies for LWRs, HTGR, fusion reactor and RI production. Since the JMTR is connected with hot laboratory through the canal, re-irradiation tests can conduct easily by safety and quick transportation of irradiation samples. First criticality was achieved in March 1968, and operation was stopped from August, 2006 for the refurbishment.
The reactor facilities are refurbished during four years from the beginning of FY 2007, and necessary examination and work are carrying out on schedule as follows.

- Aged-investigation: Primary and secondly cooling tubes and so on were confirmed as a good condition by the investigation.
- Component replacement: Control rod drive mechanism, reactor control system, primary cooling pumps, secondary cooling pumps, electric power supply system and so on, were decided to replace.
- Specific designs for component replacement; Designs were finished, and replacement components were decided from a viewpoint of future maintenance, reliability and so on.

The renewed and upgraded JMTR will start from FY 2011 and operate for a period of about 20 years (until around FY 2030). The usability improvement of the JMTR, such as higher reactor available factor, shortening turnaround time to get irradiation results, attractive irradiation cost, business confidence, is also discussing as the preparations for re-operation.

OUTLINE OF JMTR

The JMTR is a testing reactor conducted to the irradiation tests of materials and fuels. It had achieved first criticality in March 1968. High neutron flux generated in the core of the JMTR is utilized for the irradiation experiments of fuels and materials, as well as for radioisotope productions. The JMTR provides various irradiation facilities, such as many types of irradiation capsules, shroud irradiation facility and hydraulic rabbit irradiation facility.

For post irradiation examinations (PIE), irradiated capsules or specimens are transferred to the hot laboratory, which is connected to the reactor building through a water canal. Owing to the shielding capability of the water, irradiated radioactive capsules or specimens are safely transferred underwater through the canal. Cross section of the JMTR and hot laboratory are shown in Fig.1.

The reactor pressure vessel, 9.5m high with 3m in inner diameter, is made of low carbon stainless steel (SUS304L) and is located in the reactor pool, which is 13m deep. The control rod drive mechanisms are located under the pressure vessel for easy handling of the irradiation
facilities and fuels in the core.

The core of the JMTR is in a cylindrical shape with 1.56m in diameter and 0.75m high made up of 24 standard fuel elements, five control rods with fuel followers, reflectors and H-shaped beryllium frame.

Cooling water in primary cooling system is pressurized at about 1.5MPa to avoid local boiling in the core during power operation.

The heat generated in the core is removed by the cooling water in the primary cooling system. The cooling water flows downwards in the core and transfers the heat from the core to secondary cooling system through heat exchangers. The heat transferred to the secondary cooling system is removed away into the atmosphere in cooling towers. Cutaway view of reactor is shown in Fig.2.

The JMTR is utilized for the basic and the applied researchers on the fuels and materials of fission reactors and fusion reactor, and also utilized for radioisotope productions. Power ramping tests for the nuclear fuels are also performed to study the integrity and safety of the fuels.

Test specimens irradiated in the JMTR are transferred to the hot laboratory for the PIE. The data obtained are used for the development of nuclear fuels and materials as well as safety assessment of the LWRs.

Radioisotopes produced in the JMTR are widely utilized in the medical treatment, industries and agriculture [1-3].

START OF NEW JMTR

The reactor facilities are refurbished during four years from beginning of FY 2007, and the operation of new JMTR will start in FY 2011.

The usability improvement of the JMTR

The usability of the JMTR will also be improved to be attractive to users, shown as follows.

1. Achievement of the reactor available factor from 50% to 70%.
2. Shortening of turnaround time to get irradiation results earlier.
3. Realization of more attractive irradiation cost in comparison with other testing
reactors in the world.

(4) Establishment of more simple irradiation procedure and more satisfied technical support system.

(5) Guard of the business confidence by perfect information control, etc.

As for the item (1), the possibility of reactor scram by the accident will be decreased by the replacement of reactor components as described above. In addition, even if the failure of components occurs, the repairing the failed components will also become easier. These will shorten the time of out-of-operation. Actually, The JMTR has already had a experience of high capability of operation, that is more than 180 days in a year in two times. Then, the replacement of old and unreliable components leads the higher capability of operation. Furthermore, optimization of the overhaul time of the reactor defined once per year by the Japanese regulation will take longer operation period during one year. Items from (2) to (5) are now under discussion taking users requests into consideration.

Target of new JMTR

(1) Proposal of Attractive Irradiation Tests

Proposal of attractive irradiation test will be carried out by advanced technologies such as new irradiation technology, new measuring technology and new PIE technology. Cooperation with various nearby PIE facilities, surrounding the JMTR, is also under discussion in order to extend the capability of the PIE.

(2) Establishment of International Center

Construction of the research base utilized internationally as an Asian center of testing reactors is now under consideration. In Asian area, some excellent testing reactors are operated, such as HANARO in Korea, OPAL in Australia. Each of these reactors has individual and original characteristics, and can take supplementary role in each other.

(3) User-Friendly Management

User-friendly management must be established by above-mentioned improvement on usability of the JMTR. The technical support system for users will be established from the support by specialists of irradiation technology and irradiation research, such as specialists of reactor fuel and reactor materials. The users will be able to discuss sufficiently on the detail irradiation method with these specialists at the planning stage of irradiation. This is an
example of the improvement of the usability easy to use for many users due to the fulfillment of the technical support system.

**Expected roles of new JMTR**

As described above, the JMTR will be refurbished by the replacement of old-designed components and development of new irradiation facilities. Also, the usability is planned to be improved. As for these improvements, the following roles are expected on the new JMTR.

(1) Lifetime Extension of LWRs
   - Aging management of LWRs
   - Development of next generation LWRs

(2) Progress of Science and Technologies
   - Development of fusion reactor materials and developments
   - Development of HTGR (High Temperature Gas cooled Reactor) fuels and materials
   - Basic research on nuclear energy, etc.

(3) Expansion of Industrial Use
   - Production of silicon semiconductor for hybrid car
   - Production of $^{99}\text{Mo}$ - $^{99m}\text{Tc}$ for medical diagnosis medicine

(4) Education and training of nuclear scientists and engineers

Above expected role of the new JMTR is shown in Fig.3. The new JMTR is planned to contribute the worldwide research fields and industrial fields by playing these important roles.

**REFURBISHMENT OF JMTR**

Refurbishment of the JMTR is promoted by two projects, "replacement of reactor components" and "construction of new irradiation facilities".

**(i) Replacement of reactor components**

The replaced components are decided from the accumulated experience/knowledge through these forty years operation. Aged or old-designed components of control rod drive mechanism, reactor control system, primary cooling pumps, secondary cooling pumps, electric power supply system and so on, will be replaced by present-designed ones. For example, the circuits of reactor control system and process control system which consist of a huge amount of
relays and soldered wirings will be replaced by present-designed integrated circuits.

As for un-replacing facilities, for example heat exchangers, pressure vessel, secondary cooling towers etc, safety review was carried out from a view point of view of the aging. Their long-term operation in future has been certified by this investigation.

By these replacements aiming at the safe/steady reactor operation, the failure possibility of each component will be decreased, and the failed component will be able to repair promptly. This leads improvement of the rate of reactor operation in future.

Replacement of reactor components is shown in Fig.4 and component replacement schedule is shown in Fig.5.

(ii) Construction of new irradiation facilities

New irradiation facilities, i.e. irradiation test facilities of materials and fuels, production facilities for silicon semiconductor and medical radioisotopes, will be installed in the JMTR.

- New material and fuel irradiation tests

Irradiation test facilities of materials and fuels are now being developed and will be installed in the JMTR during a shutdown period of about 4 years until 2010 with requirements from both regulatory and development uses of LWRs for the purpose of the long term/up-graded operations.

Requirements are addressed on high performance of LWRs, e.g. power up rating, longer operation cycles and modified water chemistries for lifetime extension of the power plants to obtain evaluation data of fuel and materials under irradiation conditions. To meet one of these requirements, an irradiation capsule with larger test section with large sized specimen of reactor materials is now being developed to investigate the scale effect on the IASCC behavior. A new type of a power ramp test facility is also under development to provide the constant surface temperature of fuel rod specimen during a boiling transient. It is planned to realize the linear test-fuel power by controlling the pressure of surrounding $^3$He gas screen, absorber of neutrons.

- New irradiation facility for industrial purpose

Present development plan of irradiation facility for industrial purpose includes the development of irradiation facility for production of silicon semiconductor. Target of the development is to establish the irradiation facility of large sized silicon ingot with 8 inches in diameter which meets the trend requirement of the field of hybrid cars and so on.

Another plan is to provide the $^{99m}$Tc for medical use. The hydraulic rabbit irradiation
facility, which is well developed and already used in the JMTR irradiation, can be applied. Now, investigation of production performance and costs estimation are being carried out [4].

CONCLUSIONS

The JAEA considered that the JMTR is a testing reactor supporting the basic technology of the nuclear energy, and decided the refurbishment of the reactor facilities during four years from FY 2007; operation of the new JMTR will be started from FY 2011.

In the same time, irradiation facilities corresponding to the user needs, such as Nuclear and Industrial Safety Agency, will be installed in the JMTR to contribute the lifetime extension of LWRs by the user’s fund. Additionally, the contribution to the development of the ITER and the industrial use etc., are under discussion in the JAEA.

In the practical use of the JMTR, the JAEA will promote the expansion of the JMTR utilization, and will improve the usability (e.g. improvement of the reactor available factor, shortening of the turnaround time, achievement of the attractive irradiation cost, establishment of the satisfied technical support system, retention of the business confidence) taking account of the opinion obtained from external experts such as “the JMTR user’s committee”, “the Council for Science and Technology Policy” and so on.

REFERENCES

Fig. 1 Cross section of JMTR and hot laboratory.

Fig. 2 Cutaway view of reactor.
Fig. 3 Expected role of the new JMTR.

Fig. 4 Replacement of reactor components.
<table>
<thead>
<tr>
<th>system</th>
<th>FY</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactor control system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exhaust system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power supply system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boiler system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purification system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Green: Specification design, fabrication and replace works, inspections etc.

Fig.5 Component replacement schedule.