Research Reactor Design for Export to Myanmar

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1. Introduction

Myanmar is striving to acquire the innovative technology in all field areas including maritime, aerospace and nuclear engineering. There is a high intension to construct a new research reactor for peaceful purposes.

The Ministry of Science and Technology (MOST) and Ministry of Education (MOE) are the important government organizations for Myanmar's education and they control most of institutes, universities and colleges.

The Department of Atomic Energy (DAE), one of the departments under MOST, leads research projects such as for radiation protection as well as radiation application and coordinates government departments and institutions regarding nuclear energy and its applications. Myanmar's Scientific and Technological Research Department (MSTRD) under MOST guides researches in metallurgy, polymer, pharmacy and biotechnology and so on, and acts as an official body for Myanmar industrial standard.

The Department of Higher Education (DHE) under MOE controls art and science universities and colleges including research centers such as Asia Research Center (ARC), Universities Research Center (URC), Microbiology Research Center and so on and does to expand research areas and to utilize advanced technology in science.

The wide use of radiation and radioisotopes is developed in Myanmar especially for the field areas such as Medical Science and Agricultural Science. Co^{60}, $I^{131}$and $Tc^{99}$are the major use of radioisotopes in diagnosis and therapy. In Agricultural Science, H^{3}, C^{14}, C^{60} etc are used to provide biological effects of radiations on plants, radio-isotopic study of soil physics and tracer studies. [1, 2, 3]

2. Design Requirements

2.1 General requirements

According to aforementioned several situations, Myanmar should have a research reactor for the purposes:

- To develop Nuclear Reactor Technology
- To establish Nuclear Engineering Departments
- To produce radioisotopes for the use of radiations widely in several field areas
- To apply nuclear energy peacefully in future.

2.2 Basic Design Principles

The basic design principles of Myanmar Research Reactor (MRR) should be as follow:

1) multi-purpose research reactor, and
2) non-proliferation and economical reactor.

2.2.1 Multi-purpose reactor

MRR is essential now for

- education and training of personals for the future establishment of department of nuclear engineering in Myanmar universities,
- radio-isotope production for current needs in medical science and agricultural science and for future needs in industrial application, and
- recent need in neutron activation analysis in many areas.

2.2.2 Non-proliferation and Economical Reactor

It is essential for the developing countries like Myanmar from the safety and economic point of view that reactor and fuel should be highly proliferation resistant during their application and also at their disposal stage. Economical and reliable supply of enriched uranium fuel is another essential requirement.

2.3 Core Design Goals

The design goals of MRR would be

- 10 MWth Small power reactor in open-tank-in-pool type
- Natural Circulation LWR system with heavy water reflector
- Passive emergency cooling with enough safety margin
- Use of digital technology in control and safety system.

3. Reactor Fuel Options

3.1 Metal Fuel Options

Nowadays, the application of high density Low Enrichment Uranium (LEU) for research reactor is sought for in worldwide. There are many fuel candidates, not only uranium compounds but also uranium Alloys, were introduced by several fabricators. Of these, U_3Si_2 is excellent one and U-Mo draws interest from the nuclear society of several countries due to its advantages which are possibility of high density and waste reduction, and easier to reprocess as well as longer cycle length than U_3Si_2. [4, 5]

3.1.1 Rod Type Fuel Elements

Although the manufacturing technique of rod type fuel is well proven, it has some disadvantages such as limiting on temperature, weak mechanical strength and so on.

3.1.2 Plate Type Fuel Elements

It has high performance than rod type and good mechanical strength. However, it is needed research and development in manufacture processes for some future candidates, e.g. U-Mo. [6, 7]

3.2 Ceramic Fuel Core Option

Ceramic fuels such as UN and UC have advantages of high heat conductivities and high melting points. However they are more prone to swelling than oxide fuels and are much less well understood.

3.2.1 Uranium Oxide Ceramic Fuels

A uranium oxide ceramic is formed into pellets and inserted into Zircaloy tubes that are bundled together. It is widely used in LWRs.

3.2.2 ThO_2-UO_2 Fuels

Thorium fuel concept was proposed due to its advantages such as high natural abundance, improving fissile fuel utilization for thermal reactors and decreasing production of plutonium isotopes as well as long-lived radioactive waste. [8]

The heterogeneous ThO_2-UO_2 option is used for longer cycle length rather than other options such as homogeneous ThO_2-UO_2 and annular duplex pellet options. This fuel has better proliferation resistance. [9]

4. Core Design Options

Concerning with core design options, various reactor core options were analyzed. Some candidate options are described as follow.

4.1 HANARO Type Core

HANARO is a 30 MWth open-tank-in-pool type reactor that uses LEU fuel pin assemblies. Shape is very conventional for multi-purpose use. [4, 5] However, core arrangement should be complex to adopt many control devices and irradiation holes. Fuel assemblies with fuel pins does not have enough thermal margin in case of high density fueloptions.

4.2 JHR Type Core

JHR is a 100 MWth mlti-purpose tank pool reactor and a new material-testing reactor in Europe. Fuel elements used in JHR are also U_3Si_2 and U-Mo. [6, 7]

They proposed many flexible arrangements of fuel elements either in hexagonal shape core or in daisy shape core. Fuel elements consist of cylindrical array of curved fuel plates and central holes either for control rods or irradiation port.

4.3 OPAL Type Core

OPAL (Open Pool Australian Light-water) reactor is a 20 MWth multipurpose research reactor that uses low-enriched uranium-silicide fuel plates with aluminum cladding. Core is made of clusters of flat fuel plates which make very high neutron flux level [10]. However, this core shape is not good for having a central beam port and irradiation holes.

5. Future Works

Through a simple approach of design requirements, core design options were analyzed. Then it would be continued to investigate nuclear core design with detail analysis on fuel performance and safety. Maximization of flux level is not essential for MRR, proliferation resistance will be the major concern for fuel material choices. It is expected that ThO_2-UO_2 fuel with homogeneous and heterogeneous layout is most suitable for Myanmar from this point of view. Because of design flexibility, JHR type core will be adopted.

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