REFURBISHMENT AND MODERNISATION OF PUSPATI TRIGA REACTOR: LESSONS LEARNT

Z. MASOOD*, M. F. ZAKARIA, I.A. HUSSIN
Reactor Technology Division, Malaysian Nuclear Agency,
Bangi, 43000 Kajang, Malaysia

*Corresponding author: zarina@nuclearmalaysia.gov.my

ABSTRACT

The PUSPATI TRIGA Reactor first became critical in June 1982, and has been in operation since then. Over the years, several of the reactor systems, structures and components (SSCs) experience ageing and obsolescence problems and had to be refurbished, replaced or modernised. Initially refurbishment or replacements were carried out with SSCs of equivalent quality or capability. Subsequently SSCs were replaced with higher specification to allow for future upgrading of the reactor. Features of new SSCs should include all features of SSCs to be replaced and consider human machine interface to avoid any incidents. Lessons learnt over the years have been applied to the reactor control console modernisation project. In this project the involvement of our personnel during the design, fabrication and testing stages will enable us to have the capability to solve any associated problems with minimal vendor involvement. The close cooperation between regulators of Malaysia and vendor country was also beneficial to ensure that the project meet international safety standards

1. Introduction

The PUSPATI TRIGA Reactor (RTP) is located at the Malaysian Nuclear Agency in Bangi, Malaysia. It first became critical on 28 June 1982 and has been in operation since then. This TRIGA Mark II reactor as well as the fuel elements was purchased through a tripartite agreement between the Governments of Malaysia and United States of America and the International Atomic Energy Agency. The main purpose of the only research reactor in Malaysia is for conducting research and training of staff and students. In addition, this reactor receives about 3000 visitors annually and is part of the nuclear technology awareness programme carried out by the Malaysian Nuclear Agency.

RTP is a 1 MW pool type reactor that uses 19.9% enriched uranium zirconium hydride as fuel. The reactor core sits at the bottom of a 6.5m aluminium tank and has 127 locations for positioning fuel elements, control elements and irradiation facilities. The coolant and moderator is light water and absorber is boron carbide. The reactor and core are shown in figure 1

Throughout more than 30 years operation, the reactor systems, structures and components (SSCs) experienced ageing problems and obsolescence of components and parts. Several refurbishment and replacement projects have been carried out over the years and lessons learnt were incorporated in current and future modernisation projects

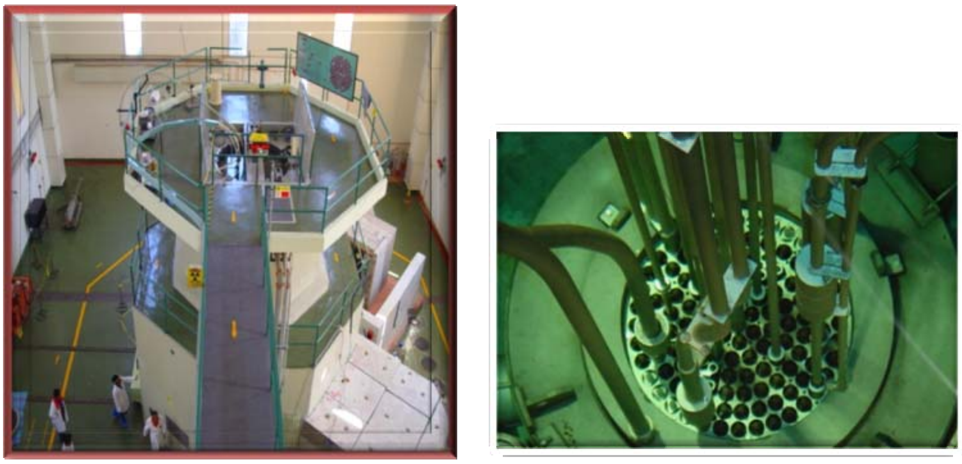

Figure1: PUSPATI TRIGA Reactor and View of Core
.

2. Refurbishment and Modernisation Projects

The refurbishment, replacement and modernisation projects at the reactor are listed in Table 1 [1]

Year	System or Component	Type of Work Done
1986	Rack & Pinion Gear (Rotary Rack)	Repair
1989	Primary Pump	Repair, added 2 new units
1992	Pneumatic Transfer System (PTS)	Replace in-core terminus
1994	Heat Exchanger	12 tubes plugged
1995	Secondary Cooling System	Cooling Tower replacement
1999	Active Ventilation System	Refurbishment (Nov 99 -Jun 2000)
2010	Primary Cooling System	Replace primary pumps, install 2 plate type heat exchanger and SCADA
2012-2014	Reactor Control Console	Modernisation – Change analog system to digital system

Table 1: Major refurbishment, replacement and modernisation projects

These projects can be broadly divided into 3 phases as follows:

Phase 1: Refurbish or replace with similar feature
Phase 2: Replace with enhance feature/capability
Phase 3: Replace with new feature/capability – modernisation

2.1 Phase 1: Refurbish or Replace with Similar Feature

Initially, SSC's that were found to malfunction were repaired or replaced with components of the same or similar features or capabilities. This was carried out because replacement parts were available and easy to purchase. Early projects such as replacement of the in-core pneumatic transfer terminus, replacement of cooling towers and refurbishment of the active ventilation system can be categorised in this phase. There was minimal involvement of the reactor staff in the specification of design requirements as there were no new features incorporated in the design.

2.2 Phase 2: Replace with Enhance Feature/Capability

The second phase of the refurbishment of SSC's, incorporated some enhance or new features or capabilities. This is due to the advancement of available technologies and the requirements of enhanced safety features. The upgrading of the primary cooling system in 2010 saw the replacement of the tube and shell type heat exchanger with a more efficient plate type heat exchanger. An extra plate type heat exchanger was added in expectation of future reactor power upgrade project. Features such as capability for remote switching of primary pumps and heat exchanger (including sequential opening of valves) from the control room and the ability to monitor the water temperature, flow rate, pH and conductivity via the SCADA control and monitoring system, were added.

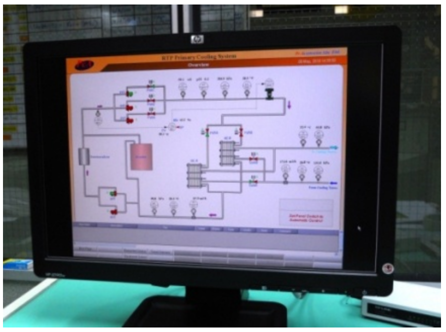

Fig 2: New Plate Type Heat Exchanger and SCADA system

This project required careful consideration since the replacement of the primary cooling system is safety significant. There is a higher level of involvement of reactor staff in defining the technical and safety requirement of the new system as well as during the installation and commissioning stage.

2.3 Phase 3: Replace with New Feature/Capability - Modernisation

The replacement of the original analog control console with a digital control console is the third phase. The analog control console was facing ageing and obsolescence problems as it frequently failed and parts could not be purchased. Some components used in the console were manufactured in the late 1970's or early 1980's. A decision to modernised the control console was taken and funding was finally received for the 2011-2015 financial cycle.

A detail technical specification had to be developed as the control system is completely new and the reactor staff was unfamiliar with the requirements. It was decided that the reactor protection system will still be 'hard-wired' or analog, while the data acquisition and control system will be digital. New control rod drive assemblies were also required so that it will be compatible with the digital console. New features such as reactor trip switches installed on the reactor top and reactor hall, seismic monitors, reactor water level monitoring system and enhanced fuel temperature monitoring system were added. Human machine interface was also considered during the design.

A vendor was sourced that was willing to co-develop the reactor control system and train the young engineers during the design, fabrication and testing stages. These young engineers will also be capable of carrying out maintenance and repair work with minimal vendor involvement.

This is a major replacement project and is safety significant, hence, the national regulator had to be informed and authorisation to implement the project must be received. Since this is the first of a kind project undertaken by both the reactor operator as well as the regulator, assistance of the regulator from the vendor country was sort.

The new digital control console has been installed and is currently undergoing test. It is scheduled to be commissioned and fully operable by the end of 2013.

3. Lessons Learnt

In the early days of the reactor operation, the refurbishment or replacement of failed systems or components were straight forward as the same components or parts were available and can be sourced easily. As the reactor aged, more components or parts became obsolete and difficult to source as there was lack of support from the original vendor and there were no local manufacturers capable of replicating the components or parts.

Safety requirements also changed and the reactor systems and components had to be upgraded. This required the re-assessment of which systems or components needed to be replaced or modernised. The availability of sufficient funding is also crucial in implementing such projects.

Most of the original reactor staff have retired or left the department. Hence, the recent replacement and modernisation projects were managed by young engineers with the advice of a few senior reactor staff. In order to be self-reliant in the future, these young engineers need to be involved in the design, fabrication and testing stages of the projects. This will enable us to manage the maintenance, trouble shooting and repair work without depending on the vendor. Fortunately, a vendor for the modernisation of the reactor control console was found that was willing to assist us in our endeavour to be self-reliant.

The modification of safety significant reactor systems, structures or components are subjected to the approval or authorisation of the national regulator since the reactor is licensed under the Malaysian Atomic Energy Act, 1984. The installation, testing and commissioning phases of the control console modernisation project need separate authorisation. Hence, close cooperation between the reactor operator and national regulator is required so that the project can be implemented according to schedule. The national regulator has also acquired the assistance of the regulator from the vendor country to assess the safety documentation and carry out joint inspection. This is essential so that the project is implemented according to international safety practice.

4. Conclusion

Refurbishment, replacement and modernisation of the PUSPATI TRIGA Reactor have been carried out in phases and according to experience gained over the years. New safety requirements require the reactor to be re-assessed and additional features have to be included in the design of new systems and components. Future projects will incorporate the lessons learnt over the years so that we will be self-reliant in the design and maintenance of SSC's. Close cooperation with the regulator is also important so that all the regulatory requirements are met and project implemented on schedule.

5. References

[1] Z. Masood, A. Bokhari, M.S. Kassim, 2009. Modernization and Refurbishment of the TRIGA MkII Research Reactor at the Malaysian Institute for Nuclear Technology Research, presented at the IAEATechnical Meeting on Modernisation and Refurbishment of Research Reactor, Delft, Netherland.

[2] Nuclear Malaysia, 2010. Commissioning Report of RTP Primary Cooling System, NUKLEARMALAYSIA/L/2010/34