Ageing Management Program of Kartini Reactor for Safe Operation

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Abstract
This paper discusses the regular inspections of the Kartini reactor tank liner as part of the ageing management program. Kartini reactor is located in Yogyakarta, in Indonesia. The aim of the regular inspections is to assess the reactor tank condition as part of the ageing monitoring program to ensure safe operation of the reactor. The reactor was inspected utilizing a series of non-destructive inspection methods between 2001 and 2006. One of the inspection results was the detection of two swelling features seen on the bottom of the reactor tank. Kartini reactor has been in operation for 28 years and the observed swelling has been monitored over the past 5 years. The regular measurements and observations show that the swelling has stopped increasing in size and has now reached a stable size. After assessment and analysis of the cause of the swelling the reactor is considered to be in good condition and safe for future operation.

Key words: Ageing management program, Kartini reactor

1. Introduction

Kartini reactor has been in operation for 28 years (first critical in 1979). This reactor is one of the research reactors which is operated by BATAN (National Nuclear Energy Agency of Indonesia). Kartini is an example of the TRIGA MARK II family of reactors and is an open pool reactor with a reactor power of 100 KW. The reactor tank is constructed from 1050 aluminium (99.5% pure Al) and is 6 mm in thickness. In order to assure and maintain the safe operation of the reactor, and ageing management program has been implemented. This program involves maintenance, monitoring and in service inspection of the systems, structures, and components of the Kartini reactor such as: reactor tank liner, reactor core support structure, instrumentation and control systems, irradiation facilities, heat exchanger tubes, etc. This paper discusses the implementation of ageing management program for Kartini reactor tank liner through inspection activities. Inspections have been conducted since 2001 up to 2006 by BATAN personnel under supervision of IAEA experts. One of the inspection results was the observation of two swelling features seen on the bottom of tank. Although swelling has occurred on the bottom of the reactor as a consequence of ageing the rate of swelling of these features has decreased and the features are now stable in size. Careful analysis and assessment of the root causes of the swelling indicate that they do not present a threat to future safe operation of Kartini and the reactor is considered to be in good condition and safe for continued operation. The implementation of this ageing management program through regular scheduled inspections will ensure that the reactor tank will remain safe for operation throughout its service life.

2. Inspection History

Inspection to the reactor tank was conducted firstly in 2001 during major shutdown by using a series of non-destructive inspection methods, such as: visual, ultrasonic thickness, dye penetrant testing, hardness surveys, and replication of features of interests. Through visual inspections indicated that the tank has only minor defects. The two swelling features seen on the bottom of tank indicated as S1 and S2 could not be examined in detail due to shortfalls in equipment capability. At that time they were not considered to be a serious issue for future safe operation. The wall thickness was predominantly in original condition of approximately 6 mm. A few thickness data reading were found to be low (less than 5 mm), however, the origin of these low readings is uncertain and were considered to be variations due to the original manufacturing process. Replication of the surface defects indicated that the defects that were observed were a minor nature and are not of concern from a safety perspective. A small crack (6 mm long) was detected by dye penetrant technique in the weld metal of the upper belt. The crack was examine more closely by replication technique was analyzed and will not cause fracture. This defect was an original manufacturing defect caused by a hot tear from the welding process and was confined to the weld cap. Hardness values were consistent with published data and only minor neutron damaged has occurred. In general, the inspection results in 2001 revealed that the Kartini reactor tank is still in good and safe condition for continued operation [1].

Then under IAEA TC Project INS/9/022, in 2004 BATAN received new inspection equipment. An under water camera video scope for visual inspection and ultrasonic testing equipment to measure wall thickness were obtained. In December 2004 and July 2005 by using this equipment, a more detailed re-inspection to the reactor tank was conducted. Inspection concentrated on to the areas of interest such as the swelling areas to obtained more detailed images and measurements to allow a better assessment of these features. Kartini reactor license expired in November 2005 and one of the license renewal requirements was to demonstrate to BAPETEN (Nuclear Energy Control Board) that the reactor was safe for future operation and an operating license could be issued. Therefore re-inspection to the reactor tank using visual, ultrasonic and replicas were conducted again in December 2005 and September 2006.

3. Method

Non-destructive inspection methods were utilized in the period between 2004 and 2006 using visual, ultrasonic thickness, and replication techniques. Visual inspection was utilized to assess the general condition of reactor tank liner. Ultrasonic thickness measurement was used to obtain the thickness of the tank wall and tank bottom. To provide the swelling profile such as height and areas of swelling, a replica technique using dental putty was applied. This technique is one of non-destructive inspection method which can be applied in dry or wet conditions and can also used to measure accurately the dimension of defects and the surface profile. The principle of this technique is to make an impression of the surface to be examined using dental putty. The result of the first impression is called the negative replica, by using the first impression as a mold for the second impression, an accurate copy of the original surface is produced and is a model of the swelling feature that is to be measured.

To obtain a negative replica of the swelling on the tank bottom of Kartini reactor, a manipulator and a fitting to contain the dental putty is lowered into reactor tank and guided by video scope to the correct position on the swelling area. The replication putty is held in position until it sets in a few minutes. Then the manipulator was brought up, and its negative replica is released from the jig. A positive replica is then made of the negative replica as detailed above. Detailed measurement of the swelling profile be obtained measure the height and area of the swelling. Height gauge is used to make these measurements [2,3].

4. Results and Discussion

Thickness data readings of the wall at various locations were obtained and these ranged between 5.3 mm 5.5 mm. Thickness measurement on the swelling areas of S1 and S2 on the tank bottom were found to be between 5.3mm and 5.5 mm indicating that the metal thickness in the areas of swelling was similar to the wall thickness and to the original metal thickness [2,4].

Thorough visual inspection indicated that the defects in the reactor tank were minor and it was observed that the swelling profiles on the bottom tank of Kartini reactor were reaching a finite size based on examination of past readings.

Data related to the areas of swelling areas and height of the swelling from inspection results made in December 2004, July and December 2005 and September 2006 are tabulated in Table 1 [3,5]. Figure 1 shows the measurement of swelling height as a function of time. Figure 2 shows the graph of S1 and S2 swelling areas (a) and height (b) as a function of time. Data presented in the Table 1 shows that the swelling area and height had grown slowly in size and became relatively stable (grow has ceased). Taking into account the remaining thickness of the aluminium at the swelling location the swelling could not be accounted for by the formation of corrosion products from aluminium due to the low "Pilling-Bedworth ratio"for aluminium [4]. The occurrence of the swelling was analyzed as an ageing consequence. It is obvious that some localized pressure is being exerted on the outside of the aluminium tank liner to create the swelling. Root cause analysis of swelling problem has been discussed more detail in the reference [6].

TABLE 1: AREA and HEIGHT OF SWELLING [3,5]

Area of Swelling S1 (in mm^2)				Area of Swelling S2 (in mm^2)			
Dec. 2004	July 2005	Dec. 2005	Sept. 2006	Dec. 2004	July 2005	Dec. 2005	Sept. 2006
1365.07	1380.17	1389.40	1404.59	1082.78	1749.00	1839.08	1839.67
Height of Swelling S1 (in mm)				**Height of Swelling S2 (in mm)**			
Dec. 2004	July 2005	Dec. 2005	Sept. 2006	Dec. 2004	July 2005	Dec. 2005	Sept. 2006
7.72	7.72	7.78	7.78	7.00	7.49	7.56	7.59

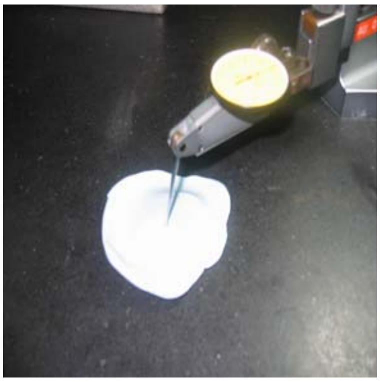
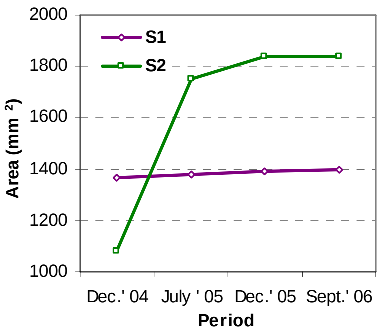
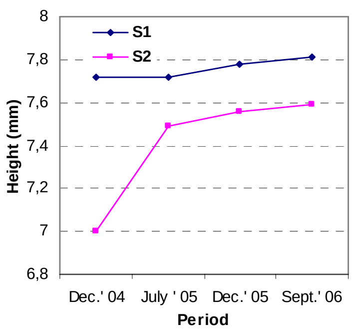


FIG.1.
Measurement of Swelling Height



(a)



(b)

FIG.2.
The Graph of Swelling Areas of S1 and S2 (a) and Swelling Height (b)

5. Conclusion

Although swelling has occurred on the bottom of the reactor tank as an ageing consequence of the component after 28 years of operation, the swelling has shown to have stopped and has reached its minimum extent on these features. An inspection regime has been established for Kartini reactor to monitor the condition of the reactor tank and so ensure that the reactor is in good condition and safe for continues operation. Swelling areas will be monitored every 3 months utilizing visual equipment and every 6 months utilizing replica and ultrasonic techniques. A comprehensive inspection will be conducted every 5 years. Thorough regular inspections to determine the condition of the reactor tank will be conducted.

Over the past 5 years regular inspection have provided data that has allowed a prediction of the tank condition extending into the future and has demonstrated the benefits of in-service inspection and maintenance to ensure continued safe operation of the reactor.

In November 2006 Kartini reactor received a new 4 years operating license from the BAPETEN.

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