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The Status of the Damaged Fuel Assemblies in HANARO

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1. Introduction

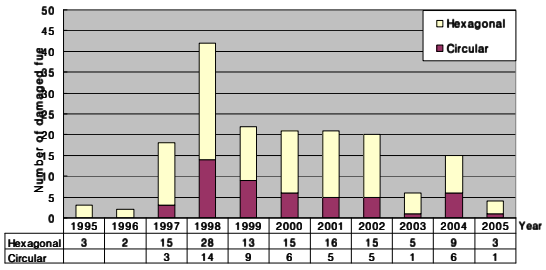
Research reactor HANARO, has been operated successfully from the 1st reactor operation cycle in 1995 to the 39th cycle in 2005. During that period, 297 fuel assemblies were used and they are stored in the spent fuel storage pool. Among them, 51 circular fuel assemblies and 123 hexagonal ones experienced mechanical damages of their parts due to flow induced vibration.

This paper describes that the status of the damaged fuel investigated in HANARO reactor since 1995 and the cause of the damage and some countermeasures to prevent a recurrence.

2. The Status of the Damaged Fuel Assemblies and the Cause Analysis

2.1 The status of the Damaged Fuel for each Year

Figure 2.1 shows the damaged fuel for each year. The number of damaged fuels at the beginning of the reactor operation in 1995 and 1996 was only 5 hexagonal fuels. Those arose from reactor operators' carelessness and mismanagement. In 1997, it was confirmed that 3 of the circular fuels and 15 of the hexagonal fuels were damaged severely through the visual inspection.



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Hexagonal	3	2	15	28	13	15	16	15	5	9	3
Circular			3	14	9	6	5	5	1	6	1

Figure 2.1 Status of the Damaged Fuel for each year

As it can be seen in Figures 2.2 and 2.3, the major damage of the hexagonal fuel assemblies was a corner pad of the spacer wore out ear and cut 77 % which were occurred by a fretting after the primary pump runs about 100 days. In the case of the circular fuel assemblies, 40 % of the damaged fuels appeared that slot for the bottom guide at BEP (Bottom End Plate) was enlarged. Most of these damages were caused by the FIV (Flow Induced Vibration) in the fuel channels [1-3].

The total number of damaged fuel in 1998 was 42, which was 14 circular fuels and 28 hexagonal ones. This was the highest record by then. The reason was that the total power produced in 1998 was increased more than 50 % when compared with 1997 and the operation time was also increased 13 %. This made an increase of the primary pump running time and the fuels loaded in the reactor core were more influenced by the FIV. To solve the wear problems by the FIV, the design of the fuel was changed through a wear and a strength test and loaded from the end of 1998. In result of using the approved hexagonal fuel, the fuel damage in 1999 was obviously decreased to less than 48 % when compared with the previous year, even though the primary pump running days increased from 115 days to about 160 days in average.

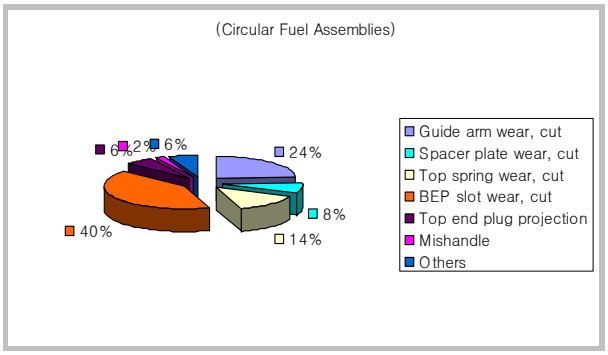


Figure 2.2 Distribution Chart of the Damaged Fuel Assembly

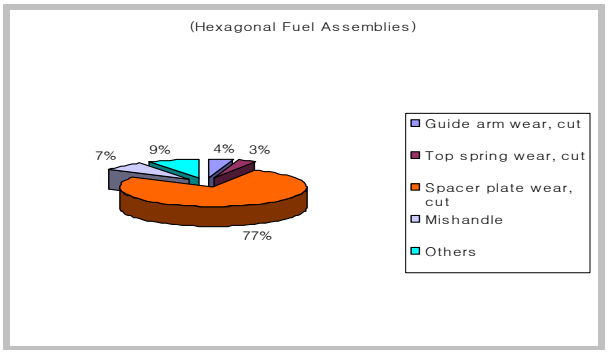


Figure 2.3 Distribution Chart of the Damaged Fuel Assembly

In case of the circular one, the design has been changed for the BEP slots, the spacer plates and the spacer tube. In spite of improving fuels, the hexagonal fuel assembly was still observed a wear of the spacer and cut of the inner web of the spacer caused by the wear out of the pin of the fuel elements and the bottom guide arm was separated from the circular fuel assembly. It was a different defection from the former ones. The

3rd design change of fuels was performed. The results of the changed fuel design in 2003, the damages were decreased more than 70% when compared with 2002. The design of the spacer in the hexagonal fuel assembly was modified and one of the top-spring of the circular one was changed in 2004. Also, the old fuel assembly has been repaired at KAERI from 2003 and then used in 2004.

2.2 The Cause Analysis of the Damaged Fuels

There are 3 kinds of the causes of the damaged fuel assemblies. First, the fuel assemblies were damaged due to a FIV in the fuel channels. The types of the damages were cut of the rod tip, wear of the TEP/BEP, wear and bend of the spacer, expansion of the guide arm slot of the BEP [4]. The most damaged part of the circular fuels was the wear and cut of the BEP slot as shown in Figure 2.2. On the fuel rod fixing on BEP by TIG welding, a space between a bottom guide and slot of the BEP is created by shrinking of BEP. This space make the bottom guide arm become loose. To solve the problems of the FIV, the fuel component design have been changed in such a way to have more vibration-resistance.

Second, the fuel was damaged by the fuel handling tool [5]. There are three fuel handling tools in HANARO, which lengths are 13 m, 8.9 m and 7.4 m. These were made by stainless steel and had been used until 2000. In the case of the damaged fuels caused by the fuel handling tools, they occurred due to a breakaway of the top guide, a bending of the central rod and a dropping down of the fuel when being moved by the fuel handling tool. To solve those matters, the fuel handling tool was changed as follows:

- The material of the fuel handling tool was changed to aluminum Al 6061 and its weight was reduced by 60 % approximately.
- The diameter of the bottom of tool was changed from 55 mm to 46
- The ball lock jam was solved as changing the locking method.
- A spring balancer was modified to sense the abnormal weights and to give the various alarming sounds according to the weights.

Third, the damages were occurred by the reactor operators' mishandling of the fuel assembly. The incidents were mainly occurred in the initial stage of the reactor operation. For example, dropping the fuel down was occurred because the operator didn't confirm the status of the locking of the fuel handling tool. This problem could be solved by training and education of the procedures.

3. Conclusions

- In order to solve a FIV, the design of fuel assemblies have been changed four times.
- In order to make up for the defections of the fuel handling tool, four things had been changed such as a material with aluminum, diameter of the tool bottom, lock/unlock method of the bottom guide and a redesign of the spring balancer.
- The handling of the fuel assembly by the reactor operators was successfully accomplished through the up-to-date procedures and related education. In addition, the new reactor operators who are very good at handling tools for the fuel assembly should be educated most of the reactor operators are getting aged.

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