Development of Hydride Neutron Absorber

Hydride neutron absorbers have been proposed to be used in Fast Breeder Reactor. Demonstration of pellet fabrication have been successfully done. Irradiation behavior of hydride materials were tested in the fast experimental reactor, JOYO.

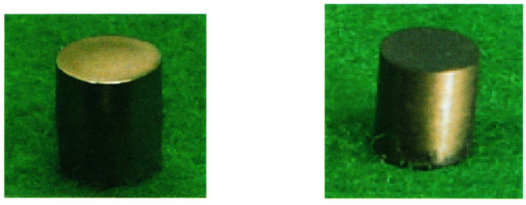
A metal-hydride has very high hydrogen atom density, which is equivalent to that of liquid water. Fast neutrons in nuclear reactors are efficiently moderated and are absorbed in the metal-hydride. The Hf hydride and Zr-Gd hydride are considered as neutron absorber in FBR (Fast Breeder Reactor).

The development program of hydride neutron absorber was started in Jun 2006. It was accepted as an innovative nuclear research and development program of Ministry of Education, Culture, Sports, Science and Technology of Japan. The program was accomplished in March 2009.

In this study the core design is performed to examine its characteristics and to evaluate cost reduction effect. One of the major R&D items of the present the program is development of hydride pellet, which is used in the reactor core[1]. Figure 1 shows the Hf hydride pellet and Zr-Gd hydride pellet. The slight barrel-shaped transformations were observed, since the pellets were expanded by hydrogen absorption. The transformations can be removed by grinding their sides [2,3].

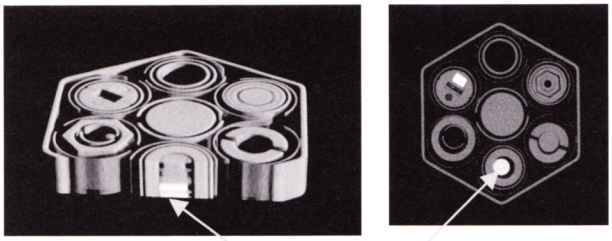
Irradiation test of hydride neutron absorber was conducted in the fast experimental reactor, JOYO, at Japan Atomic Energy Association (JAEA), where Hf hydride disks and Zr-Gd hydride disks were irradiated with neutron fluence of 2.92×10^{21}(n/cm^2) (E>0.1MeV) and 3.25×10^{21}(n/cm^2)(E>0.1MeV) for Hf hydride ones and Zr-Gd hydride disks respectively. Irradiation temperatures are 590°C and 580°C for Hf hydride disks and Zr-Gd hydride disks, respectively. After irradiation, the capsule containing of the hydride disks was tested by X-ray CT Inspection method (Fig.2). The result show that the capsule was irradiated with keeping it's integrity. The chipping and the cracking of the disks were not found in the hydrides.

After the non-destructive examinations, the capsule was cut for sampling of the irradiated hydride disks for destructive examinations; measurement of weight, metallographic test, X-ray diffraction test, measurement of thermal diffusivity. No swelling was found in the disks. Figure 3 shows the results of thermal diffusivity test. Thermal diffusivity data of un-irradiated sample (blue diamond symbols) are also plotted in Fig.3 for comparison with irradiated data (red rectangular symbols). Figure 3 shows that no effect of neutron irradiation on thermal diffusivity of Hf hydride. This is the first experimental result of thermal diffusivity of irradiated Hf hydride. In the case of oxide (e.g. UO_2), it is well known that the thermal diffusivity decreases with the increase of the accumulated neutron irradiation dose because of radiation damage. The present results of thermal diffusivity of irradiated Hf hydride are noteworthy.



Hf hydride pellet　　Zr-Gd hydride pellet

Fig. 1 Hydride neutron absorber pellets



Hf hydride disk

Fig. 2 X-ray CT image of irradiated capsule

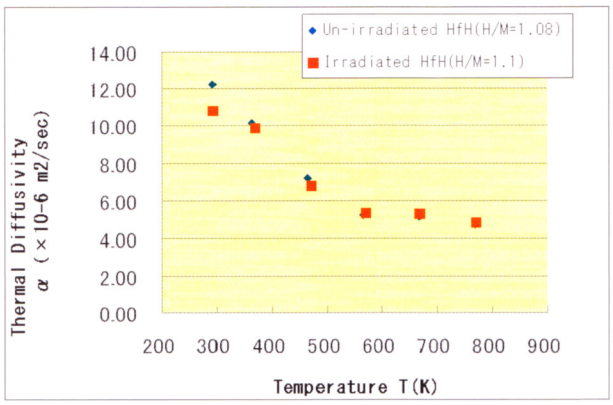


Fig. 3 comparison of thermal diffusivity data of irradiated Hf hydride disk with un-irradiated one

References

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Key Words

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