Effect of recycled U_3O_8 powders on doped UO_2 pellets property

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1. Introduction

To reduce the fuel cycle costs and the total mass of spent light water reactor (LWR) fuels, it is necessary to extend the fuel discharged burn-up [1]. Extending the fuel discharged burn-up, while enhancing the safety features is one of the major challenges to nuclear energy industries because it can reduce the maintenance and fuel cycle cost [2]

Research on fuel pellets focuses on increasing the pellet density and grain size to increase the uranium contents and the high burn-up safety margins for LWRs. KAERI has developed a doping technology to increase the density and grain size of UO_2 pellets. In this technology, the 1000ppm of additives were used and the grain size of UO_2 pellets was increased up to 50μm. This grain size is about 5 times larger than that of commercial UO_2 pellet.

In a commercial UO_2 fuel pellet manufacturing process, defective UO_2 pellets or scraps are produced and those should be reused. A common recycling method for defective UO_2 pellets or scraps is that they are oxidized in air at about 450 ºC to make U_3O_8 powder and then added to UO_2 powder. In the oxidation of a UO_2 pellet, the oxygen propagates along the grain boundary. The U_3O_8 formation on the grain boundary causes a spallation of the grains. So, size and shape of U_3O_8 powder deeply depend on the initial grain size of UO_2 pellets. Since the grain size of doped UO_2 pellet is quite larger than that of commercial pellet, it is expected that the shape and size of U_3O_8 from large grain sized pellets are somewhat different to those from conventional pellets.

In this study, the effect of U_3O_8 powders on the doped UO_2 pellet property was examined. Two kinds of U_3O_8 powders which have different size to each other were prepared. Those U_3O_8 powders were mixed with doped UO_2 powders and sintered into pellets. Density and grain size evolution of pellets with increase of U_3O_8 contents were evaluated and compared.

2. Experimental

Mixed powder of $MnO\text{-}Al_2O_3$ additive and UO_2 was prepared. Total amount of Mn-Al in the powder mixture was 1000ppm in weight. Two kinds of U_3O_8 powders were prepared. ADU UO_2 powders larger than 150μm and Mn-Al doped UO_2 pellets were oxidized to U_3O_8 powders at 450^{o}C in air, respectively. The initial grain size of the Mn-Al doped UO_2 pellet was about 40μm.

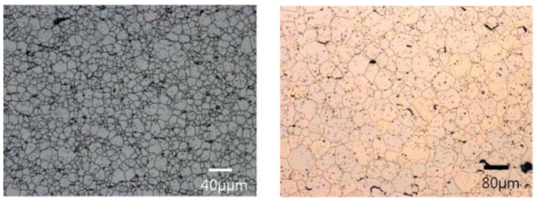
0~10wt% of those U_3O_8 powders were added to MnO-Al_2O_3 –UO_2 powder mixtures and then mixed for 24h with a tumbling mixer.

Final powder mixtures were pressed into green pellets and then sintered powder sintered at 1730 ºC for 4 h in flowing H_2 gas.

The sintered density of the pellets was measured by a water immersion method. The pellets were sectioned axially, ground and polished. The polished pellets were thermally etched at 1290 ºC in carbon dioxide gas in order to examine their grain boundaries. The pore and grain structure were examined by an optical microscope and grain size was determined by a linear intercept method.

3. Results

Fig. 1 shows the typical grain structure of sintered pellets. This figure clearly showed that the grain structure was greatly altered by the origin of U_3O_8 powder in the powder mixture. The grain size and density were decreased considerably in the UO_2 pellet which was fabricated by using the powder mixture of UO_2 with the U_3O_8 obtained by oxidation of large grained UO_2 pellet.



(a) (b)

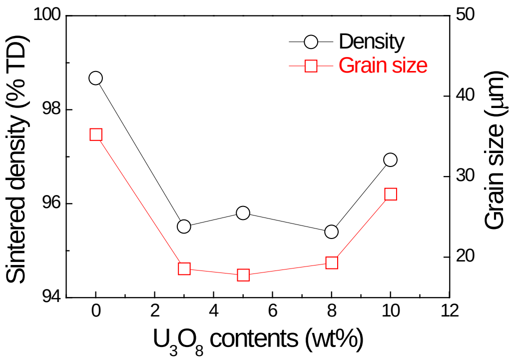
Fig. 1. Effect of U_3O_8 powders on the grain structures of sintered pellets: The U_3O_8 powders originated from (a) UO_2 sintered pellet, (b) powder.

Fig. 2 shows the density and grain size change according to initial U_3O_8 contents in UO_2 pellets. The density and grain size of the UO_2 pellet which was fabricated by using the pellet-oxidized U_3O_8 powder was shown in Fig. 2 (a). The density and grain size decreased due to the addition of U_3O_8 powder. It could be thought that a sinterability of the powder mixture was degraded by the pellet-oxidized U_3O_8 powder.

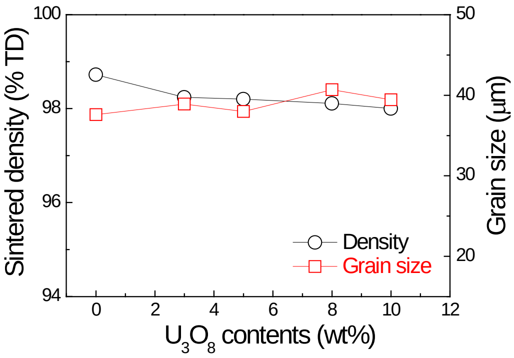
On the other hand, the density and grain size of UO_2 pellet which was produced by using the powder-oxidized U_3O_8 powder hardly changed (Fig. 2 (b)).

Two kinds of U_3O_8 powders have a different size to each other. The particle size of powder-oxidized U_3O_8 powder is lower than that of pellet-oxidized powder.

Therefore, it can be thought that there is a difference of specific surface area between pellet-oxidized and powder-oxidized U_3O_8 powder. The siterability of powder mixture would be affected by these differences.



(a)



(b)

Fig. 2. The density and grain size of Mn-Al and U_3O_8 doped UO_2 pellet: (a) pellet-oxidized U_3O_8 doped, (b) powder-oxidized U_3O_8 doped.

4. Conclusions

The effect of U_3O_8 powders on the doped UO_2 pellet property was examined. The UO_2 pellet was fabricated by using two kinds of U_3O_8 powders which have different size to each other. And then, the density and grain size change of fabricated pellets were investigated.

In the results, the powder-oxidized U_3O_8 powder hardly affects the sinterability, but the pellet-oxidized U_3O_8 powder degraded the sinterability. Therefore, in the recycling of U_3O_8 powder, it can be concluded that the powder-oxidized U_3O_8 powder is more profitable.

ACKNOWLEDGEMENT

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