원심분무법에 의한 U-10wt.%Zr 합금분말의 미세조직
Microstructure of Centrifugally Atomized U-10wt.%Zr Alloy Powder

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1. Introduction

Either TRU-Zr metal alloy or (TRU-10wt.%Zr)-Zr dispersion fuel is considered as a blanket fuel for HYPER(Hybrid Powder Extraction Reactor). In case of dispersion fuel, the particles of TRU-10wt.%Zr metal alloy are dispersed in Zr matrix. Blanket rod is made of sealed tubing containing actinide fuel slug in columns.

Two computer codes, MACSIS-H for the alloy type fuel and DIMAC for the dispersion type fuel, have been being developed for the fuel design. In order to increase the accuracy of the simulated results, material properties and fuel performance data are required. Although there are lots of experimental data on the metallic fuel of U-Pu-Zr and U-Zr, they are for the fuel types having Zr fraction less than 20wt%. Therefore, few data are available for the HYPER system fuel in which Zr fraction is higher than 30wt%. The basic material properties of Uranium were assumed to be very similar to those of TRU. A simulated fuel using Uranium instead of TRU was fabricated and tested to produce the required basic material data for the HYPER system fuel design.

In this work, as a basic study to fabricate dispersion-type (U-Zr)-Zr fuel, we investigated characteristics of rapidly solidified U-10wt%Zr powders.

2. Experimental procedure

Uranium lumps with purity 99.9% and zirconium sponges were induction-melted in a graphite crucible coated with a high-temperature-resistant ceramic. The molten metal was fed through an orifice onto a rotating graphite disk in an argon atmosphere. In order to obtain the desired size distribution and shape, the atomization parameters, such as feeding rate of melt, revolution speed of disk, etc., were adjusted. The atomized powder was collected in a container at the bottom of the funnel shaped chamber.

Powder size distribution of the atomized powder was classified by sieve analysis. The density of powder according to particle size was measured by Archimedean immersion method. The morphology and microstructure of the powder according to atomized particle size were

characterized with a SEM (scanning electron microscope). The phases of as-atomized powder were analyzed by X-ray diffraction, using the Cu Kα wave length.

The atomized powder was cold pressed to about 80% of theoretical density, and then hot extruded to 8-mm-diameter rod at 1073K. The microstructure of (U-10wt%Zr)- 50wt.%Zr fuel was also investigated.

3. Result and discussion

The characteristics of U-10wt%Zr alloy powder solidified rapidly by the centrifugal atomization process has been examined. The results indicate that most of atomized U-10wt%Zr alloy powders have a smooth surface and frequently near-perfect spherical shape with few attached satellites. All phases of atomized powder are found to be α-U phases and δ-UZr_2 with fine and homogeneous structure, and as powder size decreases, these phases are much finer owing to high cooling rate. The density of atomized U-10wt.%Zr powder decreases slightly as the particle size increases. This is due to the increased frequency of internal pores. During the extrusion, U-10wt.%Zr particles are dispersed in Zr matrix by mechanical work, and they are broken and torn into harder Zr matrix.

4. Conclusions

(1) Most of the atomized U-Zr powders have a smooth surface and generally near-perfect spherical shape with few attached satellites.

(2) Atomized powders are found to be α-U phases and δ-UZr_2 with fine and homogeneous structure, and as powder size decreases, these phases are much finer owing to high cooling rate.

(3) During the extrusion, U-10wt.%Zr powders are dispersed in Zr matrix by mechanical work, and they are broken and torn into harder Zr matrix.