The Effect of Sintering Time on the Sinterability of UO_2-6wt%Gd_2O_3

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1. Introduction

Gadolinia(Gd_2O_3) is an efficient neutron absorber and widely used as a burnable poison in most nuclear power reactors[1,2]. Higher content Gd-bearing UO_2 fuels are needed to meet the high burn-up and the longer cycle operation.

UO_2 powder needs a milling treatment like a ball-milling to improve a flowability of powder. Especially, in the case of binary oxide, such as a (U, Gd)O_2 pellet, an adequate homogenization step for binary oxide powder mixture is necessary because it influences not only the compactability and sinterability of the powder mixture but also the homogeneity of the microstructure in the mixed oxide pellet and hence, the powder milling technique[3-5] has been widely used in this area. Also fission gas, which was produced in the pellets during the reactor operation, can be retained effective within the pellets. Therefore larger grains and larger pores in the microstructure of (U,Gd)O_2 sintered pellet need to release fission gases as low as possible from the irradiated pellets.

In this work, the effects of sintering time and admixed content of poreformer on the sinterability of UO_2-6wt%Gd_2O_3 are investigated.

2. Methods and Results

ex-DC UO_2(U-235 : 2.0 wt%) powder and Gd_2O_3(mixed content ; 6 wt%) powder are mixed 60 minutes in Nauta-mixer and then the powder mixture was milled and homogenized with a hammer mill. To have a good flowablity milled powder was precompacted and granulated in a roll compactor(roll pressure : 40 bar) with a sieve(sieve dia. : 1.5 mm). A granulated powder without poreformer(Case 1) and a granulated powder with a 1wt% of poreformer(Case 2) were prepared to compact green pellets. The green pellets are sintered at a 1750 ^oC, H_2 atmosphere with varying sintering time(4, 8, 12, 16 and 24 hrs). Fig. 1 shows the schematic fabrication flowsheet and Fig. 2 shows the schematic diagram of processing equipment. Green density and sintered density are measured geometrical and immersion method, respectively. The grain sizes are measured by intercept method.

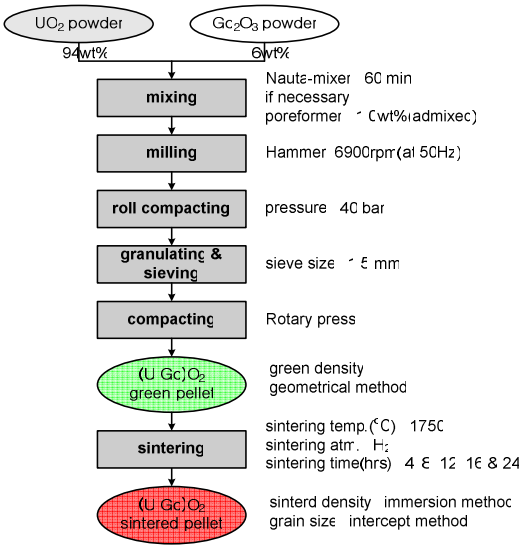

Figure 1. Fabrication flow sheet of (U, Gd)O_2 pellet

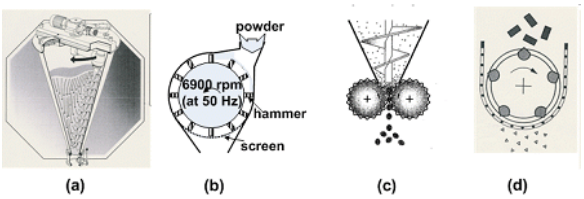

Figure 2. Schematic diagram of processing equipment
(a) Nauta mixer, (b) hammer mill, (c) roll-compactor and (d) granulator with sieve

2.1 Sintered density as a function of sintering time

Fig. 3 shows the sintered density(%T.D.) of UO_2-6wt%Gd_2O_3 pellet as a function of sintering time at 1750 ^oC under H_2 atmosphere. Case 1 is a case of no poreformer admixed (0 wt%) and Case 2 is a case of 1 wt% poreformer admixed in the UO_2-6wt%Gd_2O_3 powder mixture. As shown in Fig. 3, in general, the sintered density slightly increases as a sintering time increases. The Case 2 shows the saturated sintered density above 16 hrs of sintering time, but the Case 1 shows no saturation tendency. It considered that the difference is due to the difference of sintered density between the Case 1 and Case 2. That is, there are few pores in a pellet having a higher sintered density, therefore the sintered density increases no more at the expense of pore annihilation. However, a pellet having a lower sintered density

densifies with increasing sintering times because of some annihilable pores in it.

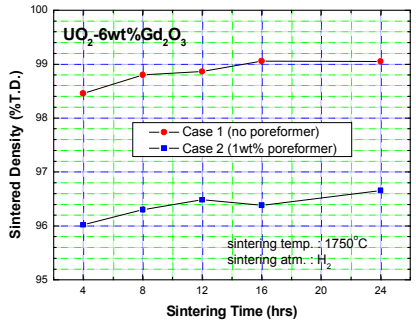

Figure 3. Theoretical sintered density of UO_2-6wt%Gd_2O_3 as a function of sintering time under same condition (1750°C and H_2).

2.2 Sintered density as a function of poreformer contents admixed

Fig. 4, which is a reverse of Fig. 3, shows clearly an addition effect of the poreformer. As shown in the figure, the sintered densities of the Case 1 and the Case 2 reach to a range of 98.5 to 99%T.D. and a range of 96.0 to 96.5%T.D. That is, the differences of sintered densities between the Case 1 and the Case 2 are about 2.5%T.D., however the difference is smaller as the sintering time increases. It is considered to relate the numbers of annihilable pore in a sintered pellet.

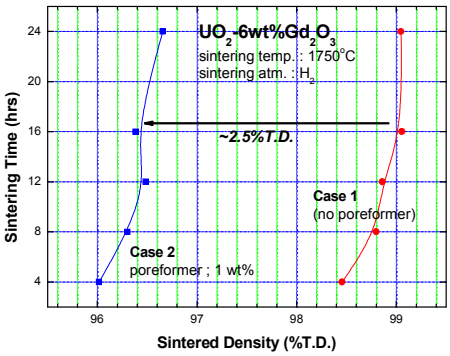

Figure 4. Reverse of Fig. 3

2.3 Microstructure of UO_2-6wt%Gd_2O_3 Sintered Pelletl

The grain size of UO_2-6wt%Gd_2O_3 sintered pellet measures in the range of 3.5~12.7 μm as a function of sintering time, and it increases with increasing sintering time. For example, the grain size is about 3.5 μm for 4 hrs of sintering time, 5.7 μm for 8hrs and 12.7 μm for 24 hrs. But it is observed that the addition amount of poreformer has no effect on the grain size of UO_2-6wt%Gd_2O_3 sintered pellet.

3. Conclusion

Effects of sintering time and admixed content of poreformer on the sinterability of UO_2-6wt%Gd_2O_3 are investigated. Results are as following.

T - The sintered density increases as the sintering time increases.

1 - 1 wt% of addition content of poreformer decreases the sintered density by about 2.5%T.D. under the same sintering conditions.

- The grain sizes increases with increasing sintering time.
- The grain size is not affected by the addition content of poreformer

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