Effect of a CAM treatment on the sinterability of $(U,Gd)O_2$

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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], higher additive content of Gd_2O_3 in the UO_2 matrix, which is a Gd-bearing UO_2, is needed to meet a higher burn-up and longer cycle operation. However, it is known that the manufacturing of a high content Gd-bearing UO_2 pellet is not easy due to the solubility of Gd_2O_3 in UO_2.

Milling of a powder mixture is the best way to solve the heterogeneous microstructure of the (U, Gd)O_2 sintered pellet. There are many pulverizing devices to minimize the particle size and to homogenize the powder mixture, such as a ball mill[2], DM(Dynamic Mill)[3], CAM(Continuous Attrition Mill)[4], etc. Among these mills, both the CAM and DM are devised by KAERI(Korea Atomic Energy Research Institute).

In this study, we investigate the effect of a CAM milling on the sintering property of an $(U,Gd)O_2$ sintered pellet with various additive contents of Gd_2O_3.

2. Experimental method

A schematic diagram of a CAM(Continuous Attrition Mill) is shown in Fig. 1. A paddle at a 150 rpm revolves in it. The input charges of the powder and media(zirconia ball ; 8 mm dia.) were 20 vol% and 70 vol.% of the CAM inner volume, respectively. Sample size is 100 g of a (U, Gd)O_2 powder mixture. Fig. 2 shows a fabrication flow sheet of the (U, Gd)O_2 pellet. As shown in this figure, the sintered (U, Gd)O_2 [Gd content : 4~15 wt%] pellet specimens were prepared by the CAM device with 10 cycles of a milling. And the relevant details(powder preparation, fabrication condition, etc) are also given in this figure.

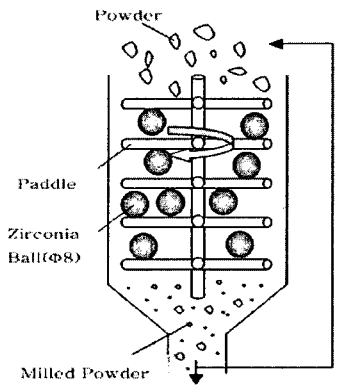

Fig. 1. Schematic diagram of a CAM

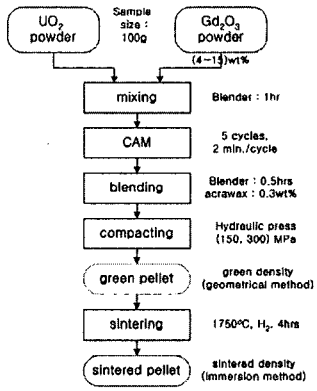

Fig. 2. Fabrication flow sheet of $(U,Gd)O_2$ pellet

3. Results and discussion

Fig. 3 and Fig. 4 show the green density and the sintered density of the (U, Gd)O_2 pellet as a function of the Gd additive contents with 2 different compacting pressures(150

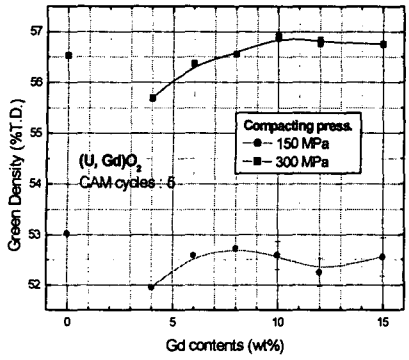

Fig. 3. The green densities of the (U.Gd)O_2 pellet as a function of the Gd contents

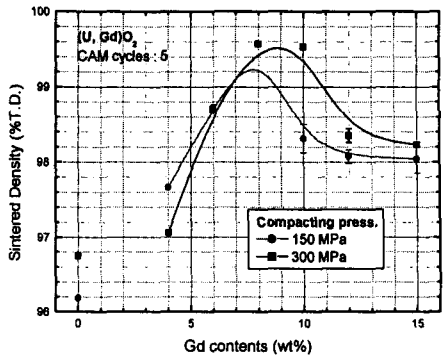

Fig. 4. The sintered densities of the (U.Gd)O_2 pellet as a function of the Gd content

& 300 MPa) under constant milling cycles(5), respectively. As shown in Fig. 3, the green density increased as both the compacting pressure and the additive content of the Gd increased. While the green density of the (U, Gd)O_2 pellet is smaller than that of the pure UO_2(that is, 0 wt% Gd). As shown in Fig. 4, the sintered density of the (U,Gd)O_2 pellet increased with an increasing additive content of the Gd up to about 8 wt%. The sintered density of the (U,Gd)O_2 pellet was saturated and decreased as the additive content of the Gd increased in the range of 9 to 15 wt% Gd. And in the lower range of the Gd content, the sintered densities of the pellets with a low compacting pressure(150 MPa) are larger than those of the pellets with a high compacting pressrue(300 MPa), while in the higher range of the Gd content, the sintered densities of the pellets with 300 MPa are larger than those of pellets with 150 MPa. It is considered that there are some relations between the additive content and the compacting pressure. As time passes, the sintered density of the pure UO_2 pellet is smaller than that of the (U,Gd)O_2. This means that a CAM treatment of a powder mixture has more favorable effects than that of a pure UO_2 powder.

The average grain size of the (U, Gd)O_2 sintered pellet increased with an increasing additive content of Gd up to 10 wt%(from 9.0 ㎛ at 4 wt% Gd to 11. 1㎛ at 8 wt% Gd). But in the range of 10 to 15 wt% of the Gd additive content, as the additive content of the Gd increased, the grain size of the (U,Gd)O_2 pellet decreased to about 6.5 ㎛ at 15 wt% Gd and the degree of free Gd in the (U, Gd)O_2 pellet increased.

3. Conclusion

Result of the experiments described in this work lead to the following conclusions :

- The sintered density and grain size of the (U,Gd)O_2 pellet increased with an increasing Gd content up to 8 wt%. But in the range of 8 to 15 Gd wt%, the sintered density and grain size of it was saturated and it decreased as the Gd content increased.

Acknowledgements

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Reference

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