Fabrication of Sintered Annular Fuel Pellet

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1. Introduction

A dual cooled annular fuel has been seriously considered as a favorable option for uprating the power density of a Pressurized Water Reactor fuel assembly. An annular fuel has a geometrically inherent advantage such as an increased heat transfer area and a thin pellet thickness. It results in a lot of advantages from the point of a fuel safety and its economy [1]. In order to actualize the dual cooled fuel, an essential element is the annular pellet with precisely controlled diametric tolerance.

However, the unique shape of annular fuel pellet causes challenging difficulties to satisfy a diametric tolerance specification. Because of an inhomogeneous green density distribution along the compact height, an hour-glassing usually occurred in a sintered cylindrical PWR fuel pellet fabricated by a conventional double-acting press. Thus, a sintered pellet usually undergoes a centerless grinding process in order to secure a pellet's specifications.

In the case of an annular pellet fabrication using a conventional double-acting press, the same hour-glass shape would probably occur. The outer diameter tolerance of an annular pellet can be controlled easily similar to that of a conventional cylindrical PWR pellet through a centerless grinding. However, it appears not to be simple in the case of an inner surface grinding. It would be the best way to satisfy the specifications for the inner diameter in an as-fabricated pellet.

In the present study, we are trying to find a way to minimize the diametric tolerance of the sintered annular pellet without inner surface grinding. This paper deals with a new approach that we have tried to reduce the diametric tolerance of the sintered annular pellet.

2. Experimental

IDR route UO_2 powder was used for a sample preparation. The granulation was conducted by pre-compaction of powder under 10 MPa in a cold isostatic press. Pre-compacted lump of UO_2 powder was crushed and granulated with 20 mesh sieve. The granules were mixed with a 0.3 wt% of zinc stearate in a tumbling mixer for 30 min. The compaction was conducted in a double acting press under 4 ton/cm^2.

The dimensions of the annular compacts were measured by using a 3-dimensional measuring system (VERTEX 230, MicroVu). The compact is about 12 mm in height and about 18 mm and 12 mm in outer and inner diameter, respectively.

The compacts were sintered at 1600 °C for 12 h in H_2 atmosphere with a precisely machined UO_2 rod inserted. The heating and cooling is at a rate of 5 K/min. Sintered density was measured by the water immersion method. The inner and outer diameters of the sintered pellets were carefully measured as a function of pellet height by using a 3-dimensional measuring system.

3. Results

In order to reduce the inner diametric tolerance during sintering process, we used a precisely machined rigid rod as an inner surface deformation stopper of an annular pellet. The inserted rigid rod acts as a support for maintaining a flat inner surface during sintering. We chose the fully densified UO_2 rod as a deformation stopper.

The schematic of the rigid rod and the annular pellet during a rod inserted sintering process was shown in Fig. 1. The diameter of a rod was measured to 10.18 ± 0.005 mm, and it does not changed after sintering and dividing from annular pellet.

Inner diameters maintain a constant value which is independent of the pellet height after sintering at 1600 °C for 12 h in H_2 atmosphere with a precisely machined UO_2 rod inserted; however, the outer surface was deformed similar to that of the conventionally sintered annular pellet. The outer diameters have different

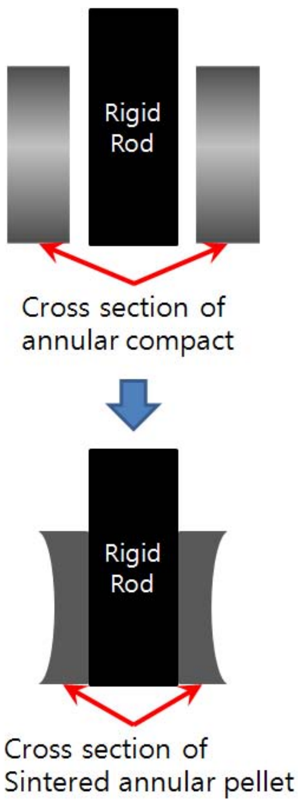

Fig. 1. Schematic of rod-inserted sintering.

values according to the pellet height. By using the rod-inserted sintering method, the measured inner diametric tolerance of the sintered annular pellet can be reduced less than ± 6 μm.

4. Conclusions

In order to minimize a diametric tolerance, we applied a UO_2 rod inserted sintering process. An annular compact was firstly compacted with a double-acting press and then sintered with a precisely-machined UO_2 rod inserted. The UO_2 rod could prevent an inhomogeneous deformation of the inner surface during sintering, and thus, it reduced the inner diametric tolerance of a sintered annular pellet.

ACKNOWLEDGMENTS

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