The Effect of hammer-milling on the sinterability of UO_2 powder

Sang Ho Na[a], Yeon Ku Kim[a], Si Hyung Kim[a], Han Soo Kim[a], Myung June Yoo[b]
a Korea Atomic Energy Research Institute, 150 Dukjin-dong, Yuseung-gu, Daejeon 305-353, Korea, shna@kaeri.re.kr
bKEPCO Nuclear Fuel Company, Ltd., 493 Dukjin-dong, Yuseung-gu, Daejeon 305-353, Korea

1. Introduction

In general, it is known that the characteristics of a powder depend largely on the particle size of the powder, and both the compactability and sinterability of the powder are affected by its size. Milling of a powder enhances the sinterability, resulting in a large and homogeneous grain structure of a pellet.

There are many pulverizing devices to minimize the particle size, such as a ball mill[1], Dynamic Mill[2], hammer mill[3], CAM(Continuous Attrition Mill)[4-6], etc. Among these mills, especially, the Dynamic Mill, hammer mill and CAM have been reported to have a large effect on the milling and homogenizing in a powder mixture with an increasing sintered density[3-6].

In this work, sintering characteristics of hammer-milled ex-ADU UO_2 powder are investigated to anticipate a sinterability of powder mixture.

2. Methods and Results

The powder specimen is ex-ADU UO_2 powder, which was imported from CAMECO, Canada. This powder specimen is milled by a hammer mill. A schematic diagram of the hammer mill is shown in Fig. 1. The hammer mill has 12 hammers with a revolution of 6,900 rpm.

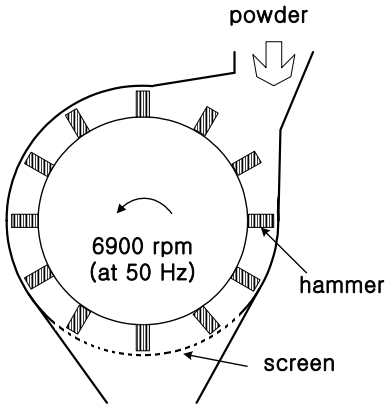


Fig. 1. A schematic diagram of a hammer mill

As shown in Fig. 2, green pellets were prepared with 2 different fabrication routes. One is fabricated with hammer-milled powder(Fig. 2(a)) and the other is fabricated with intact powder(Fig. 2(b)). Green pellets were prepared with varying compacting pressures(150 ~300 MPa) and then sintered at two temperature conditions (1700°C and 1750°C) for 4 hrs under a hydrogen atmosphere.

The green density and sintered density were measured by the geometric and immersion method, respectively.

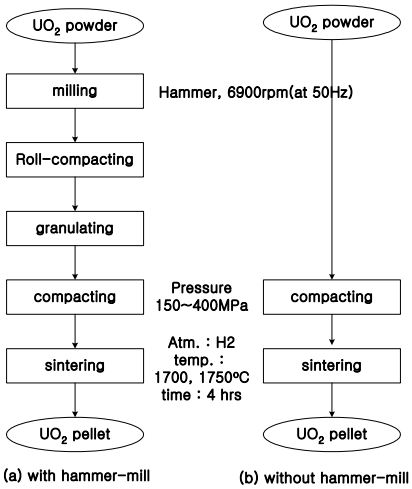


Fig. 2. UO_2 pellet fabrication route

2.1 Effect of hammer mill

Fig. 3 shows the green density vs. sintered density as a function of milling effect under the sintering temperature of 1750 °C. The case (a) and the case (b) started with the hammer-milled powder and intact powder, respectively. As shown in Fig. 3, the sintered density increased with an increasing green density, regardless of milling condition. However, the sintered density of case (a) is higher than that of case (b) under the same green density. It appeared that the increase of sintered density is due to the effect of hammer-milling. Fig. 5 shows the microstructure of UO_2 pellet as a function of hammer milling. The microstructure of case (a) is more uniform and higher than that of the case (b).

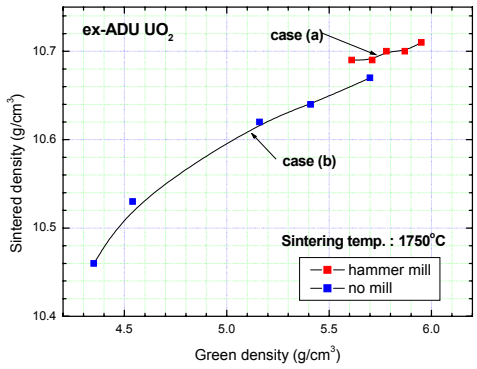


Fig. 3. Green density vs. Sintered density as a function of milling effect.

2.2 Effect of sintering temperature

Fig. 4 shows the green density vs. sintered density with 2 different sintering temperatures (1700°C and 1750°C) for the hammer-milled powder. Case (a) is in the case of 1750°C and case (c) is in 1700°C. As shown in Fig. 4, the sintered density increased with an increasing of green density, regardless of sintering temperature. But the sintered density of the case (c) is saturated above the green density of about 5.9 g/cm^3. Fig. 4 shows also the sintered density of case (a) is higher than that of case (c) under the same green density. It appeared that the sintering temperature has a strong effect to increase the sintered density of UO_2 pellet, which was originated from hammer-milled powder. Fig. 5 shows the microstructure of UO_2 pellet. The grain size of case (b) is larger than that of case (c)

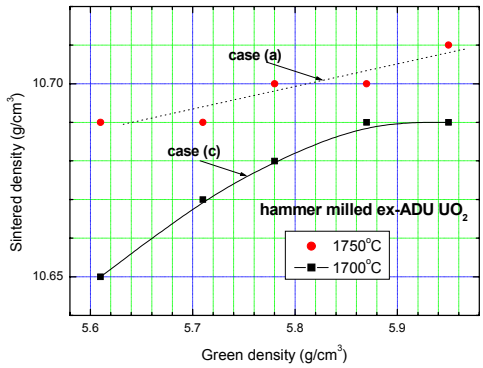
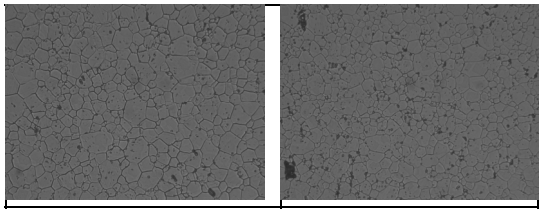
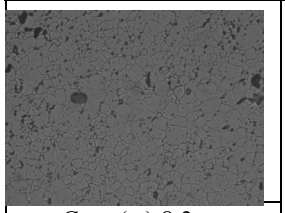


Fig. 4. Green density vs. sintered density with 2 different sintering temperatures.



Case (a) 11.0 ㎛ | Case (b) 8.7 ㎛



Case (c) 8.3 ㎛

Case (a) ; hammer-milled, 1750°C , 4 hrs
Case (b) ; intact, 1750°C, 4hrs
Case (c) ; hammer-milled, 1700°C, 4hrs

Fig. 5. Microstructure of UO_2

3. Conclusion

The effect of hammer mill on the sinterability of UO_2 was investigated to anticipate the sinterability of binary oxide. Results are as following.

- The effect of hammer mill enhances the sinterability of UO_2 pellet.
- The sintering temperature has a strong effect to increase the sintered density and grain size.

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