

Relation Between Density and Porosity in Sintered UO_2 Pellets

Sang Ho Na, Si Hyung Kim, and Young-Woo Lee,

Korea Atomic Energy Research Institute
150 Dukjin-dong, Yuseung-gu, Daejeon 305-353, Korea
shna@kaeri.re.kr

Myung June Yoo

KEPCO Nuclear Fuel Company, Ltd.
493 Dukjin-dong, Yuseung-gu, Daejeon 305-353, Korea

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Abstract

The relation between sintered densities and porosities in UO_2 pellets is investigated. The open porosity decreases linearly up to about 95% T.D.(theoretical density) as the sintered density increases whereas, above 96% T.D., sintered UO_2 pellets do not have any open pores. The fraction of open porosity to the total porosity also decreases linearly as the sintered density increases, though the slope is lower than that of open porosity and, above 95% T.D., the fraction decreases rapidly to approach a zero.

Key Words : sintered density, UO_2 pellet, open porosity, closed porosity

1. Introduction

UO_2 is the most widely used as a nuclear fuel for current nuclear power generation. The fabrication process of UO_2 pellets is generally similar to powder metallurgy. Pores are an inherent part of sintering. Accordingly, porosities are present in UO_2 pellets. Total porosity includes both open (those connected to the surface) and closed(those not connected to the surface) pores. In general, open pores directly affect properties such as permeability, vacuum tightness, and surface available for catalytic reaction and chemical attack,

whereas closed pores have little effect on these properties[1]. In the case of UO_2 , if any open pores are present in a pellet, moistures in air can be much easily adsorbed through open pores. Moisture-adsorbed pellets can degrade the function of fuel during operating in the nuclear power plant. Therefore it is requested to fabricate a pellet without open porosity to avoid any moisture adsorption.

In this work, a relation between the sintered density and the porosity(open and closed) is investigated as a function of density for the sintered UO_2 pellets.

2. Experimental

ex-AUC UO₂ powders, which were manufactured from a UNH solution in KAERI, were used in this work. In order to adjust the sintered density of UO₂ pellets, various contents of zinc stearate(0~4wt%) were admixed with the UO₂ powder. In the case of zinc stearate admixed in UO₂ powder, sintered density of UO₂ pellet decreased 4%T.D.(Theoretical Density) as 1 wt% of zinc stearate was admixed. Cylindrical compacts were prepared from the mixtures at various compacting pressures in the ranges between 200 and 500MPa, using a constant weight fill of 20g of UO₂ powder, by means of a double acting hydraulic press. These compacts were sintered at 1700°C for 4 hrs under a hydrogen gas atmosphere in a continuous pusher-type furnace. Sintered density of UO₂ pellets was measured by impregnation method with m-xylene solution. From the data obtained by density measurement using m-xylene, open porosity, ε_o, can be calculated as follows[2,3] :

$$\epsilon_o = \frac{W_{sat} - W_{dry}}{W_{sat} - W_{susp} - W_{dry} \frac{\rho_x}{\rho_{TD}}} \times 100 (\%)$$

where W_{sat}, W_{dry} and W_{susp} are the saturated weight, the dry weight and the suspended weight of UO₂ pellet, respectively. ρ_x and ρ_{TD} is the density of m-xylene and the density of UO₂ pellet, respectively.

3. Results and Discussion

Fig. 1 shows open porosity, ε_o and open porosity/total porosity, ε_o/ε_t as a function of sintered density for the sintered UO₂ pellet and Fig. 2 shows a magnification of part A in Fig. 1. As shown in these figures, the curves of ε_o and ε_o/ε_t is of a sigmoidal type as a function of

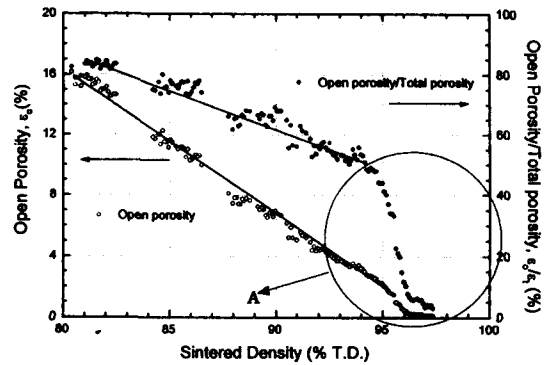


Fig. 1. Open Porosity and Open Porosity/Total Porosity as a Function of Sintered Density of UO₂ Pellet

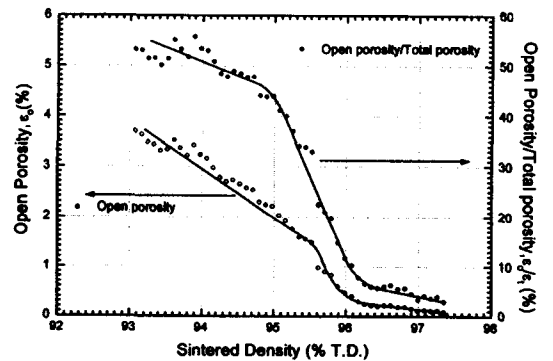


Fig. 2. Magnification of Part A in Fig. 1

sintered density. That is, the open porosity decreases with a linear relation (ε_o = 94.09-0.97x, x ; sintered density(%T.D)) up to 95% T.D. But above this density, the open porosity decreases rapidly and nearly all the open pores eliminated when the sintered density reached to 96% of theoretical density. This is in good agreement with other results[4-6]. The curve of ε_o/ε_t shows a similar tendency to that of ε_o. That is, ε_o/ε_t decreases with a linear relation (ε_o/ε_t = 294.3-2.6x) up to about 94%T.D. At this sintered density, both the open and closed pores are present in nearly equal amounts. Thereafter, ε_o/ε_t

decreases rapidly toward 0% at about 96%T.D.

Therefore, in order to avoid any moisture adsorption on a pellet surface through open porosities, it is necessary to fabricate the sintered pellet having a density of at least 96%T.D.

4. Conclusions

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

- 1) Open porosity decreases in a sigmoidal type as the sintered density increases.
- 2) Open porosities are not present in UO_2 pellets having a density of at least 96%T.D. in this fabrication process.

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