# Optimization of $UO_2$ Granule Characteristics for $UO_2$-Mo Pellet Fabrication

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## 1. Introduction

In the nuclear fuel performance of an LWR, the thermal conductivity of a $UO_2$ fuel pellet is one of the most important properties. The steep temperature gradient and high centerline temperature in the fuel pellet results from a low thermal conductivity of $UO_2$, which is a typical ceramic material. The in-reactor performance, integrity, safety and accident tolerance of the nuclear fuel can be significantly affected by the thermal conductivity of the $UO_2$ fuel pellet.

The improvement in the thermal conductivity of the $UO_2$ fuel pellet can enhance the fuel performance in various ways. Typically, the FGR (Fission Gas Release) can be reduced by the application of a large-grain fuel pellet because the moving path of the fission gas to the grain boundary is much longer. In addition, the mobility of the fission gases is reduced by the lower temperature gradient in the $UO_2$ fuel pellet. That is to say, the capacity of the fission gas retention of the fuel pellet can increase.

In addition, the lower centerline temperature of the fuel pellet affects the accident tolerance for nuclear fuel as well as the enhancement of fuel safety and fuel pellet integrity under normal operation conditions. In addition, the nuclear reactor power can be uprated owing to the higher safety margin.

Thus, many researches on enhancing the thermal conductivity of a nuclear fuel pellet for LWRs have been performed in various ways [1-3]. From the viewpoint of the development of fuel pellet fabrication technology, an enhancement of the thermal conductivity of a pellet can be obtained by the addition of a higher thermal conductive material in the $UO_2$ pellet. It is known that a $UO_2$-metal composite pellet is one of the most effective concepts.

However, to maximize the effect of the metallic phase for thermal conductivity enhancement, a continuous channel of the metallic phase in the $UO_2$ matrix must be formed. Additionally, if the fabrication process of a $UO_2$-metal composite pellet is compatible with a conventional sintering process, the developed technology will be favorable.

To enhance the thermal conductivity of a $UO_2$ pellet, there are the various methods for an appropriate arrangement of the high thermal conductive material in a $UO_2$ matrix. In this work, we intended to control the placement of the Mo metallic phase as a high thermal conductive material. To continuously arrange the metallic Mo in the $UO_2$ matrix, a $UO_2$ granulation technique was applied. In addition, to optimize the $UO_2$ granule characteristics, a fabrication test for the effect of $UO_2$ granule densities and size on the $UO_2$-Mo composite pellet was performed, and the density and microstructure of the sintered pellet were observed.

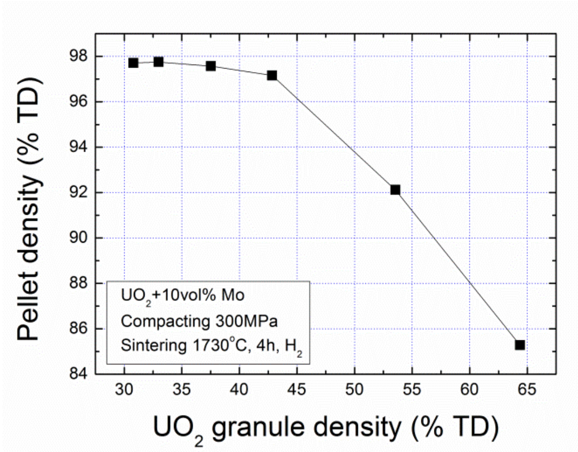


**Fig. 1.** Sintered density of $UO_2$-Mo pellet as a function of $UO_2$ granule density.

## 2. Experimental and Results

ADU-$UO_2$ (Ammonium Diuranate) powder was pre-compacted using a single acting press at various pressures of 30 to 600 MPa, and a pre-compact was crushed and sieved. A sieve of various mesh sizes was applied to make $UO_2$ granules of various sizes.

Mo metal powder at 10 vol% (SIGMA-ALDRICH, 99.9%) was mixed with the prepared $UO_2$ granule using a simple mixing method. The powder mixtures were compacted using a single acting press at about 300 MPa, and sintered at 1730 ℃ for 4h in a flowing $H_2$ atmosphere.

The sintered density of the $UO_2$-Mo pellet was determined using an immersion method, and a microstructure of the sintered pellet was observed using optical microscopy.

Figure 1 shows the sintered density of the $UO_2$-Mo pellet as a function of $UO_2$ granule density. It was shown that the $UO_2$-Mo pellet density increased with a decrease in the $UO_2$ granule densities. In addition, the sintered pellet density was saturated below the $UO_2$ granule density of 35%TD.

The microstructure evolution of a $UO_2$-Mo pellet as a function of $UO_2$ granule density is shown in Figure 2. It is shown that the connectivity of the Mo metallic

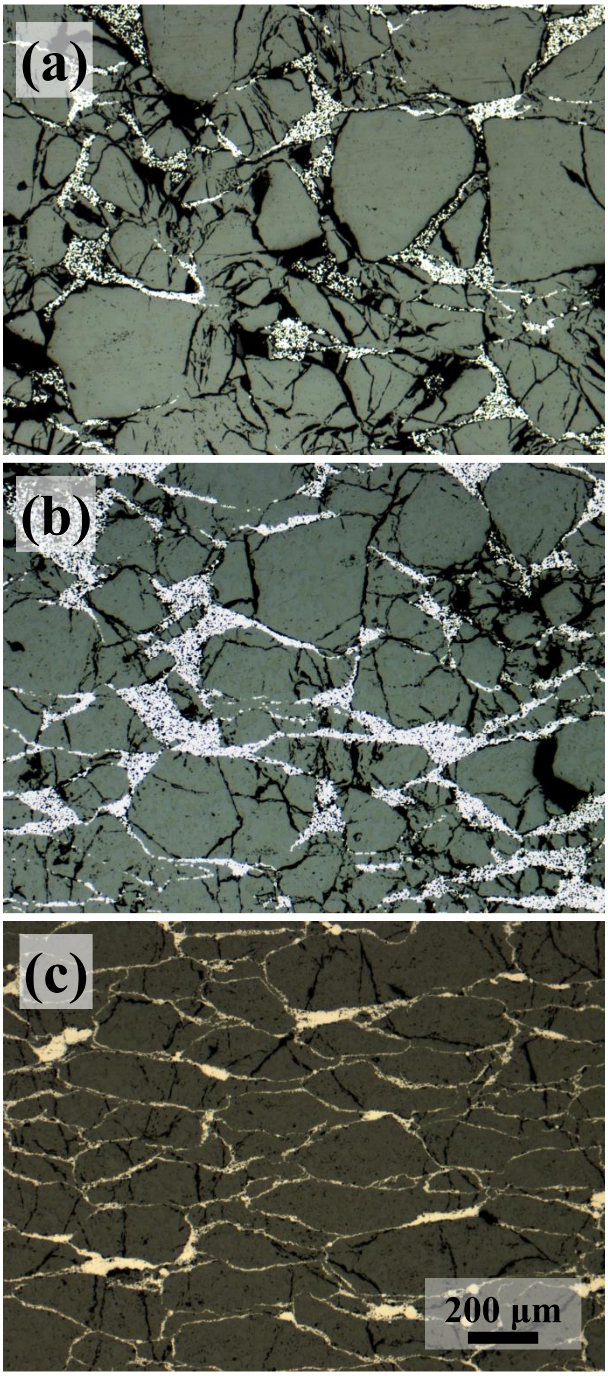


**Fig. 2.** The microstructure evolution of $UO_2$-Mo pellet as a function of $UO_2$ granule density: (a) 64%TD, (b) 53%TD, and (c) 33%TD.

phase and the integrity of the $UO_2$ matrix are gradually improved with decreasing $UO_2$ granule densities. In addition, the integrity of the interface between the $UO_2$ matrix and Mo metallic phase is enhanced.

It was shown that the inner density of the $UO_2$ granule in Figure 2 (c) is slightly lower than that of the granule in Figure 2 (a). However, the enhanced integrity of the interface between the $UO_2$ matrix and Mo metallic phase can effectively increase the thermal conductivity of a $UO_2$-Mo pellet. In Figure 2 (c), if the slight gaps in the $UO_2$ matrix can be entirely eliminated, the thermal conductivity of the $UO_2$-Mo pellet can further enhanced.

In addition, it can be said that the developed process of $UO_2$-Mo pellet fabrication is compatible with a conventional sintering process of a $UO_2$ pellet. The measurement and assessment of the fabricated $UO_2$-Mo pellet are now on going.

### 3. Summary

To enhance the thermal conductivity of a $UO_2$ fuel pellet, the development of fabrication technology of a $UO_2$-Mo composite pellet with high density as well as a continuous channel of the Mo metallic phase was carried out. In addition, we intended to develop a compatible process for a conventional $UO_2$ fuel pellet fabrication process.

### ACKNOWLEDGEMENT

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