

Carbothermal reduction sintering of MOX fuel for fast-neutron reactors

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1. Introduction

The oxygen-to-metal (O/M) ratio of MOX pellets for fast-neutron reactors is imposed during sintering in a hydrogen-rich atmosphere. In mass-production sintering furnaces, the O/M ratio of MOX pellets rarely falls below 1.98 due to poor gas flow. This study experimentally evaluated the carbon thermal reduction method, which involves sintering MOX powder with added graphite powder, as an alternative to the reducing gas method for achieving low O/M ratios.

2. Experiments

MOX powder containing 30% Pu (prepared by mixing UO_2 powder with 50% Pu-MOX powder without prior heat treatment) was blended and ball-milled with graphite powder at concentrations of 0, 3000 ppm, and 6000 ppm, and hand-pressed into 10 mm high specimens using a 3 mm press die. These compacts were then heated at a rate of $10^\circ\text{C}/\text{min}$ to 1650°C using a thermal balance (TG) connected to an oxygen-control system, held at that temperature for two hours, and cooled at a rate of $30^\circ\text{C}/\text{min}$. The sintering atmosphere consisted of Ar + 4.5% H_2 gas (without humidification).

3. Results

The variations in the O/M ratio of MOX were evaluated based on the weight changes obtained using the TG setup. Figure 1 shows the behaviour of the O/M ratio of a MOX sample (A), to which 3000 ppm of graphite was added, and sample (B), to which no graphite was added. The rate of the change in the O/M ratio slowed at around 400°C . At temperatures between 1300 and 1400°C , the O/M ratio of sample (A) was lower than that of sample (B). After cooling, sample (A) achieved an O/M ratio of 1.979(1), whereas sample (B) had a higher value of 1.984(1). An O/M ratio of 1.906(1) was obtained with a graphite addition of 6000 ppm, but the density of the sintered body decreased significantly, leading to the exclusion of this concentration due to poor mechanical properties.

4. Conclusions

It has been found that adding 3000 ppm of carbon powder can effectively reduce the O/M ratio during the sintering process of MOX. For mass-production-scale sintering furnaces with poor gas flow, adding graphite to the feedstock powder is a promising method of reducing the O/M ratio of MOX for fast-neutron reactor applications.

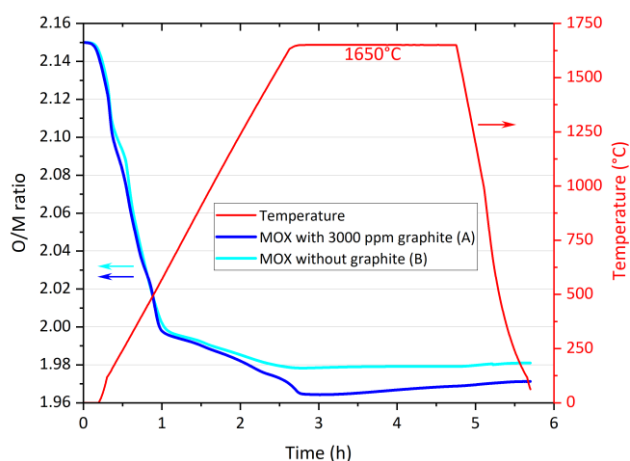


Figure 1. Variations in the O/M ratio of MOX containing 3000 ppm graphite (A), and without graphite (B), as a function of time and temperature during sintering in Ar + 4.5% H_2