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Title: FABRICATION OF NON-FERTILE AND EVOLUTIONARY MIXED OXIDE FUELS

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FABRICATION OF NON-FERTILE AND EVOLUTIONARY MIXED OXIDE FUELS

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INTRODUCTION

Non-fertile and evolutionary mixed oxide (EMOX) fuels for light water reactors have been fabricated using the solid-state reaction method. Specifically, the non-fertile fuel form fabricated for this study was a PuO_2-ZrO_2-CaO-Er_2O_3 composition. Weapons-grade plutonium served as the source of PuO_2. The non-fertile fuel offers the key advantage of the "deep burn" capability for a once-through cycle. The non-fertile fuel achieves this performance through the absence of uranium, which breeds plutonium, in the fuel composition. An EMOX fuel form with a composition of PuO_2-UO_2-ZrO_2-CaO was also fabricated using weapons-grade plutonium and depleted uranium. The EMOX fuel concept allows for greater plutonium destruction as compared to standard MOX fuel and provides a licensing path forward towards eventual implementation of non-fertile fuels in light water reactors.[1] This paper summarizes the ongoing activities and past accomplishments for the fabrication of non-fertile and EMOX fuel pellets.

METHODOLOGY

Powder Characterization

Precursor powders (PuO_2, ZrO_2, CaO, Er_2O_3, and UO_2) were characterized using several analytical techniques. Specifically, the equivalent spherical diameter of the powders was determined using laser diffraction analysis. Scanning electron microscopy (SEM) was used to characterize particle morphology. Impurity levels were determined using gas chromatography - mass spectrometry (GC-MS). Powder batching homogeneity was determined using x-ray fluorescence (XRF) spectrometry.

Pellet Fabrication

The flow diagram for the non-fertile fuel pellet fabrication is shown in Figure 1. The precursor oxide powders were blended according to the following weight percentages: ZrO_2 (80.4), CaO (9.7), PuO_2 (8.3) and Er_2O_3 (1.6). The plutonium oxide for the fuel was obtained by converting the plutonium component of a nuclear weapon to plutonium oxide using the hydride/oxidation process at LANL. The precursor oxides were blended with

lubricant (0.2 wt.% stearic acid) and binder (0.2 wt.% polyethylene glycol) using a combination of dry ball milling and vibratory milling processes. The milled powder was uniaxially pressed into pellets at 310 MPa. The green pellets were sintered for 5 hours at 1700°C in air.

The flow diagram for the EMOX fuel pellet fabrication is shown in Figure 2. The precursor oxide powders were blended according to the following weight percentages: ZrO_2 (30.1), CaO (2.4), UO_2 (53.5) and PuO_2 (14.0). The plutonium oxide for the fuel was obtained by converting the plutonium component of a nuclear weapon to plutonium oxide using the hydride/oxidation process at LANL. The precursor oxides were blended with lubricant (0.2 wt.% stearic acid) and binder (0.2 wt.% polyethylene glycol) using a combination of dry ball milling and vibratory milling processes. The milled powder was uniaxially pressed into pellets at 310 MPa. The green pellets were sintered for 5 to 10 hours at temperatures ranging from 1400°C to 1700°C. The fuel pellets were sintered in several atmospheres including argon, argon - 6 % hydrogen, and air.

Fuel Pellet Density and Microstructural Analysis

The bulk density and volume percent of open porosity were determined using the immersion density technique. Grain and pore structure including average size and size distribution were determined using optical microscopy (OM) and SEM analysis. Compositional homogeneity and phase structure were determined using electron microprobe analysis and x-ray diffractometry.

RESULTS

A fabrication process for producing non-fertile and EMOX fuel was demonstrated. The effects of powder milling and sintering conditions (time, temperature, and atmosphere) on microstructural development (phase development, compositional homogeneity, porosity, and grain size) were determined.

REFERENCES

[1] Eaton, S.L., Beard, C.A., and Buksa, J. J., "Evolutionary Mixed Oxide Fuel Performance in Pressurized Water Reactors," this conference.

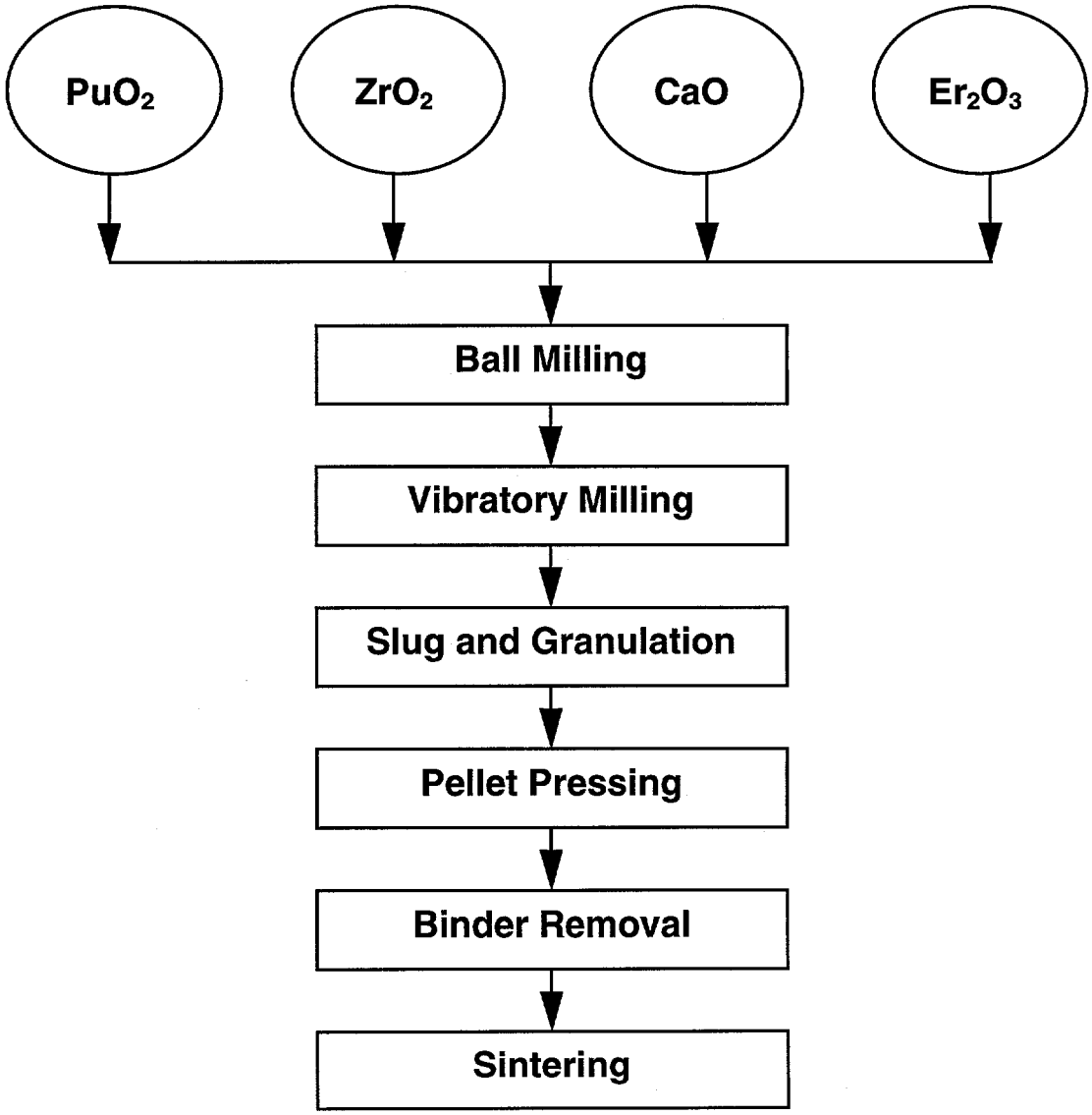

Figure 1. Non-fertile Fuel Pellet Fabrication Process

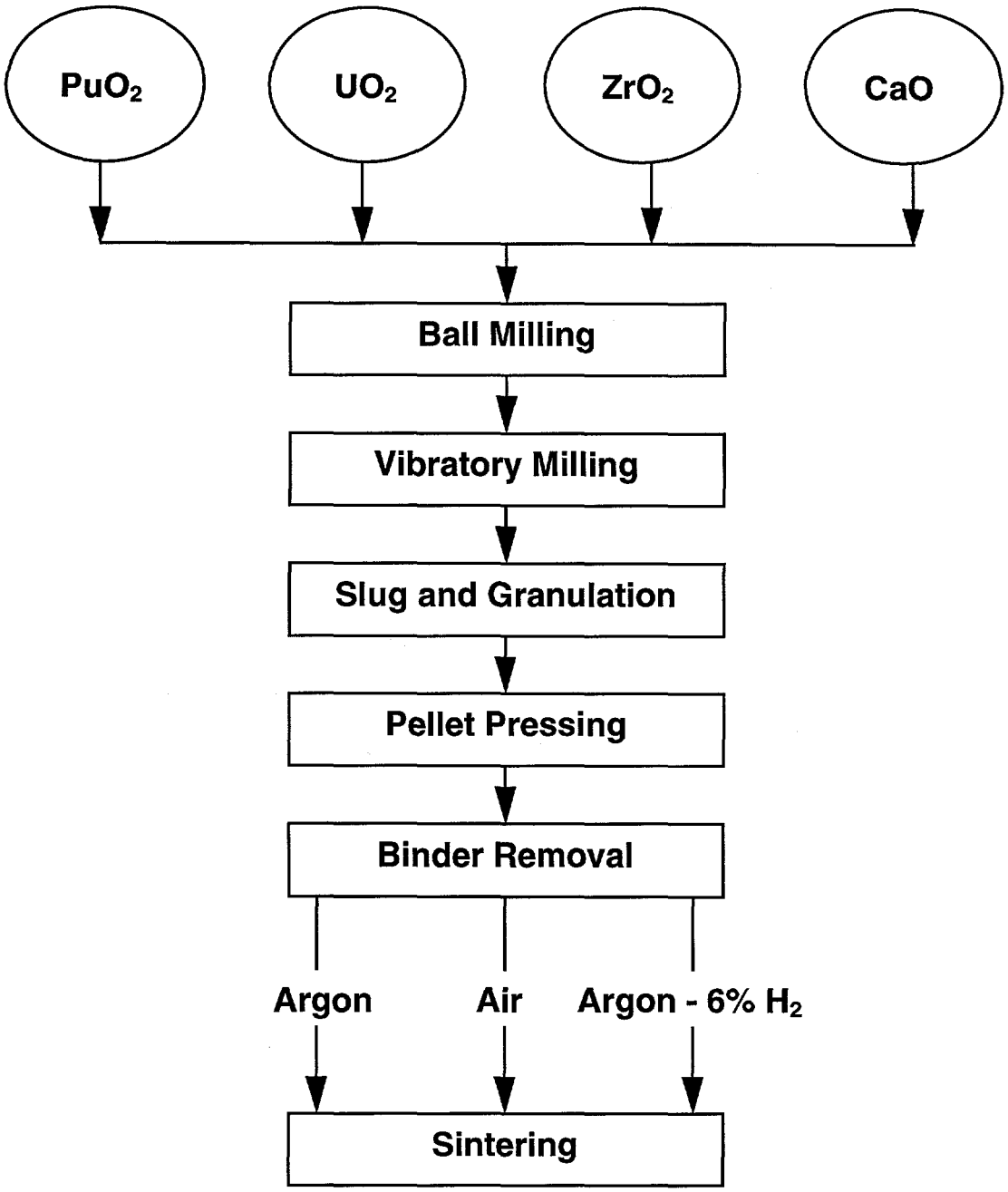

Figure 2. EMOX Fuel Pellet Fabrication Process