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Effects of Oxygen Partial Pressure During Sintering at Laboratory and Industrial Scales on FR MOX Fuels

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In order to prepare the industrial deployment of Sodium Fast Reactor (SFR), a French prototype is envisaged for 2025 (ASTRID: Advanced Sodium Technological Reactor for Innovative Demonstration). Its MOX (mixed oxide) fuels will be produced by a new industrial facility, currently under development and named AFC (for "Atelier de Fabrication des Coeurs", core fabrication facility).
The fabrication process of MOX fuel is based on powder metallurgy processes. The UO_2 and PuO_2 mixture is pelletized and then sintered at about 1700°C under reducing atmosphere of Ar/4%H_2/H_2O. Fuel has to be in compliance with specifications. In particular, the O/M (atomic oxygen to metal ratio) has to be hypostochiometric and close to 1.97 and the microstructure has to be dense, around 95 %ThD and free of cracks. The O/M and microstructure can affect numerous properties of the fuel during operation including thermal conductivity, mechanical properties and fuel-cladding interactions. To comply with these specifications, better knowledge of sintering at laboratory and industrial scale is needed.
An original analysis method has been therefore developed for a better understanding of the O/M ratio evolution and of densification mechanisms during the sintering step. By coupling a dilatometer with an oxygen zirconia probe, it is possible to identify the different redox phenomena and to plot the evolution of the O/M of the oxides versus time during the densification process. This innovative method helps overcoming the obstacles in reaching the thermodynamic equilibrium between gas and fuel. Whereas it was difficult to predict a precise final O/M, this new method produces the expected ratio every time.
This paper highlights the different final O/M values and microstructure, particularly in terms of microcracking, obtained during sintering in a continuous industrial or laboratory kiln. The impact of the evolution of moisture content in the gas is explained. Based on these results, recommendations can be made about the sintering atmosphere to improve industrial cycles and optimize fuel characteristics in order to obtain an O/M as close as possible to the target value and the right microstructure.

Country/Int. Organization

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