Thermal Property Test Study of Pellet to Cladding Interaction in CFR600 Design

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Thermal Property Test Study of Pellet to Cladding Interaction in CFR600 DesignCFR600 design has been carried on for dozens of years, in China. In order to gain an application design which can be adopted into real engineering construction, the design for controlling Pellet to Cladding Interaction (PCI) phenomenon in CFR600 is required to guarantee that the Gibbs energy distributions caused by irradiation in the fuel and structure materials must be tested well; and then, the processes of material kinetic reactions in any given thermal history, such as metallurgical phase diagrams, can be confirmed. Generally speaking, there are three main stages during this kind of fuel failure PCI: in the early life, thermal expansion is main factor to induce the changes of the material structures; in the middle life, thermal diffusivity and the fission-gas-producing enhance their deformations; in the later life, material mechanical property variations hasten them. Therefore, thermal conductivity, thermal diffusion, thermal expansion and specific heat capacity of materials are the most important properties which shall be measured. In fact, this kind of measurements belongs to the work of confirming the thermal properties of irradiated fuel pellet and cladding, based on the corresponded PCI induced metallurgical phase diagrams of them. In CFR600, the main chemical components of the fuel pellet, the cladding and the coolant are plutonium, uranium, oxide, 15-20%CW15-15Ti austenite steel and liquid sodium. In order to gain the phase diagrams of these pure materials, binary alloys and ternary alloys during PCI failure, the transient irradiation conditions and the coolant flow flux distributions in this failure scenario shall be analyzed well. So, through the qualified tests, such as DSC(Differential Scanning Calorimetry) or DTA(Differential Thermal Analyzers),this paper deeply studies the PCI induced metallurgical phase diagrams of the fuel and the cladding, and the empirical relationships between the PCI gap size and the heat rate to incipient fuel melting in its main three stages. According to this study, the PCI gap size and corresponded temperature or pressure versus relationships of material thermal conductivity coefficient, thermal diffusion coefficient, thermal expansion coefficient and specific heat capacity can be published in the CFR600 design to guarantee the safety property of the reactor.