Numerical Calculation of the Heat Transfer Characteristics of Fuel Cladding with Dirt at Low Coolant Speed

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ABSTRACT

Research of the flow and heat transfer characteristic of fuel cladding with dirt at low coolant speed is very important for cooling of the fuel assembly in LOCA. Therefore, a heated fuel rod with spacer grids and covered with dirt on the surface has been taken for investigation. The one-dimensional flowing and heat transfer model of the coolant and fuel cladding has been developed, time steady and transient simulation have been completed. Effect of dirt that blocking the flowing passage on heat transfer deterioration of fuel cladding has been studied, the influence of the dirt thickness, heat conductivity and coolant speed have been investigated. As the verification, the computed results of a 1/4 section fuel rod in this work has been compared with simulated results from the CFD analysis, the comparison shows satisfied agreement with the maximum relative deviation less than 2%. From the full study of coolant flowing and heat transfer for the 1/4 section fuel rod, we have following three findings. Firstly, dirt deposition outside the fuel rod leads to a higher wall temperature than a clean fuel rod, the increase magnitude of temperature grows up gradually while the dirt thickness increase, but grows down rapidly while the thermal conductivity of the dirt increase. Secondly, speed of the coolant has great influence on cooling of the fuel rod, a very small low coolant velocity would lead to heat transfer deterioration which caused the cladding temperature increasing greatly. Thirdly, the spacer grids has effect of enhancing cooling of the fuel rod, an obvious decrease of cladding temperature would appear in the grids position.

KEYWORDS
fuel cladding; dirt; heat transfer characteristics; low coolant speed

1. INTRODUCTION

After occurrence of LOCA in a nuclear power plant, the emergency core cooling system (ECCS) and containment spray system (CSS) would run for a long time to ensure a continuous core cooling and maintaining long-term containment of pressure and temperature within the range of acceptable. After refueling tank reaches the low water level, the ECCS and CSS system will automatically switch to the recirculation mode, taking water from the containment pit. In some cases, the fragment from pipeline breakage would flow with coolant in the core, or sprayed liquid would migrate into the containment pit filter in other cases, causing block of the filter. Integrity of the fuel rod may be endangered when the flowing channel is blocked due to accumulation of large fragments, which causes the coolant flow blockage accident in some fuel assemblies. This accident may cause blocked fuel assemblies lacking enough cooling, make fuel clad temperature rising rapidly and result in strong evaporation of coolant. In that condition, the release of radioactive material to the coolant is very possible, and the safety of the fuel claddingis highly threatened. Therefore, study the thermalhydraulic characteristics and safety

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[1]This work is co-sponsored by the National Natural Science Foundation of China (51376065, 51176052), Guangdong Key Scientific Project (2013B010405004),Guangdong Province Key Laboratory of Efficient and Clean Energy Utilization (2013A061401005), South China University of technology； Key Laboratory of Efficient and Clean Energy Utilization of Guangdong Higher Education Institutes (KLB10004).

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