# High-temperature steam oxidation behavior of Zr-*x*Sn-0.35Fe-0.15Cr alloys under simulated loss of coolant accident conditions

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**Abstract** Zirconium alloys are widely used as cladding materials for nuclear fuel elements in water-cooled nuclear power reactors due to a number of advantages now. During loss of coolant accident (LOCA), zirconium alloy cladding undergoes high-temperature steam oxidation to cause its thinning and embrittlement, which threaten the operation of nuclear reactors. In this study, Zr-*x*Sn-0.35Fe-0.15Cr (*x*=0.5, 0.75, 1.0, 1.2 and 1.5, wt.%) alloys were designed and prepared. The influence of Sn contents on the oxidation behavior of the zirconium alloys in high temperature steam at 800 ~1200℃ were investigated using a simultaneous thermogravimetric analyzer. The results show that when oxidized at 800℃ and 1000℃, the 0.5Sn alloy has the worst oxidation resistance, while the other 4 alloys have little difference; when oxidized at 1100℃ and 1200℃, with the increase of Sn contents, the oxidation resistance shows a decreasing trend. This illustrates the influence of Sn contents on the high-temperature steam oxidation resistance of zirconium alloys is closely related to temperature. The oxidation kinetics of zirconium alloys occurs to one or two transitions, which are closely related to the effects of temperature and alloy composition on the phase transition of α↔β and m-$ZrO_2$ ↔ t-$ZrO_2$. The cross-section structure of the oxidized samples varies with increasing oxidation temperature. After oxidation at 800℃, 5 alloys shows a double layer structure of $ZrO_2$ and *α*-Zr; after oxidation at 1000℃, the cross-section of 5 alloys consists of $ZrO_2$, *α*-Zr(O) and mixed prior-*β*+α-Zr(O) layers; after oxidation at 1100℃, 0.5Sn and 0.75Sn alloys shows a three-layer structure of $ZrO_2$, *α*-Zr(O) and mixed prior-*β*+*α*-Zr(O), and the 1.0Sn~1.5Sn alloys shows a double layer structure of $ZrO_2$ and *α*-Zr(O); after oxidation at 1200℃, the cross-section of 5 alloys consists of $ZrO_2$ and *α*-Zr(O) layers. This is related to the influence of O on α↔β phase transformation of zirconium alloys.

**Keywords** zirconium alloy; loss of coolant accident; high-temperature steam oxidation; phase transformation