Creep behavior of Ni-based alloy GH3535 in 700 ºC molten LiF-NaF-KF salt and Ar environment

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Abstract Molten fluoride salt is used as the fuel carrier and coolant for molten salt reactor (MSR). Under high temperature, the molten fluoride salt is highly corrosive to structure materials, resulting in the dissolution of active metal elements in structure materials. GH3535 superalloy, as the structure material of MSR in China, is subjected to stresses and molten salt corrosion at 600-700 ºC. Therefore, creep and corrosion are two main degradation mechanisms for GH3535. The creep behavior of the alloy in the air and corrosion behavior in molten salt have been comprehensively studied, it can be expected that molten salt corrosion will affect the creep of the alloy. However, there are few studies about the creep crack behavior of GH3535 alloy in high temperature molten fluoride salt.

GH3535 alloy is the important structure material for pipeline in MSR. The pipeline flows with high-temperature molten salt, and the outside of the pipeline is protected by Ar gas. In order to study the creep crack initiation behavior of GH3535 alloy in reactor service environment more accurately. The creep of GH3535 hollow tube specimen filled with fluoride salt was tested at 700 ºC, the applied stress was 135MPa and the outer of the tube was the Ar environment, which is consistent with the applied scenario of GH3535 in MSR. The experimental results indicate that the creep strain of the GH3535 hollow tube is only 2.355% when the creep test to 672 h. It can be observed that the recrystallized fine-grained region appeared on both sides of hollow tube surface, which is leaded by the processing. On the side filled with molten fluoride salt, the depth of fine-grained layer is larger, about 50 μm. The Cr depletion layer is about 4μm and corrosion holes appear in the surface of fine-grained layer. All cracks on the

molten salt side are only under fine-grained layer, which is the sub-surface deformation region. However, on the Ar side the depth of fine-grained layer is only 17 μm .The cracks on the argon side are in the sub-surface deformation region ,which extend to the surface and matrix. Therefore, partial cracks extended the entire fine-grained layer. The number of cracks and the crack depth are also larger in the Ar environment side than in molten salt. It is concluded that initiation of the creep cracks was promoted by the sub-surface deformation induced by the sample turning, and the thick recrystallized fine-grained layer prevents the crack from extending to the surface in the molten salt environment. In this test, because the fine crystal layer is thick and the corrosion layer is thin, the effect of molten salt corrosion is not reflected completely, relevant studies will be conducted in subsequent tests.

Keywords GH3535 superalloy; Creep; Cracks; Molten fluoride salt corrosion; Ar environment