Preparation of aluminized nanocrystalline coating and study of its high temperature corrosion behavior

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Ni-based single crystal superalloys are widely used in industrial gas turbines and jet engines owing to their excellent mechanical strength at elevated temperature. When conventional high-temperature protective coatings, such as aluminized coatings, MCrAlY(M=Ni, Co or combines) overlay coatings, and thermal barrier coatings etc. were used for protection of Ni-based single crystal superalloys, interdiffusion between the substrate and the coating led to formation of secondary reaction zone (SRZ) and detrimental topologically close-packed (TCP) phase in the substrate, which usually reduces the strength and the thermal-fatigue resistance of the superalloy components.

Nanocrystalline coating with the same composition of the substrate alloy exhibits excellent compatibility with the substrate, therefore any possible harmful effects induced by the inter-diffusion between the coating and the substrate can be avoided. Furthermore it can promote rapid formation of Al_2O_3 scale and enhanced the adhesion of the oxide scale, and improved the oxidation resistance of the substrate alloy. The oxidation resistance of DD98M alloy, a second generation single crystal nickel-based superalloy without Re addition, was found to be improved by DD98M alloy nanocrystalline coating at 1000°C. However the oxidation performance at higher temperature and hot corrosion resistance of DD98M nanocrystalline coating needs to be improved.

In the present study, DD98M nanocrystalline coating was deposited on surface of DD98M alloy by magnetron sputtering, then a thin layer of Al-5.2wt.%Si was deposited on the nanocrystalline layer by multi-arc ion plating. After vacuum diffusion treatment of the nanocrystalline + AlSi coating at 870°C for 3h, a bilayer duplex coating with β-NiAl outer layer and γ'-Ni_3Al inner layer were obtained. Isothermal oxidation behavior at 1050°Cin air and hot corrosion resistance in Na_2SO_4+ 25%K_2SO_4 at 900°Cof the DD98M alloy, the nanocrystalline coating and the duplex coating were investigated. After isothermal oxidation at 1050°C, mixed oxides of NiO, α-Al_2O_3, $Ta_{0.8}O_2$, $CrTaO_4$ and $NiAl_2O_4$ formed on the surface of DD98M alloy, and the oxide film cracked and spalled seriously. α-Al_2O_3 with a small amount of $NiAl_2O_4$ formed on the surface of nanocrystalline coatings. A dense pure α-Al_2O_3 film formed on the surface of the duplex coating. The nanocrystalline and the duplex coatings significantly improve the oxidation resistance of the DD98M alloy. In Na_2SO_4 + 25% K_2SO_4 molten salt at 900°C, catastrophic corrosion occurred for DD98M alloy only after 20h corrosion. The as-deposited and pre-oxidation nanocrystalline coatings improved the corrosion resistance of the alloy, and the duplex coating apparently improve the corrosion resistance of the alloy.

KEYWORDS: DD98M superalloy, Nanocrystalline coating, AlSi coating, Vacuum diffusion treatment, Isothermal oxidation, Hot corrosion