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Phase Optimized Ternary Alloy Material for Gas Turbines

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Abstract : Gas turbine blades see the most aggressive thermal stress conditions within the engine, due to Turbine Entry Temperatures in the range of 1500 to 1600°C, but in synchronization with other functional components, they must readily deliver efficient performance, whilst incurring minimal overhaul and repair costs during its service life up to 5 million flying miles. The blades rotate at very high rotation rates and remove significant amount of thermal power from the gas stream. At high temperatures the major component failure mechanism is creep. During its service over time under high temperatures and loads, the blade will deform, lengthen and rupture. High strength and stiffness in the longitudinal direction up to elevated service temperatures are certainly the most needed properties of turbine blades. The proposed advanced Ti alloy material needs a process that provides strategic orientation of metallic ordering, uniformity in composition and high metallic strength. 25% Ta/(Al+Ta) ratio ensures TaAl3 phase formation, where as 51% Al/(Al+Ti) ratio ensures formation of α-Ti3Al and γ-TiAl mixed phases fand the three phase combination ensures minimal Al excess (~1.4% Al excess), unlike Ti-47Al-2Cr-2Nb which has significant excess Al (~5% Al excess) that could affect the service life of turbine blades. This presentation will involve the summary of additive manufacturing and heat treatment process conditions to fabricate turbine blade with Ti-43Al matrix alloyed with optimized amount of refractory Ta metal. Summary of thermo-mechanical test results such as high temperature tensile strength, creep strain rate, thermal expansion coefficient and fracture toughness will be presented. Improvement in service temperature of the turbine blades and corrosion resistance dependence on coercivity of the alloy material will be reported. Phase compositions will be quantified, and a summary of its correlation with creep strain rate will be presented.

Keywords : gas turbine, aerospace, specific strength, creep, high temperature materials, alloys, phase optimization
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