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Phase Composition Analysis of Ternary Alloy Materials for Gas Turbine Applications

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Abstract : Gas turbine blades see the most aggressive thermal stress conditions within the engine, due to high Turbine Entry Temperatures in the range of 1500 to 1600°C. The blades rotate at very high rotation rates and remove a significant amount of thermal power from the gas stream. At high temperatures, the major component failure mechanism is a creep. During its service over time under high thermal 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 and gas turbine components. The proposed advanced Ti alloy material needs a process that provides a strategic orientation of metallic ordering, uniformity in composition and high metallic strength. The chemical composition of the proposed Ti alloy material (25% Ta/(Al+Ta) ratio), unlike Ti-47Al-2Cr-2Nb, has less excess Al that could limit the service life of turbine blades. Properties and performance of Ti-47Al-2Cr-2Nb and Ti-6Al-4V materials will be compared with that of the proposed Ti alloy material to generalize the performance metrics of various gas turbine components. This paper will involve the summary of the effects of additive manufacturing and heat treatment process conditions on the changes in the phase composition, grain structure, lattice structure of the material, tensile strength, creep strain rate, thermal expansion coefficient and fracture toughness at different temperatures. Based on these results, additive manufacturing and heat treatment process conditions will be optimized to fabricate turbine blade with Ti-43Al matrix alloyed with an optimized amount of refractory Ta metal. Improvement in service temperature of the turbine blades and corrosion resistance dependence on the coercivity of the alloy material will be reported. A correlation of phase composition and creep strain rate will also be discussed.

Keywords : high temperature materials, aerospace, specific strength, creep strain, phase composition
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