JET ENGINE GAS TURBINE BLADES: BEYOND THE SUPER ALLOYS

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Abstract

The High Pressure Turbine (HPT) blades of a turbo-engine, whether used in land-based power-generating equipment or in aircraft propulsion systems, are among the most severely loaded engineering components; they operate at very high temperatures, they are subjected to very high centrifugal stresses, they are susceptible to creep and fatigue damage and they are also exposed to adverse conditions such as corrosion, oxidation, sulphidation, foreign object damage, etc. Nickel-based super alloys were used to make turbine blades in the 1940s and the Turbine Inlet Temperature (TIT) has been steadily increased over the years due to material innovations such as improved alloy chemistry and protective coatings, processing innovations such as directional solidification and single crystal blade fabrication and design innovations such as complex internal cooling channels that enable the blades to operate at temperatures beyond their melting point. With the improvements attainable with the super alloys reaching the limit, efforts are underway to reduce the weight of the blades by making them out of lower density materials such as intermetallic compounds of titanium and aluminum. With the reduction in the centrifugal forces, the weight of the supporting structures such as the bearings can also be reduced, resulting in gains in fuel consumption and reduction in the generation of exhaust gases. Intermetallic compounds such as titanium aluminides and nickel aluminides, composites using such intermetallics as matrices, and ceramic matrix composites with silicon carbide fibers in a silicon carbide matrix, are being introduced in a phased manner; some of these materials have already shown their potential in the Low Pressure Turbine (LPT) stages and are advancing through the higher temperature parts of the turbo-engine with the ultimate goal of replacing the heavier super alloys. These new materials are difficult to fabricate and innovative methods based on centrifugal casting, forging and additive manufacturing from powders are being developed. This paper describes some of these important innovative developments.