Development of TiAl-based alloys for high temperature structural applications

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TiAl-based alloys represent an important class of structural materials providing a unique set of physical and mechanical properties that can lead to substantial payoffs in the automotive industry, power plant turbines and aircraft engines.

Microstructural control through solidification and heat treatments is a key factor for achieving required microstructural and mechanical properties of TiAl-based alloys. Under normal gravity, natural convection arises due to thermal and solutal density gradients. Non-equilibrium phase transformations in Ti-Al alloys are sensitive to the local liquid composition. Hence, to suppress the effects of thermo-solutal convection, terrestrial gravity solidification experiments are combined with microgravity experiments. The results of the terrestrial gravity solidification experiments, which are being used as input data for development and optimisation of the microgravity experiment on board of Maxus 9 sounding rocket, will be presented.

In many TiAl-based alloys, critical cooling rates to achieve grain refinement through formation of massive γ_M(TiAl) are relatively high which may result in shape distortion, cracking or even fracture of complex shaped castings during cooling. The latest 4th generation of TiAl-based alloys is based on alloying with elements such as Nb and Ta which significantly reduce diffusion to achieve massive transformations at low cooling rates. The current status in development, characterization of microstructure and mechanical properties and nondestructive testing using 3D computed tomography of the 4th generation of TiAl-based alloy will be presented.

The biggest problem which is hindering the manufacture of engineering components from TiAl-based alloys is their processing. Precise casting represents very promising technology for production of complex shaped components with a competitive price when compared to those of nickel-based superalloys. The difficulties arise mainly from the high reactivity of molten TiAl-based alloys with ceramic crucible. Processing of low cost precision cast turbocharger wheels by induction melting in oxide crucibles and gravity casting into ceramic moulds under argon atmosphere will be described.