Development of titanium aluminides by Spark Plasma Sintering: to a low cost near-net shape blade with enhanced properties

Thomas Voisin[1*], Jean-Philippe Monchoux[1], Muriel Hantcherli[1], Marc Thomas[2], Helmut Clemens[2] and Alain Couret[1]

1: CEMES/CNRS - Laboratory of Material Elaboration and Structural Studies, 31055 Toulouse, France
2: ONERA - The French Aerospace Lab, 92322 Châtillon, France
3: Department of Physical Metallurgy and Materials Testing, Montanuniversität Leoben, A-8700, Leoben, Austria.

With the aim of reducing fuel consumption, noise, and greenhouse gas emissions, titanium aluminides (TiAl) are of great interests to be used in the turbine blades of low pressure stage of airplane engines. TiAl alloys offer a high strength at both room and working temperature combined with an exceptional resistance to oxidation. After thirty years of development, TiAl turbine blades were implemented in the new generations of engine by several motorists as General Electric or SNECMA-SAFRAN. However, these alloys still suffer from a limited ductility at room temperature and a difficult and expensive manufacturing process.

It is within this context that the SPS process has been used and adapted in order to realize near-net shape blades in one step as well as developing a TiAl alloy fulfilling the industrial requirements. Spark Plasma Sintering (SPS) is a powder metallurgy technique where the densification occurs thanks to the simultaneous application of a pulsed direct current and of a uniaxial pressure.

Firstly, this presentation will focus on the processing of turbine blades by SPS. The different steps which have led to the design of an adequate tool will be presented. The understanding of the deformation behavior of the powder particles has been required as well as the temperature field mastering within the tool. Then, the sintering of several complex shapes has been realized and an up-scaling to a bigger SPS apparatus has led to the production of two kinds of near-net shape blades.

Secondly, investigations conducted on two TiAl alloys processed by SPS will be presented. Attention will be paid on the relationship between microstructure, mechanical properties and deformation mechanisms. SEM observations, tensile and creep tests have been realized to optimize the microstructure in order to obtain the best mechanical properties. Then, a plasticity study has allowed evidencing the different deformation mechanisms occurring in the two alloys. Conventional TEM observations have been carried out as well as in-situ straining at room temperature. TiAl alloy exhibiting outstanding mechanical properties at both room and high temperature have been produced, exceeding the industrial specifications.

** : Thomas Voisin; CEMES/CNRS, 29, rue Jeanne Marvig, 31055 Toulouse, FRANCE; voisin@cemes.fr; +33 (0)5 62 25 78 05*