European Congress and Exhibition on Advanced Materials and Processes

FEMS EUROMAT 2015
Warsaw, 20-24 Sep. 2015

Session E3.1 Materials for Transportation
Electronic Book of Abstracts
Abstract ID: 2005

Chromium-rhenium-alumina composites for powertrain application: Processing route, microstructure, properties and numerical modelling

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Chromium based composites reinforced with alumina particles combine enhanced thermal, oxidation and wear resistance with mechanical strength and hardness. Because of these valuable properties Cr/Al_2O_3 composites can be used e.g. in the automotive sector for elements of powertrain. Rhenium due to its good mechanical and thermal properties is primarily used as an admixture of nickel superalloys in the aerospace and chemical industries.

In the present paper a powder metallurgy route was used to manufacture dense Cr/Re/Al_2O_3 bulk composites with rhenium admixture of 2vol% and 5vol%. Composites were processed by hot pressing (HP) and by spark plasma sintering (SPS) techniques. The density of the sintered composites exceeded 98% of the theoretical value. Microstructural characterisation revealed that a solid solution of rhenium in chromium was partially formed. Mechanical properties such as Young's modulus, bending strength, hardness, plastic limit are promising so are oxidation and corrosion resistance.

A numerical FE model was developed for the prediction of thermal residual stresses (TRS) and damage generated in the metal and ceramic phase during cooling from high sintering temperature down to room temperature. The model uses micro-CT images of the real material microstructure as the input data. A good agreement of the simulation results for TRS and the measurements of by neutron diffraction was achieved.

The obtained Cr/Re/Al_2O_3 composites were already tested as demonstrators of valve seats in combustion engines and good preliminary results were reported.