THE EFFECT OF GRAIN SIZE ON THE MECHANICAL PROPERTIES AND THE OXIDATION INDUCED CRACK HEALING EFFICIENCY OF CR_2ALC CERAMIC

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Keywords: Cr_2AlC ceramic, grain size, mechanical properties, self-healing

ABSTRACT

The Cr_2AlC ternary ceramic compound, which belongs to the MAX phase family, has unique properties, such as high temperature strength, oxidation and corrosion resistance, good electrical and thermal conductivity, and machinability. It has been demonstrated that crack damage in this type of ceramics can be repaired by selective oxidation of the aluminium atoms. The alumina formed in the crack gap has a strong adhesion to the fracture surfaces enabling full strength recovery. However, it was observed that the restoration of the properties upon exposure to high temperature air is very slow, most likely to be due to the slow supply of Al atoms. Given the importance of grain boundaries as a path for rapid element supply to the fracture surface, it is to be expected that the strength and healing efficiency depend on the grain size of the MAX phase material. But this relation has not been demonstrated yet. It is therefore interesting to study the effect of grain size on the oxidation induced crack healing of Cr_2AlC.

In our work, the Cr_2AlC ceramics are produced by reactive hot-press sintering using the chromium, aluminum and graphite powders as the starting materials. The grain size of Cr_2AlC ceramics was controlled by adjusting the sintering temperature and holding time. In this way several materials with an average grain size in the range of 10 to 50 μm were obtained. X-ray diffraction was used to verify the phase compositions of Cr_2AlC ceramics. Crack damage was induced with a Knoop indentator in three point bending samples The flexural strength and fracture toughness of the initial material before and after healing were determined by three point bending tests and the single edge notch beam technique, respectively. The pre-cracked specimens were healed at 1100 °C in air for various times. From the experimental data the strength recovery was determined as a function of the Cr_2AlC grain size and the observations are used to build a general model for crack healing in MAX phase materials