MULTIPLE CRACK-HEALING AND STRENGTH RECOVERY IN MAX PHASE CERAMICS

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ABSTRACT

MAX phase materials such as Ti_3AlC_2, Ti_2AlC and Cr_2AlC are very attractive materials in their own right as they combine desirable metallic and ceramic properties at the same time due to their atomically layered and hexagonal crystal structure. In our earlier studies [1, 2] we demonstrated that these materials possess interesting self healing properties when exposed to high temperatures in an oxidizing environment. The recovery of mechanical strength is due to the formation of a residue of desirable composition (mainly α-Al_2O_3, but also some TiO_2); see Fig. 1.

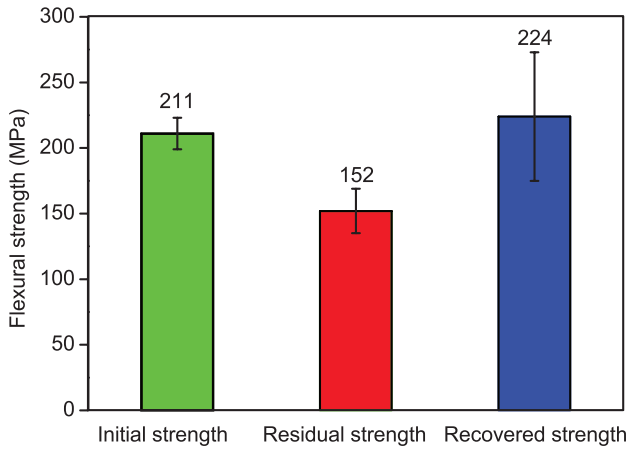

Figure 1: Strength recovery of Ti_2AlC specimens after crack healing at 1200 °C for 2 hours in air.

However, in our previous studies we only demonstrated qualitatively once-only self-healing. In the work to be presented, we demonstrate multiple self-healing (i.e. several consecutive sequences of fracture and healing) using a miniature 3-point bending test and recording the failure load. Using this approach, the degree of healing of a crack with length of about 2.5 mm (in a sample of 4 mm wide) is quantified over up to 7 healing steps; see Figure 2. The crack damage relative to the critical crack length of the virginal material (critical damage level) is presented as a function of the number of the fracture (F) and healing (H) cycle. After each fracture cycle a crack with a length of about 85 % of the critical crack length was introduced (applied damage level). The blue dashed line represents the remnant damage as determined from the decay of the fracture toughness.

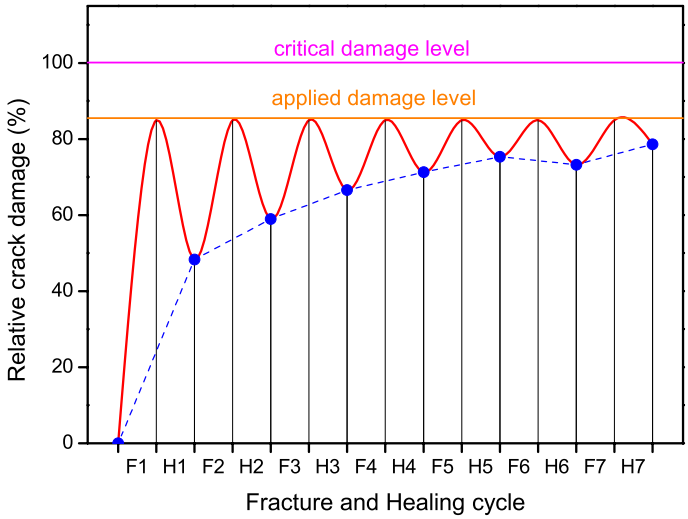

Figure 2: Damage and healing development in Ti_2AlC based on the fracture toughness data.

The fracture strength studies were combined with detailed studies on the composition of the deposit in the crack as well as the degree of filling as derived from X-ray tomographic studies. On the basis of the results obtained we derived a predictive model of the healing capabilities of MAX phase materials as a function of the initial damage and the operating conditions.

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