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EFFECT OF COLD DEFORMATION ON FATIGUE BEHAVIORS OF PARTICULATE REINFORCED MMC

G. Quan [1,2], A. Berg[1], C. Theodosiou[3], L. Wagner[1], and J. He[2]

[1] Technical University of Brandenburg at Cottbus, 03044 Cottbus, Germany
[2] Xi´an Jiaotong University, Xi´an 710049, P. R. China
[3] Exchange international student from Greece of DAAD

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Fatigue resistance is one of the most important mechanical properties of engineering materials for application safety and durability, in particularly for ceramic particle metallic materials with enhanced strength and stiffness. Cold deformation is a suitable fabrication route for such materials since it can induce particle fracture during processing. This can refine the reinforcement, however some microstructural damage may be induced. The latter can be harmful to ductility and toughness of the material, as well as fatigue resistance. Even if further heat treatment can heal all or most of such damage, the work – hardening effect might be lost to some degree. In the present investigation, fatigue tests were performed on cold and hot worked particulate reinforced MMC materials to study the effect of modified microstructures on fatigue performance.

The fatigue performance of Al_2O_{3p}/AA6061 is studied after cold and hot working (swaging) conditions (CW, HW), affected by T6 temper and different surface treatments, like electro polishing (EP), mechanical polishing (MP) and shot peening (SP). For electro polishing, the hot worked material show the best low cycle fatigue (LCF) behaviour (Fig. 1).

The mechanical surface treatment (Shot peening) results in the best endurance limit for the as received and the T6 tempered material (Fig. 2). Cold working has an inferior effect on fatigue behaviour. For all conditions, the 10^7 fatigue limits show only slight differences, although shot peening always improves both, the low cycle fatigue and the endurance limit. All results will be discussed in terms of microstructure, tensile properties, fatigue behaviour and surface treatments.

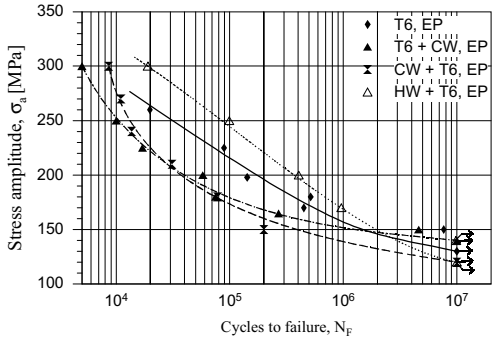

Fig.1 S-N curves, EP (Electro polished)

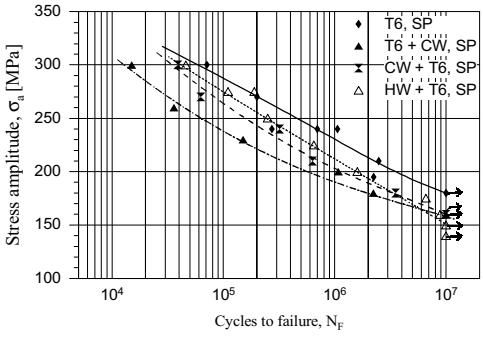

Fig. 2 S-N curves, SP (Shot Peened)

To investigate the influence of cold deformation on fatigue behaviour, optical microscopic surface observations were performed by stopping the fatigue test. For the electro polished and mechanical polished conditions multiple crack nucleation mechanism was found within the matrix area and the cracks tends to avoid the particles (Fig. 3). Crack nucleation was mainly found in the unhealed gaps, so that the cyclic lifetime is much shorter than in undeformed material. SEM analysis indicated that the fatigue cracks nucleate at the surface for electro polished condition and propagate within the matrix and along the interfaces (particle/ matrix), that is different from the final fracture morphology, which is characterized by particle breaking. After shot peening, crack nucleation site is shifted to the subsurface at lower stress amplitudes (Fig. 4).

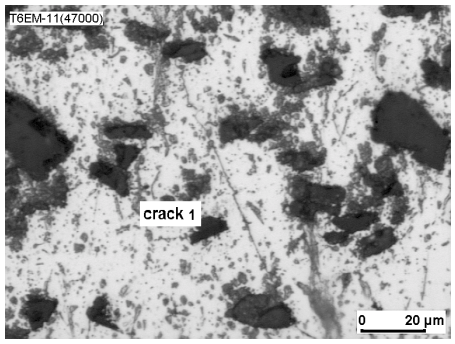

Fig. 3 Micrograph of free surface, T6 + EP + MP at $\sigma_a = 225$ MPa, new incubated crack within the matrix after 4.7×10^4 cycles

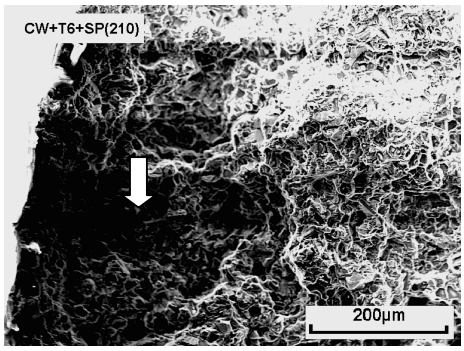

Fig. 4 Crack nucleation site of a shot peened specimen (SEM), CW + T6 + SP, $\sigma_a = 210$ MPa, $N_F = 6.3\times10^5$

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