Fatigue Crack Propagation in Martensitic and Austenitic Steels

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The mechanisms of fatigue crack growth are compared between quenched and tempered steels (BCC crystal structure) and austenitic steels (FCC crystal structure). Fatigue crack growth rates were measured in an annealed and in an aged maraging steel and in three different austenitic steels. The fatigue crack growth rates of the maraging steels are independent of the monotonic yield stress and are typical of the growth rates of steels with a BCC crystal structure. The crack growth rates in the austenitic steels are an order of magnitude lower than for the maraging steels for $\Delta K < 30$ ksi $\sqrt{in}$. The excellent fatigue crack growth resistance of austenitic stainless steels is related to the deformation induced transformation from a FCC to a BCC crystal structure taking place in the plastic zone near the crack tip.

Microhardness measurements were used to determine the plane strain plastic zone sizes as a funktion of ΔK and to evaluate the cyclic flow stress near the crack tip. The presence of a reversed cyclic plastic zone within the monotonic plastic zone was confirmed. The cyclic zone is associated with large reversed plastic strain amplitudes which lead to work hardening or work softening of the base material depending upon its monotonic yield stress and structural stability. The two maraging steels work soften near the tip of the crack while the three austenitic steels work harden. The unique crack growth

rates of the quenched and tempered steels is shown to be related to a unique cyclic flow stress reached near the crack tip after cyclic deformation within the plastic zone. It is concluded that marked improvements in fatigue crack propagation resistance of steels can only be achieved by lowering the stacking fault energy of a steel by alloying additions such as nickel or silicon.