Influence of Hardness and Residual Stresses on Fatigue Resistance: The Role of Dislocations and Microstructure

Jaroslav Pokluda

Brno University of Technology, Czech Republic

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*e-mail: pokluda@fme.vutbr.cz

Resistance of metallic materials to mechanical fatigue is a complex scientific problem. The presentation is focused on the influence of residual stresses and hardness that represents a link between fatigue process and magnetic methods. Since this influence is usually described in the literature in an empirical way based on experimental data only, we will focus on the underlying physical principles, i.e., on the role of lattice defects and microstructure in individual stages of fatigue process: crack nucleation, short-crack growth and long-crack growth. Besides the elements of dislocation theory related to fatigue damage, the microstructural interpretation of fatigue limit is mentioned. The processes of dislocation interaction with microstructural barriers, dislocation emission-reabsorption and crack closure associated with crack growth are described. Consequently, the high fatigue resistance of hard materials is shown to be mainly caused by their small characteristic microstructural distance that hinders crack nucleation and prolongs the stage of short crack growth. On the other hand, compressive residual stresses enhance fatigue resistance due to a reduction of growth rates of both short and long cracks.