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PLASTIC ZONE AT THE MIXED MODE CRACK TIP IN NICKEL-BASED SINGLE CRYSTAL
PLATE BASED ON A MODIFIED YIELD CRITERION

Abstract

Because of excellent anti-fatigue and anti-creep in high temperature condition, nickel-base single crystal alloy has become the key materials in manufacturing blades of aircraft engines and gas turbines. Fracture and crack problem is one of research focus in the field of solid mechanics and the key problem in various engineering fields. The shape and size of crack tip plastic zones are very important to analyze crack problem and there is close contact between crack propagation and crack tip plastic zone. A new modified yield criterion used for orthogonal anisotropic materials was given by adding a quadratic correction term of deviatoric stress tensor in classical Hill yield criterion in this paper. The plastic zones at the tip of I/II mixed mode crack in nickel-based single crystal plate were analyzed by using this modified yield criterion which includes tension-shear stress coupling terms. The analytical solutions of polar radius of crack tip plastic zones were derived respectively in the plane stress condition and in the plane strain condition. The influences of tension-shear stress coupling stress ratio of I/II mixed mode crack, the angles between the crack plane and crystal axis orientations of material and the temperature on crack tip plastic zones were discussed. The results obtained showed that crack tip plastic zones obtained by using new modified yield criterion considering tension-shear stress coupling were a little smaller than those obtained by using Hill yield criterion. The effect of tension-shear stress coupling on the plastic zones in the plane stress condition was bigger than that in plane strain condition. The stress ratio of I/II mixed mode crack had less effect on the shape of plastic zones and had obvious effect on the dimension of plastic zones. The angle between the crack plane and crystal axis orientations of material had more effect on the shape of the crack tip plastic zones. The temperature has greater influence on the size of crack tip plastic zones.

Key words: aerospace propulsion system; mixed mode crack; plastic zone; nickel-based single crystal plate; yield criterion