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Effects of melt-pool geometry on microstructure structural damage behavior for single crystal superalloys in rapid solidification process

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Abstract: Electro-machining surface stochastic failure is one of the main factors which limit the use of electrical discharge machining in hot end of aeronautics and astronautics. This study proposes the recast layer (RL) failure prediction model and analyses the effect of unit melt-pool geometry on recast layer structural stability in single crystal by analyzing cellular-dendrite microstructure around ring layer. Both model calculation and experimental results show that melt-pool geometry parameters-radius-depth ratio and tangent angle directly influence ring RL thermal structural stability. Smaller radius-depth ratio range and larger tangent angle (on (100) substrate) can significantly improve RL performance or even avoid high temperature service structural damage. For certain undesirable melt-pool geometry, the RL damage crack location has selectivity on specific secondary orientation. High temperature oxidation, crack initiation and propagation mode together influence RL failure modes in high temperature atmospheric environment. Electro-machining surface reliability can be effectively evaluated with the prediction model, and the geometry parameters can be used to provide efficient data for surface structure design.

Keywords: Rapid solidification microstructure; Single crystal superalloys; Melt-pool geometry; Secondary orientation; Thermal fatigue