

论文

喷丸强化过程及冲击效应的数值模拟

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摘要:

运用大型有限元软件LS-DYNA建立了喷丸强化处理过程的三维有限元模型, 研究了弹丸冲击作用下, 铝合金材料Al 2024-T3动态响应过程中的应力波结构、应变率效应及应力波衰减效应等动态参量; 研究了弹丸搭接率对于残余应力场的影响, 建立了高覆盖率多丸粒强化模型; 研究了冲击顺序、材料应变率及初始残余应力对强化效应的影响; 研究了喷丸强化后的表面微观变形特征. 分析结果表明, 弹丸高速冲击引起的弹塑性双波会在材料内部形成高应变率效应; 弹丸搭接率 ζ 对于强化效应有明显影响, $\zeta=1/2$ 是近似的临界值; 不同冲击顺序对于强化效果的影响较小, 材料应变率对于强化效果有显著影响; 初始残余应力对于喷丸强化最终形成的残余应力场的影响取决于弹丸冲击速度; 经过喷丸强化处理, 零件表面形成微米级凹坑, 并且随着冲击次数和喷丸覆盖率提高, 凹坑深度逐渐增加.

关键词: 喷丸 有限元法 残余应力 冲击 应变率 覆盖率

NUMERICAL SIMULATIONS OF SHOT-PEENING PROCESS AND IMPACT EFFECT

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Abstract:

The shot-peening process and impact effect were simulated by using software LS-DYNA. Propagation and interaction of stress waves in the treated material were analyzed based on numerical simulation results. The stress wave structure, high strain-rate effect and attenuation of stress wave were also investigated. The overlapping ratio between shots was studied and the high peening coverage model was established. The effects of impact sequence, material strain-rate and initial residual stress on the residual stress and the surface deformation were examined. The results indicate that the high strain-rate induced by shot impact is related to the elastic and plastic wave structure. The surface quality is essentially affected by overlapping ratio and its approximate critical value is found to be 1/2. The effect of impact sequence can be neglected, but the strain rate plays an important role in determining the level and distribution of the residual stress field. The influence of original residual stress in the target is significantly dependent on the impact velocity. The shallow pocket in depth is induced on the top surface of material by multiple impacts, and the surface deformation increases with the increase of impact time.

Keywords: shot-peening finite element method residual stress impact strain rate coverage ratio

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