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微纳技术与精密机械

脉冲激光焊接HastelloyC-276合金的熔池流动传热特性分析

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摘要： 基于流体动力学方程和传热方程建立了三维瞬态模型,用于研究脉冲激光焊接0.5 mm厚Hastelloy薄板时熔池的流动行为及传热特性。应用Fluent软件,采用有限容积法(FVM)求解控制方程,用SIMPLE算法处理速度与压力的耦合。引入P_e来衡量焊接熔池中对流传热与传导传热的相对强弱,并以此分析焊接熔池的传热特性。结果表明:沿焊接方向,焊接熔池的流动速度随着离熔池中心距离的增加先增加后减小;在给定试验条件下,熔池流动速度在离熔池中心0.2 mm左右时出现最大值,且沿焊接方向前方稍大于后方,而后迅速减小为零;焊接熔池中对流的存在使得焊接熔池熔深较小而熔宽较大;最终的焊接形貌由对流传热与传导传热相互作用而成。对焊缝形貌的数值模拟结果与实验结果进行了比较,计算结果与实验结果吻合较好。此模型可为脉冲激光焊接Hastelloy C-276薄板时熔池流体流动行为的分析提供理论依据。

关键词： 激光焊接 脉冲激光器 流体流动 数值模拟 焊缝形貌

Analysis of fluid flow and heat transfer in weld pool during pulsed laser welding Hastelloy C-276 alloy

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Abstract: A 3D transient model was established based on the theories of fluid dynamics and heat transfer to analyze the fluid flow and the heat transfer characteristics in the liquid pool when a pulse laser was used to weld the Hastelloy C-276 alloy. On the basis of software Fluent, the Finite Volume Method (FVM) was employed to solve the control equations and the algorithm of SIMPLE was adopted to deal with the coupling of velocity and pressure. The P_e number was induced to evaluate the relative importance of convection and conduction then to analyze the heat transfer characteristics of welding pool. The research indicates that fluid flow velocities along the welding direction in the liquid pool increase with the increasing of the distance from the melting pool center, and then decrease. Under the given conditions, the maximum flow velocity is firstly found at the 0.2 mm from the melting pool center, then it reduces to zero rapidly and velocities in front of the melting pool along the welding direction are slightly larger than that of in the rear ones. Furthermore, The convection leads the melting pool to wider and shallower and the interaction of convection and conduction decides the final weld joint morphology. The numerical simulation is in good agreement with the experimental results, Which proves that the model can provide a theoretical basis for the analysis of the fluid flow in the weld pool during pulsed laser welding thin Hastelloy C-276 alloy.

Keywords: laser welding pulsed laser fluid flow numerical simulation weld joint morphology

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