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基于小孔形状的TCS不锈钢激光+GMAW-P复合焊热场模型

张转转, 胥国祥, 武传松

1) 山东大学材料液固结构演变与加工教育部重点实验室, 济南 250061

2) 江苏科技大学材料科学与工程学院, 镇江 212003

摘要: 为合理描述激光能量在小孔内的分布特征, 采用光线追踪法处理光线在小孔内的多次反射和孔壁的Fresnel吸收, 对线热源小孔模型做出了改进. 根据小孔形状尺寸的计算结果, 确定激光焊体积热源分布参数. 将标定后的激光焊体积热源分布参数应用于激光+熔化极脉冲电弧(激光+GMAW-P)复合焊的组合式体积热源模型, 对TCS不锈钢复合焊准稳态温度场进行了数值分析. 开展了TCS不锈钢复合焊工艺实验, 将复合焊缝形状尺寸的模拟结果与实测结果进行了对比, 验证了所建立的复合焊热场模型. 基于小孔形状的复合焊热场模型能较好地模拟TCS不锈钢复合焊温度分布与焊缝成形. 利用该模型计算了不同工艺条件下TCS不锈钢焊接HAZ形状尺寸以及HAZ内不同位置处的热循环曲线, 分析了TCS不锈钢复合焊的热循环特征, 为接头组织与性能的预测分析奠定了基础.

关键词: 小孔形状 复合焊 TCS不锈钢 热场模型 热循环

THERMAL FIELD MODEL FOR LASER+GMAW-PHYBRID WELDING OF TCS STAINLESS STEEL BASED ON THE PREDICTED KEYHOLE SHAPE

ZHANG Zhuanzhuan, XU Guoxiang, WU Chuansong

1) Key Lab for Liquid--Solid Structure Evolution and Materials Processing (Ministry of Education), Shandong University, Jinan 250061

2) School of Materials Science and Engineering, Jiangsu University of Science and Technology, Zhenjiang 212003

Abstract: In order to describe the distribution characteristics of laser energy inside the keyhole reasonably, the ray tracing method is used to deal with the multiple reflections of laser beam in the keyhole and Fresnel absorption on the keyhole wall. The line-source based keyhole model is modified. The predicted shape and size of the keyhole are employed to determine the distribution parameters of the volumetric heat source for laser beam welding, which are applied to the combined heat source model for hybrid laser+ pulsed gas metal arc welding (laser+GMAW-P) process. Based on such an adaptive heat source model, the numerical analysis of quasi-steady state temperature field in hybrid welding of TCS stainless steel is conducted. The hybrid welding experiments of TCS stainless steel are carried out, and the predicted weld shape and size are compared with the measured results to validate the established thermal model for hybrid welding. It is found that the thermal model for hybrid welding of TCS stainless steel based on the predicted keyhole shape can well simulate the temperature profiles and weld formation. Besides, the thermal model is used to calculate the shape and dimension of heat-affected zone (HAZ) and thermal cycles at different positions in HAZ under different process conditions, and the characteristics of thermal cycles of TCS stainless steel in hybrid welding are analyzed, which lay the foundation for the prediction of microstructure and properties of TCS stainless steel weld joints.

Keywords: keyhole shape hybrid welding TCS stainless steel thermal model thermal cycle

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通讯作者: 武传松

作者简介: 张转转, 女, 1987年生, 博士生

通讯作者E-mail: wucs@sdu.edu.cn

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