2022 第十五届全国激光加工学术会议
15th National Conference on Laser Processing
2022年10月 | 武汉

准连续激光增材制造 TC4 钛合金工艺研究

彭艺杰[1]，范伟[1]，谭华[1*]，林鑫[1]，黄卫东[1]

[1] 西北工业大学凝固技术国家重点实验室，西安市友谊西路 127 号，710072

*Email: tanhua@nwpu.edu.cn

摘要：准连续激光是介于连续激光和脉冲激光之间的一种激光模式，在增材制造过程中利用准连续激光能够灵活调控晶体生长行为，进一步实现单晶、类单晶、等轴晶试样的制备。目前，相关研究主要集中于工艺对组织的影响机制，对基础成形工艺特性往往忽视。然而，单个沉积点的几何形貌以及表面质量对组织形成具有显著影响。基于此，本研究以 TC4 粉末为材料、以准连续激光为热源，在不同激光作用时间和激光功率条件下制备多组沉积点，结合有限元方法模拟温度场，研究了沉积点形貌变化与粘粉现象，并通过多点沉积实验进行验证。主要结论如下：（1）沉积点的高度受到传热传质过程的综合影响，而沉积点的直径则主要受到传热过程的影响，因此在准连续激光模式下不能通过简单计算激光输入能量来进行参数优化。（2）沉积点粘粉数量随激光作用时间的增加而增多，随激光功率的增大而减少。此外，粘附粉末更倾向于形成在沉积点的边缘而不是中心区域。（3）论证了准连续激光的应用在细微晶粒和高打印质量零件制造方面具有潜力。

关键词：增材制造；准连续激光；TC4 钛合金；有限元分析

Study of quasi-continuous-wave laser additive manufacturing process for TC4 titanium alloy

Yijie Peng[1], Wei Fan[1], Hua Tan[1*], Xin Lin[1], Weidong Huang[1]

[1] State Key Laboratory of Solidification Processing, Northwestern Polytechnical University, No.127, West Youyi Road, Xi'an, 710072

*Email: tanhua@nwpu.edu.cn

ABSTRACT: Quasi-continuous wave laser (QCW), which lies between continuous wave laser and pulsed laser in terms of its laser mode, can be used to flexibly regulate crystal growth behavior during the additive manufacturing process. This makes it possible to prepare single crystals, quasi-single crystals, and equiaxed grains. Currently, research on QCW technology mainly focuses on the effect of processing parameters on microstructure formation, but ignores the basic process characteristics. However, the geometric morphology and surface quality of individual deposition points significantly affect

microstructure development. Therefore, this study utilized TC4 powder as the material and QCW laser as the heat source to prepare multiple deposition points under different laser exposure times and power conditions. Combined with finite element method simulation of temperature field, morphological changes of deposition points and powder sticking phenomenon were investigated and validated through multipoint deposition experiments. The main conclusions are as follows: (1) The height of deposition points is influenced by integrated heat and mass transfer processes, while the diameter is mainly affected by heat transfer. Therefore, parameter optimization cannot be simply calculated based on the input energy in QCW mode. (2) The number of powder sticking increases with increasing laser exposure time, while decreasing with increasing laser power. Additionally, adherent powder is more likely to form at the edge than at the center of the deposition point. (3) The potential of QCW laser in manufacturing fine-grained materials and high-quality parts has been demonstrated.

KEYWORDS: additive manufacturing; quasi-continuous-wave laser; TC4 alloy; finite element analysis

*第一作者（报告人）联系方式：彭艺杰、13259217369、yijiepeng@mail.nwpu.edu.cn