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铝合金激光送丝熔覆成形的微观组织及力学性能研究

胡溢洋[1]，米高阳[1]，王春明[1]

[1] 材料科学与工程学院，华中科技大学，武汉，430074

D202180395@hust.edu.cn

增材制造（Additive manufacturing）具有结构设计灵活性高、材料利用高的特点，为复杂构件近净成形提供机遇。激光送丝熔覆沉积速度快，构件致密度高，对于铝合金材料的激光送丝熔覆，材料对激光的反射率大，输入能量难以把握，成形困难，熔覆层易形成气孔、裂纹等缺陷。基于以上问题，本文围绕航天领域构件表面修复的实际工程需求，结合激光送丝熔覆修复基础研究，设计 5 系铝合金激光送丝熔覆试验。研究了激光功率、扫描速度和送丝速度这三个重要工艺参数对单层单道熔覆成形的影响规律，得到了部分工艺窗口。制备了多层堆高构件，发现每层熔覆层均以其上一道熔覆层为基底非自发形核生成柱状晶，熔覆层中心部位为等轴晶，从下至上 β（Mg5Al8）相减少，晶粒变大。平行于熔覆方向的拉伸试样强度达到 232Mpa，略高于基板（201Mpa），屈服强度为 121Mpa，达到基板的 91%（133Mpa）。制备了多层多道构件，成形件从底部到顶部的显微组织中，重新析出的黑色粗大杂质相逐渐增多。平行于熔覆方向的拉伸试样的抗拉强度为 256Mpa，屈服强度为 127Mpa；垂直于于熔覆方向的拉伸试样的抗拉强度为 229Mpa，屈服强度为 122Mpa。本研究建立了 5 系铝合金激光送丝熔覆技术工艺-组织-性能的联系，为激光送丝熔覆技术的实际应用提供理论基础与工程经验。

关键词：增材制造；5 系铝合金；激光熔覆；拉伸强度

Additive manufacturing has the characteristics of high structural design flexibility and high material utilization, which provides opportunities for near-net shape of complex components. Laser wire feeding cladding has fast deposition speed and high component density. For laser wire feeding cladding of aluminum alloy materials, there is a large reflectivity to the laser, the input energy is difficult to grasp, forming is difficult, and the cladding layer is easy to form pores, cracks, etc. defect problem. Based on the above problems, this paper focuses on the actual engineering needs of the surface repair of components in the aerospace field, combined with the basic research of laser wire feeding cladding repair, and designs a 5 series aluminum alloy laser wire feeding cladding experiment. The influence of three important process parameters, such as laser power, scanning speed and wire feeding speed, on single-layer single-pass cladding formation was studied, and some process windows were obtained. The multi-layer stacking components were prepared, and it was found that each cladding layer used the previous cladding layer as the base to form columnar crystals by non-spontaneous nucleation. decrease, the grain size becomes larger. The tensile specimen strength parallel to the cladding direction reaches 232Mpa, which is slightly higher than that of the substrate (201Mpa), and the yield strength is 121Mpa, reaching 91% of the substrate (133Mpa). Multi-layer multi-channel components were prepared, and the re-precipitated black coarse impurity phase gradually increased in the microstructure of the formed parts from the bottom to the top. The tensile strength of the tensile specimen parallel to the cladding direction is 256Mpa, and the yield strength is 127Mpa; the tensile strength of the tensile specimen perpendicular to the cladding direction is 229Mpa, and the yield strength is 122Mpa. This study establishes the process-structure-property relationship of 5-series aluminum alloy laser wire-feeding cladding technology, and provides theoretical basis and engineering experience for the practical application of laser wire-feeding cladding technology.

Key words: additive manufacturing; 5 series aluminum alloy; laser cladding; tensile strength

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胡溢洋（第一报告人）联系方式：胡溢洋，18971114068，D202180395@hust.edu.cn