超声复合磁力研磨异型管参数优化设计及分析

陈燕，曾加恒，钱之坤，赵杨，陈宇辉

（辽宁科技大学，辽宁 鞍山 114051）

摘　要：目的 改善镍基合金异型管表面质量，降低表面粗糙度。**方法** 在内置辅助磁极磁力研磨基础上添加轴向超声振动，促使磁力研磨粒子对管件内表面进行轴向划擦、刻划作用。采用响应面法对试验进行3因素3水平方法设计，建立参数优化三维数学模型，分析超声频率、超声振幅、主轴转速在两因素交互作用下，对异型管内壁表面质量、表面粗糙度的影响，并得出试验最佳参数组合。**结果** 响应面法优化设计在超声频率19 kHz、超声振幅19 μm、主轴转速1200 r/min条件下的加工效果最佳。在优化工艺参数下进行超声复合磁力研磨试验，加工30 min后，管件内壁表面粗糙度由原始2.4 μm降至0.31 μm，管件内表面残余拉应力由+49 MPa转变为残余压应力–47 MPa。**结论** 在内置辅助磁极磁力研磨基础上添加超声轴向振动，使得研磨粒子翻滚加剧，研磨轨迹复杂化，有效改善了管件内壁表面粗糙度和表面加工质量。响应面法能够对试验结果进行优化参数数学建模设计，拟合出了最佳的加工参数组合，良好的应力状态有效地提高了工件的疲劳强度。

关键词：磁力研磨；超声复合；响应面法；镍基合金；异型管

中图分类号：TG356.28　**文献标识码：**A　**文章编号：**1001-3660(2019)03-0268-07

DOI：10.16490/j.cnki.issn.1001-3660.2019.03.036

Parameter Optimization Design and Analysis of Ultrasonic Composite Magnetic Abrasive Finishing

CHEN Yan*, *ZENG Jia-heng*, *QIAN Zhi-kun*, *ZHAO Yang*, *CHEN Yu-hui

(University of Science and Technology Liaoning, Anshan 114051, China)

ABSTRACT: The work aims to improve the surface quality of nickel based alloy special-shaped tubes and reduce the surface roughness by machining the nickel based alloy special-shaped tubes with ultrasonic combined magnetic abrasive finishing and investigate the effects of ultrasonic frequency, ultrasonic amplitude and spindle speed on the inner wall surface quality and surface roughness of special-shaped tubes by response surface methodology. The axial ultrasonic vibration was added on the basis of the built-in auxiliary magnetic pole magnetic abrasive to promote the magnetic abrasive particles to scratch and carve the inner surface of the tube. The response surface method was used to design the 3-factor and 3-level method, and the three-dimensional mathematical model was set up to analyze the effects of ultrasonic frequency, ultrasonic amplitude and spindle speed on the surface quality and surface roughness of the inner wall of the special-shaped tube under two factors to obtain the best combination of parameters. The optimum design of response surface method was the best in the condition of ultrasonic frequency 19 kHz, ultrasonic amplitude 19 μm and spindle speed 1200 r/min. Under the optimized process parameters, the ul-

收稿日期：2018-07-16；**修订日期：**2018-09-23

Received：2018-07-16；**Revised：**2018-09-23

基金项目：国家自然科学基金（51775258）

Fund：Supported by the National Natural Science Foundation of China (51775258)

作者简介：陈燕（1963—），女，博士，教授，主要研究方向为精密加工。邮箱：laochen412@gmail.com

Biography：CHEN Yan (1963—), Female, Doctor, Professor, Research focus: precision machining. E-mail: laochen412@gmail.com