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超声复合磁力研磨加工镍基合金 GH4169 异形管

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摘　要: 为解决镍基合金 GH4169 异型管内壁难研磨及研磨不均匀问题，采用超声复合磁力研磨光整加工方法进行试验。分析在超声复合磁力研磨条件下，主轴转速、加工间隙、超声频率和超声振幅对异形管内壁表面质量的影响。结果表明：在超声轴向频率为 19 kHz、振幅 19 μm，主轴转速 1000 r/min，磁性磨粒平均粒径 250 μm，加工间隙 2 mm 加工条件下，加工 30 min 后，管件内壁表面粗糙度 *R*a 由原始的 2.4 μm 降至 0.31 μm。通过在管件内部添加圆柱形辅助磁极，使得内外两磁极形成闭合磁场回路，增加磁场力的作用。辅助磁极连接高频轴向超声振动，使得吸附在磁极上的磁性磨粒在旋转运动和轴向高频振动复合作用下划擦、研磨管件内表面。由于研磨轨迹发生交叉复杂化，使得异型管内壁研磨后的表面质量和表面粗糙度得到明显提高；管件内壁表面残余应力由拉应力+52 MPa 转变为压应力−48 MPa，表面应力状态得到较好的改善。

关键词: 磁力研磨；镍基合金；异形管；超声复合；辅助磁极
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Special-shaped Pipe of Nickel Based Alloy GH4169 by Ultrasonic Assisted Magnetic Abrasive Finishing

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Abstract: This investigation aims to solve the problem of difficult and uneven grinding by using ultrasonic assisted magnetic abrasive finishing (UAMAF) in the nickel-based alloy GH4169 with tube shaped inner wall. The effects of spindle speed, machining gap, ultrasonic frequency and ultrasonic amplitude on the surface quality of the special-shaped tube inner wall were analyzed under the condition of UAMAF. The test was carried out under the processing conditions of ultrasonic axial frequency of 19 μm, an amplitude of 19 μm an spindle speed of 1000 r/min, an average particle size of 250 μm of magnetic abrasive grain, and 2 mm machining gap. Results show that after 30 minutes of processing, the surface roughness of the inner wall of the pipe was reduced from the original *R*a 2.4 μm to *R*a 0.31 μm. Addition of a cylindrical auxiliary magnetic pole inside the pipe fitting causes the inner and outer magnetic poles form a closed magnetic field loop thereby increasing the magnetic field force. The vibration from the auxiliary magnetic pole is connected with the high-frequency axial ultrasonic vibration. It causes the magnetic abrasive particle adsorbed on the magnetic pole scratch to grind the inner surface of the pipe under the combined action of the rotary motion and the axial high-frequency vibration. Due to the cross-complication of the grinding trajectory, the surface quality and surface roughness of the inner wall of the tube are significantly improved. The residual stress on the inner wall surface of the pipe changes from tensile stress of +52 MPa to compressive stress of −48 MPa, and the surface stress state is improved.

Keywords: magnetic abrasive finishing; nickel base alloy; heteromorphic tube; ultrasonic assisted; auxiliary magnetic pole

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