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微纳技术与精密机械

电磁流变效应微磨头加工的电磁耦合协同作用机理实验

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摘要： 采用正交试验方法比较了锥形工具旋转和工作台旋转两种状态下的定点加工效果,实验研究了微磨头加工过程中的电磁耦合协同作用机理。在电磁耦合场中,固相粒子被极化形成电偶极子。当锥形工具旋转时,旋转的电偶极子由于洛伦兹力引起的自旋力偶的作用发生原位振动,对工件表面产生有规律的冲击,促进了材料去除,相对于工作台旋转模式其材料去除深度明显加大;但在电磁场较弱的微磨头外围,原位振动会对链串结构造成破坏,从而减小材料去除范围。电磁场耦合方式对电磁流变协同效应有很大影响,磁场励磁电压对材料去除的影响程度最大,其次是电场电压和旋转速度。在本文试验条件下,当锥形工具旋转且励磁电压较低(5 V)时具有较好的电磁流变协同加工效果。

关键词： 电磁流变液 协同效应 微磨头加工 电磁耦合场 材料去除

Experiments of synergistic effect of electro-magnetically coupled field in EMR finishing

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Abstract: Orthogonal tests in two rotational modes (the rotational tool mode and the rotational worktable mode) are conducted to confirm the synergistic effect mechanism of an electro-magnetically coupled field in the Electro-Magneto-Rheological(EMR) effect-based tiny-grinding wheel finishing. Under the electro-magnetically coupled field, the EMR polarized particles of the rotational tiny-grinding wheel generate the Lorentz force and the spin couple, then the in situ vibration of the EMR particles due to the spin couple can impact regularly on the workpiece surface and promote material removal, so the material removal depth in the rotational tool mode is larger than that in the rotational worktable mode. However, if the interaction force of the particle chains is weak, the in situ vibration will break the particle chains and reduce the material removal. The couple mode of electric and magnetic field has a significant influence on the machining efficiency of the EMR finishing. It shows a good synergistic effect of the EMR finishing in the voltage of electric field of 1 kV and the excitation voltage of magnetic field of 5 V in the rotational tool mode.

Keywords: Electro-magneto-rheological(EMR) fluid synergistic effect tiny-grinding wheel finishing electro-magnetically coupled field materiel removal

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