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ORIGINAL ARTICLE

Study on improving the trajectory to elevate the surface quality of plane magnetic abrasive finishing

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Abstract This paper aims to improve the surface integrity and surface homogeneity with various trajectories by a newly self-designed experiment device. In the experiments, three kinds of polishing trajectories were studied with attached revolution motion to magnetic abrasive brush (MAB) based on conventional magnetic abrasive finishing (MAF) process. The surface roughness, the cross-sectional shape, and the 3D micro-morphology were chosen as the response variables to explore the feasibility and benefits of the proposed improving polishing method. The results show that the plane homogeneity and surface quality improved in varying degrees after improving the polishing trajectory. In addition, combining MAF theory to analyze related reasons, the trajectory expression of the magnetic abrasive particles (MAPs) was established and was simulated by Graph software. The theoretical analysis is consistent with the experimental results which indicated that analysis of polishing trajectory can be used to predict polishing results. Thus, it is feasible to plan polishing trajectory reasonable according to workpiece profile and surface quality requirements.

Keywords Surface quality · Magnetic abrasive finishing (MAF) · Homogeneity · Trajectory

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1 Introduction

Currently, the process research of magnetic abrasive finishing (MAF) technology to remove the burrs; improve the surface finish, flatness, and homogeneity; and reduce surface textures has been a lot [1–9]. The basic principle of MAF technology is fill the gap between the magnetic pole and the workpiece with magnetic abrasive particles (MAPs) and lubricant. The MAPs will be magnetized in the presence of a magnetic field and arranged along the lines of magnetic force to form a flexible magnetic abrasive brush (MAB) which is a multifunctional machining tool in the MAF process [10–13]. When the magnetic pole is rotating, the relative motion between the MAB and workpiece takes place. Under the effects of magnetic force acting on the MAB, the workpiece surface finishing is done [14, 15]. The method belongs to ultra-precision polishing and has many advantages: a lower machining force, self-adaptability to a complicated workpiece profile, easy controllability of cutting edges, and low temperature rise [16–18]. However, the conventional plane MAF process was accomplished by rotation of MAB and linear reciprocating motion of workpiece as shown in Fig. 1a [19, 20], which resulted in single polishing trajectory, poor homogeneity, clear textures, and other disadvantages.

In order to overcome these defects, the linear reciprocating movement of workpiece, the rotation motion, and a revolution motion of MAB can be realized by a newly self-designed experiment device in this paper; the polishing trajectory is shown in Fig. 1b [21–24]. Surface roughness, cross-sectional shape, and 3D micro-morphology after polishing were detected and compared [4, 25–27]. The results show that the polishing effects can be made better, the homogeneity of plane can be elevated, and the polishing area can be increased with attached revolution motion to MAB. This paper carries out a theoretical analysis and draws a trajectory of MAPs by