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An In-Situ Integrated Micromachining System for Intricate Micro-Parts Machining

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Abstract : This study presents a novel versatile high-precision integrated micromachining system that combines contact and non-contact micromachining techniques to machine intricate micro-parts precisely. Two broad methods of micro fabrication-1) volume additive (micro co-deposition), and 2) volume subtractive (nanometric flycutting, ultrafine w-EDM (wire Electrical Discharge Machining), and micro honing) - are integrated in the developed micromachining system, and their effectiveness is verified. A multidirectional headstock that supports various machining orientations is designed to evaluate the feasibility of multifunctional micromachining. An exchangeable working-tank that allows for various machining mechanisms is also incorporated into the system. Hence, the micro tool and workpiece need not be unloaded or repositioned until all the planned tasks have been completed. By using the designed servo rotary mechanism, a nanometric flycutting approach with a concentric rotary accuracy of 5-nm is constructed and utilized with the system to machine a diffraction-grating element with a nano-metric scale V-groove array. To improve the wear resistance of the micro tool, the micro co-deposition function is used to provide a micro-abrasive coating by an electrochemical method. The construction of ultrafine w-EDM facilitates the fabrication of micro slots with a width of less than 20-μm on a hardened tool. The hardened tool can thus be employed as a micro honing-tool to hone a micro hole with an internal diameter of 200 μm on SKD-11 molded steel. Experimental results prove that intricate micro-parts can be in-situ manufactured with high-precision by the developed integrated micromachining system.

Keywords : integrated micromachining system, in-situ micromachining, nanometric flycutting, ultrafine w-EDM, micro honing
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