Investigation on form-preserving polishing of optical element/system via an active fluid jet

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A wide variety of optics are required to be manufactured efficiently in high form accuracy together with an ultra-smooth texture. Single point diamond turning (SPDT) shows an advantage of high efficiency in form generation since it can produce optical surfaces with sub-micrometer form accuracy directly. However, the machining tool mark is a significant fact that leads to expected diffraction, which will seriously affect the optical performance. The inevitable residual turning marks affect the performance of the optical surface, which produces a diffraction effect and stray light. The relationship between optical performance and tool marks distribution is studied to guide for the high-performance machinining. Moreover, the strategy of eliminating the tool marks as well as preserving the surface form should be studied and carried out. Motivated by this, an efficient post-treatment method of a diamond-turned surface with low cost, wide applicability, and superior form-preserving capability has been paid more attention. In this paper, an active fluid jet (AFJ) polishing technology for removing diamond turning marks is introduced and investigated. A simulation model of turning marks removal (TMR) in the AFJ polishing is developed based on the material removal characteristics and fluid-structure interaction analysis. A series of spot polishing tests are carried out to study the effect of the AFJ polishing parameters on the material removal rate of the turning marks through orthogonal experiments and check the validity of the proposed model. Accordingly, a combination of parameters that can remove turning marks efficiently is obtained. Considering the form-preserving ability, a spiral polishing test is conducted and the result shows that a preferred value of material removal which is suitable for eliminating the turning marks without destroying the surface form can be determined by the changes of surface profiles and microtopography. Hence, a form-preserved polishing process can be realized through adjusting dwell-time and tool-path in the AFJ polishing process. Finally, the practicality of the AFJ polishing method is demonstrated on an aluminum surface. The experimental results and the theoretical analysis prove that AFJ polishing technology can lead to the post-treatment of diamond-turned surfaces in a form-preserving manner.