Research on Material Removal of Magnetorheological Finishing

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Abstract. Magnetorheological finishing (MRF) is a novel precision optical machining technology. Owing to its flexible finishing process, MRF can eliminate subsurface damage, smooth rms micro roughness and correct surface figure errors. The finishing process can be easily controlled by a computer. Material removal model in MRF is established. According to Preston equation in optical machining, mathematic model of material removal rate in MRF rotating at fixed rate is established through hydrodynamic analysis of the MR fluid flow in the polishing zone. The validity of the model is examined by the experimental results.

Introduction

Magnetorheological Finishing (MRF) is a newly developed optical machining method which can fine finish optical materials efficiently. Magnetorheological finishing is an advanced ultra-precision machining technology, which combines with the new researching results in the precision machining of optics. It was developed by W. I. Kordonski in 1990s. Owing to its controllable and flexible polishing process, subsurface damage couldn’t be produced on the workpiece, and the polishing process can be easily controlled by a computer. The problem of poor efficiency of traditional aspheric optical polishing can be effectively solved. High quality surface of optical glass can be achieved by controlling the parameters in MRF [1, 2]. Combined with electromagnetics, hydrodynamics and chemistry, MRF has been applied in optical machining. Plane surface, sphere and asphere made of different optical materials can be machined. MRF can meet the manufacturing requirement of optics in aviation, space and defense area and has a broad prospect of application.

Mechanism of Magnetorheological Finishing

As a kind of smart material, the viscosity of magnetorheological fluid (MR fluid) can be continuously changed with the change of magnetic field intensity. The MR fluid in the magnetic field stiffens quickly, then returns to its original fluid state when left the field, accordingly the shear stress of it can change from hundreds to over one thousand times. So MR fluid is a kind of controllable medium and a large number of applications of this smart material have been widely used. According to the properties of the controllable character of MR fluid with the magnetic field intensity, the MR fluid dispersed with appropriate amount of fine abrasives is used as an actuating medium to polish hard and brittle materials such as optical glass. High precision and ultra smooth surface can be achieved with MRF [3]. The material removal rate in MRF can be controlled by altering the magnetic field intensity. In addition, the polishing properties and machining path can be controlled in process. This makes it possible to finish aspheric apparatus of optical glass with high efficiency and precision.

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In the process of MRF, MR fluid dispersed with certain concentration of fine abrasive is injected to the region between the workpiece surface and the rotating wheel, at the same time a controllable high