The Grinding of Optical Glasses on an Ultra-Precision Machine Tool

Mark Craig Gerchman
Rank Pneumo Inc.
Keene, New Hampshire 03431 USA

This presentation will review a recent investigation concerning the grinding of optical glasses on an ultra-precision machine tool. This investigation has determined production grinding process parameters for several glass types. The glass types used were selected based upon their visco-elastic properties to be representative of many optical design glasses. This investigation was performed using commercially available production equipment. The goal of this process investigation was to create by grinding, together with subsequent post-polishing, glass surfaces for direct visible optical applications.

This presentation will begin by providing an overview of the production equipment used for this study. The ultra-precision machine tool used for grinding was a Rank Pneumo ASG-2500 with a vertical spindle grinding attachment. This arrangement permitted the peripheral cross-axis grinding of both the spherical and aspherical surfaces used in this investigation. The suitability of this machine tool for the generation of glass surfaces will be determined from examination of the structural loop stiffnesses. The presentation will also discuss operation of a CNC/LDVT wheel setting routine employed for this grinding. Wheel specifications and the technique used for on-machine wheel trueing and dressing will be reviewed. The post-polishing process was accomplished on a Rank aspheric polishing machine utilizing pneumatic polishing techniques.

The presentation will continue by examining the grinding material's removal process. Although ductile-regime grinding has been executed on this machine tool, the parameters influencing stock removal mandate excessively long processing times. To make the precision grinding of optical glasses acceptable to production economics, this investigation has pressed process parameters into brittle-regime grinding. By working the optical glasses beyond the visco-elastic limits significant reductions in processing times have been achieved. The subsequent post-polishing has been accomplished within similarly short processing times.

Results for several different glass types will be presented. The glasses investigated were selected by several criteria. The materials studied were preferred Schott glass types and spanned a range of different visco-elastic characteristics. Because glass manufacturers offer hundreds of available glass types, only a few representative sample types could be examined. Correlations between visco-elastic parameters and grinding and polishing results will be reviewed. Extrapolation of this information will be useful for establishing guidelines for working parameters for other glass types.

From investigating the generation of both aspheric and spheric surfaces, it is clear the process requires the results of grinding to have both accurate surface macro-geometry (form) and a surface texture appropriate for subsequent post-polishing. The flexible pneumatic post-polishing provides a means for the reduction of surface roughness without the disruption of surface geometry. By providing these joint processes the production of direct aspheric optical surfaces in glass has been made possible.