RAPID OPTICAL FABRICATION WITH COMPUTER CONTROLLED OPTICAL SURFACING

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The design needs for large optical components for advanced strategic defense systems and reconnaissance systems presented the optical industry with fabrication capability requirements that could not be met by conventional fabrication methods rooted in telescope making techniques. Faced with the lack of enabling production technology for this type of optics, Itek undertook to develop a new generation of optical fabrication technology that would fulfill the following requirements:

The process should handle both annular on-axis and odd-shaped off-axis optics.

- It should generate highly aspheric surfaces with or without rotational symmetry.
- It should produce final surface geometry without requiring that the glass be in a stain-free condition during the fabrication process.
- The surfacing process should not use a net normal force to prevent print-through.

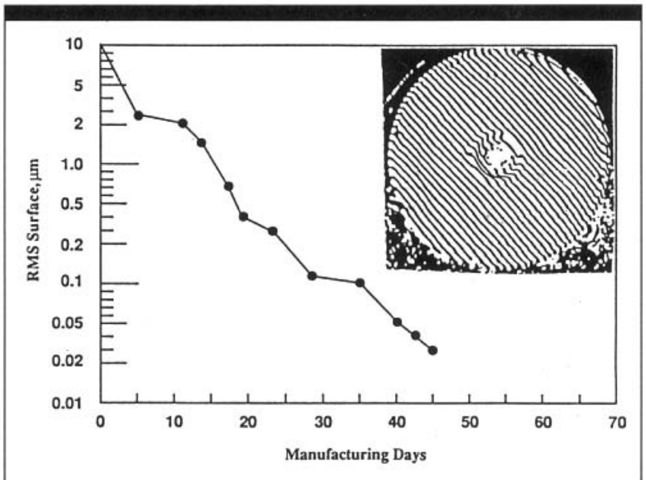
A limited effort on this development started in the '70s, but actual breakthroughs in this technology came during the last five years, resulting in fabrication capability that meets all the above requirements. Since it is based on computer technology, it has been termed Computer Controlled Optical Surfacing (CCOS).

The CCOS machines consist of robots that move an orbital tool over the surface of the optic. The velocity of the tool assembly across the work surface is purposely varied to provide accurate control over the polishing time and the associated material removal.

The CCOS technology is based on the surfacing operation using small size tools. Originally, the tool pressure was supplied by pneumatic loading of the tool. This approach, if used on lightweighted blanks, would produce print-through of the rib structure due to strongly localized strain pattern caused by normal net force produced by tool loading. This problem has been solved by a novel approach in which the needed surfacing pressure for either grinding or polishing has been obtained by a vacuum induced suction force in the tool-workpiece interface. In this approach, the net normal force acting on the work surface has been reduced to 'zero' and the source for print-through has been removed.

The CCOS process provided the industry for the first time with enabling technology for efficiently producing off-axis segments. One example is the rapid asphetization, grinding, and polishing of a thin 2-meter off-axis aspheric mirror. The mirror blank was prepared and slumped. Next, the facesheet surface was generated spherical and the facesheet back was acid etched to stop the growth of microfractures. The CCOS process was used to aspherize, grind, and polish the surface. The entire fabrication operation from blank preparation to final surfacing was completed within one year.

Although these results are good, process improvements since that time have produced significantly better results. The figure presents a convergency chart for recent fabrication of a large f/1.5 parabolic mirror. In this case, the microbinding process was carried to the level of about 0.2 μm RMS. This allowed for polishing out the mirror in about four weeks. The entire surfacing process took only 45 days. Typically, conventionally grinding and polishing this type of mirror would take about one year.



CONVERGENCE DATA FOR LARGE PARABOLA