Opticam SM update

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ABSTRACT

Rank Pneumo has worked in cooperation with the Center for Optics Manufacturing at the University of Rochester and the Center's Manufacturing Advisory Board to develop a flexible CNC machining center for spherical lens fabrication. The prototype Opticam SM machine has been built and delivered to the Center for Optics Manufacturing. The machine is currently undergoing process and cycle development at the Center. Opticam SM experiments have demonstrated the ability to grind surfaces of less than 200 angstroms rms, subsurface damage less than 2 microns, and a surface figure better than 1 wave p-v in less than five minutes.

1.0 INTRODUCTION

The Opticam SM is a flexible, multi-axis machining center which generates, fine grinds, prepolishes and centers spherical lens surfaces in one setup sequence using semi-universal tooling.

Machine resident metrology provides real-time quality management (RQM) and closed loop feedback that corrects for lens thickness, diameter, radius and centering errors. The Opticam SM is shown in Figure 1 without the tool changer.

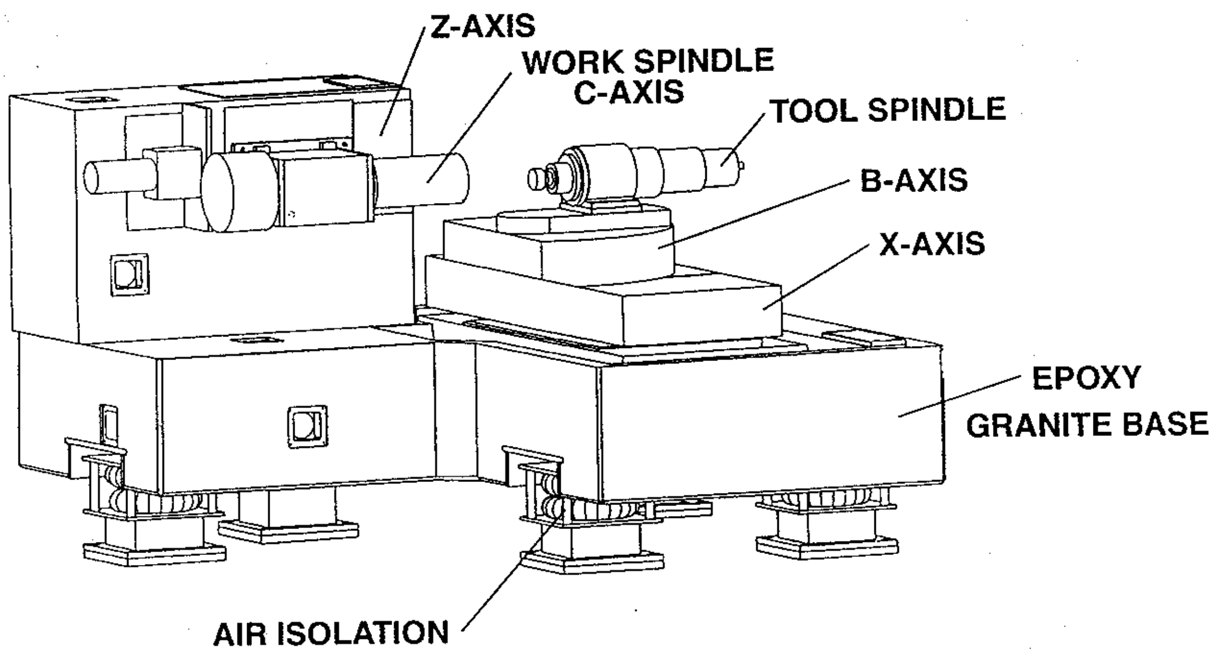

Figure 1. Opticam SM shown without the tool changer and covers.

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2.0 MACHINE DESCRIPTION

The base of the machine is fabricated from epoxy granite which offers superior dynamic stability and structural rigidity. Epoxy granite is an aggregate mixture of fine to coarse granite particles and an epoxy resin. A mold of the base is constructed and the aggregate mixture of epoxy granite is poured into the mold. The mold containing the epoxy granite is then shaken on a shaker to assure tight grain contact of the granite particles. After curing, the base is removed from the mold and painted. A variety of components can be cast into the epoxy granite such as wireways, inserts and mounting plates for other components. The base mounts on an active air isolation and leveling system.

The X and Z axes are modular slide units which mount to the epoxy granite base. Both slides utilize a crossed roller bearing system to maximize rigidity and provide precise movement. The axes are driven in translation by a precision preloaded lead screw coupled to a direct drive servo motor. A 0.1 micron resolution encoder is used to close the position loop. The X axis has 400 mm of travel and the Z axis has 250 mm of travel.

The B axis is a precision rotary axis with 90 degrees of travel and is mounted on top of the X axis. The top of the B axis provides a mounting location for the tool spindle. Rotary motion of the axis is obtained by driving a linear slide with a precision preloaded lead screw coupled to a direct drive servo motor. Two linear slide blocks linked by a rotary pin convert the linear slide motion to an angular rotation. Position feedback is obtained from a rotary encoder with a resolution of 0.144 arc seconds mounted concentric to the axis of rotation.

The fourth axis (C axis) is the air bearing work spindle. An optional ball bearing work spindle is also available. The work spindle can operate in two modes, a spindle mode or a positioning mode. In the spindle mode the work spindle can be programed to run bi-directionally in open loop with a speed range from 10 to 250 rpm. In the positioning mode, the work spindle can be programed as an index head for segmenting lenses with a resolution of 0.01 degrees. Position feedback is obtained from an encoder mounted in line with the spindle.

The Kennametal work holding fixture is mounted in the front of the spindle. A spring actuated (push to release) drawbar mechanism is used to chuck the workpiece in the work holding fixture.

The tool spindle is a precision air bearing motorized spindle with a speed range from 6,000 to 30,000 rpm. An optional ball bearing spindle is also available. The ball bearing tool spindle is currently being tested on the machine. The tool spindle incorporates a drawbar mechanism and a taper for automatic tool changing. The spindle is driven by an integral high frequency AC motor rated at 11 KW at 30,000 rpm.

An automatic tool changer is provided to change tools from the tool storage drum as shown in Figure 2. A double arm loader is used to load a new tool from the tool storage drum and to place the used tool back into the tool storage drum. The machine control tracks the location of each tool in the tool changer and the current tool being used. The tool storage drum can store up to 12 tools including the work probe.

Figure 3 shows the Opticam SM with the machine enclosure. An interior machine enclosure is also used on the machine to contain the coolant spray produced while grinding.

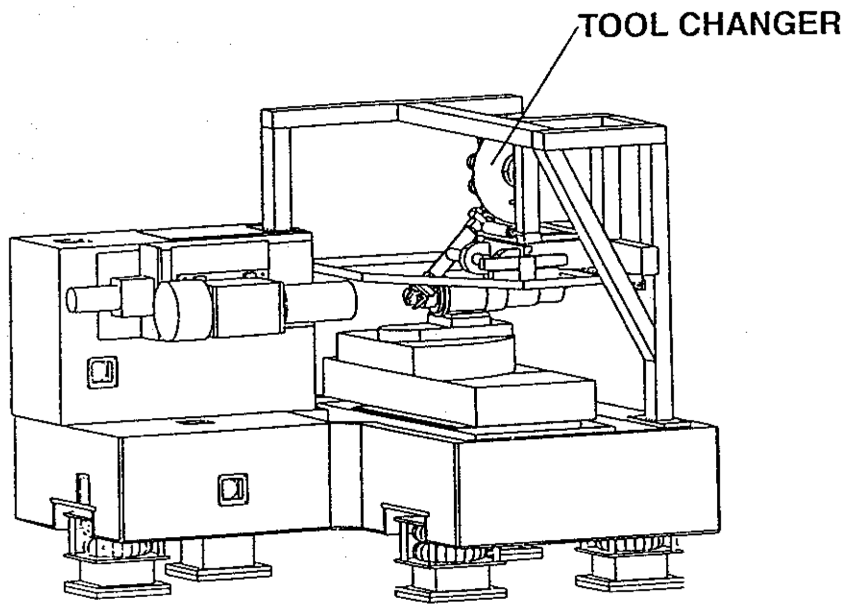

Figure 2. Opticam SM with the automatic tool changer.

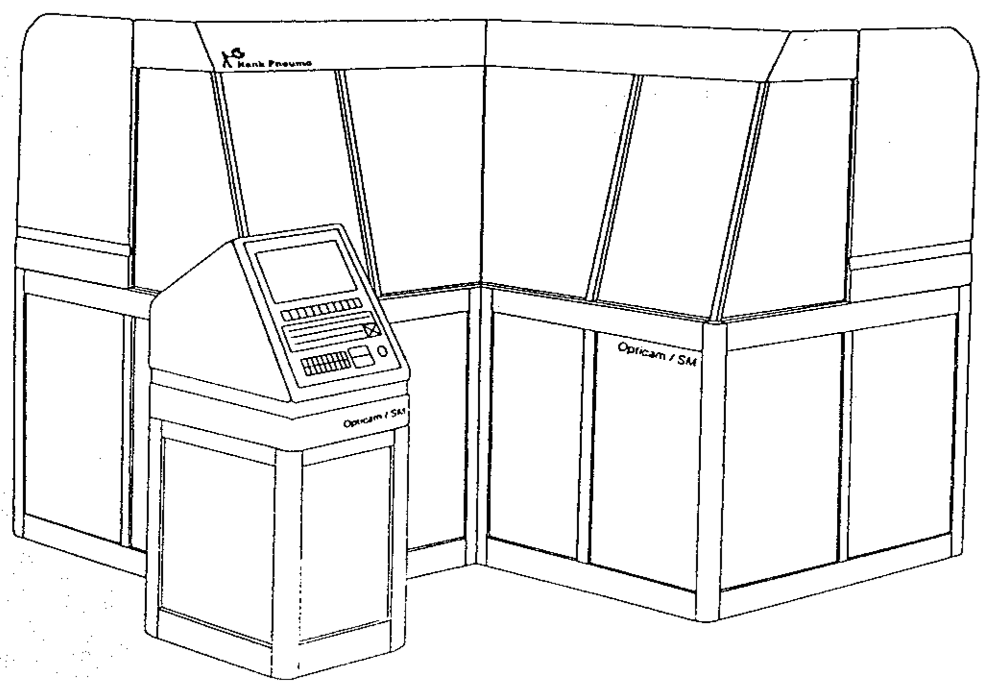

Figure 3. Opticam SM with the enclosure.

All of the machine functions and programs are controlled by the Allen-Bradle 9/240 CNC control. The 9/240 CNC control has an RS-232 serial communication port for program and data upload/down load and supervisory control.

Part and tool probes are provided to collect part and tool data. The tool probe is an optical probe which mounts into the Kennametal work holding fixture and is used to measure the tool diameter and tool length. This information is then stored in the control and eliminates the need for presetting tools. The part probe is stored in the tool changer storage drum and loaded into the tool spindle by the tool changer. The part probe is used to verify the center thickness, diameter, runout and spherical radius of the lens. The lens data can be used to correct the machining cycle or be used as Statistical Process Control data.

3.0 MACHINE TESTING AND EVALUATION

After the assembly of the major machine components is completed, the spindles must be aligned. The work spindle, the tool spindle and the B axis pivot must be aligned so that axes of these three components converge at a common point in space. Opticam SM experiments have demonstrated the ability to grind surfaces of less than 200 angstroms rms, subsurface damage less than 2 microns, and a surface figure better than 1 wave p-v in less than five minutes. Figure 4 shows an interferogram of one of a lens ground on the Opticam SM.

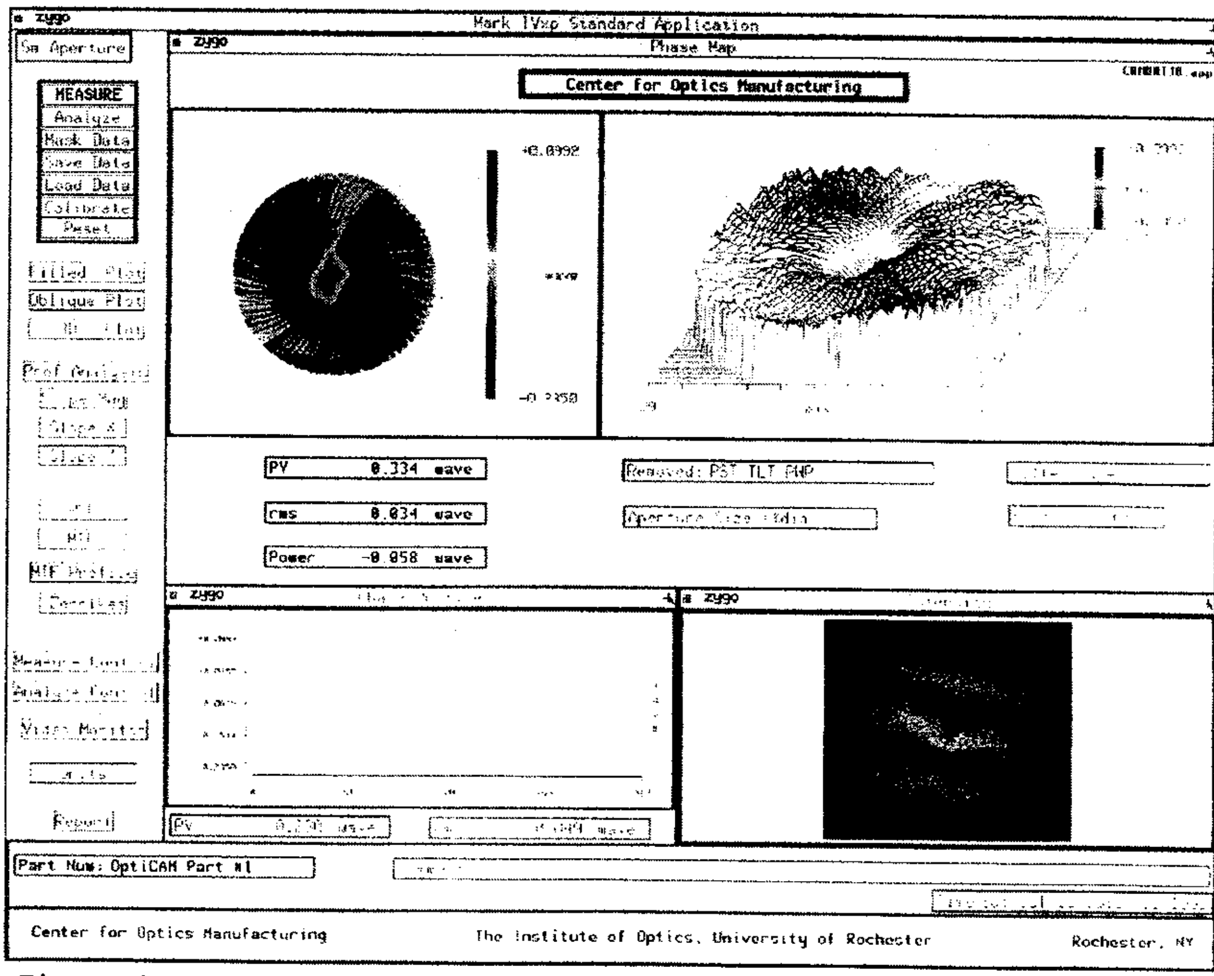

Figure 4. Interferogram of a lens ground on the Opticam SM.

The Opticam SM is currently being evaluated by the Process Science Group at COM. Opticam SM experiments will continue to advance microgrinding techniques beyond the already extraordinary achieved in the early stages of testing. However, a solid understanding of process dynamics is needed in order to further optimize quality and productivity. Therefore, the cooperative program is examining the dynamics of bound abrasive grinding by assessing variations caused by the type of diamond, grit size and concentration, bond properties, workpiece characteristics and machine parameters.

4.0 CONCLUSIONS

The Opticam SM has been built and delivered to COM under the guidance of the Center's Manufacturing Advisory Board. The machine is currently undergoing process and cycle development testing by the Process Science Group which is made up of volunteer members from several APOMA (American Precision Optics Manufacturing Association) companies and institutions. Opticam SM experiments will continue to advance microgrinding techniques beyond the already extraordinary (surfaces of less than 200 angstroms rms, subsurface damage less than 2 microns, and a surface figure better than 1 wave p-v in less than five minutes). With this collaborative effort, the utilization and optimization of the Opticam SM and future machines developed in the Opticam program will significantly enhance optical fabrication techniques.

5.0 REFERENCES

Liedes, J.T., "Opticam Machine Design," Proc. SPIE Volume 1531 Advanced Optical Manufacturing and Testing II, pp 216-222, 1991.

Renker, H.J., "Stone-based Structural Materials," Precision Engineering, London, England, 1985.