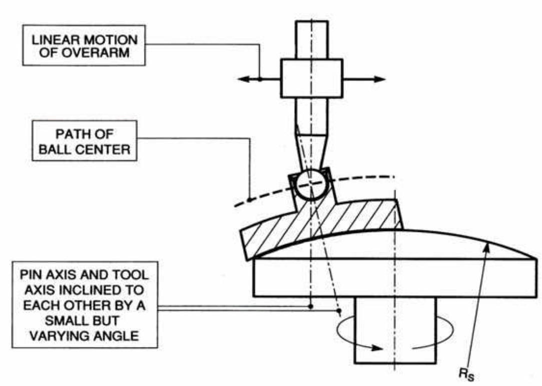
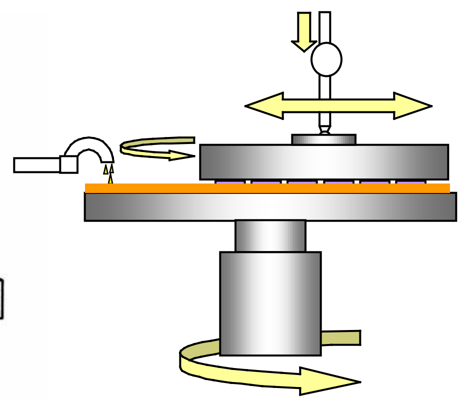
Polishing and Grinding on Strasbaugh Overarm Machines

The purpose of Strasbaugh's overarm fine-grinding and polishing machines is to provide a mechanism for applying an abrasive or polishing compound on to an optical element or a block of elements. The grinding or polishing tool used must match the curvature of the surface which is to be processed. The overarm machine action is designed to assure a constantly changing path of contact between the surface of the workpiece and the tool, thus producing a uniform curvature or a flat surface, free of irregularities.

Strasbaugh overarm grinding and polishing machines use the sweep-type or over-arm motion for precision grinding and polishing. This motion is equally useful for slow-speed and high speed, high-precision polishing and commercial quality production polishing. The slurry can be hand-fed or supplied to the work spindles by a recirculating slurry system. In general hand-fed machines are run at relatively slow speeds because they are usually set up for pitch polishing. Recirculating slurry systems are incorporated on production machines used in pad polishing or for volume production runs of single lenses or lens blocks of medium to small lenses or flatwork.



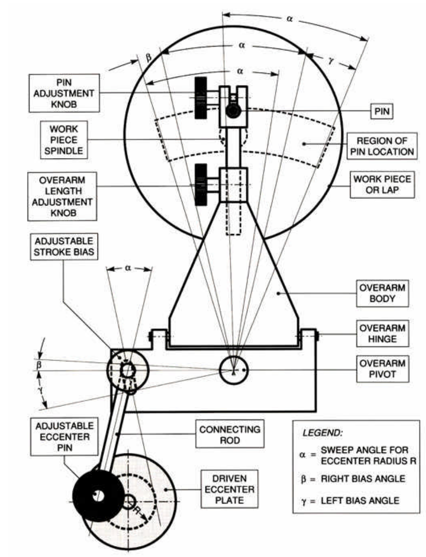


The basic sweep-motion machine is constructed as follows: A vertical spindle accepts the work piece, which are often a lens block and sometimes a single lens. A second vertical spindle terminates in an eccentric plate that is connected to a horizontally pivoting over arm by a connecting rod. The eccentric drive causes the over arm to oscillate laterally over the center of the work piece spindle. The over arm accepts a vertically held pin that either drives a grinding or polishing tool for convex radii or the lens block for concave surfaces. For certain conditions, the order of work piece and tool can be reversed.

Moderate speed, multi-spindle, overarm machines with central recirculating slurry system are the most widely used machines in the precision optics industry because they provide high precision at production rates. Versatility and simplicity characterize the sweep-type grinding and polishing machines. They are easy to operate and have a large range of radius capability and can be adjusted for nearly any condition. Some multi-spindle sweep-type motion machines are specifically designed for high-speed production grinding with either abrasive slurries or with diamond pellet laps. The same machines can also be used for high-speed polishing with hard pitch or synthetic pad polishers.

The typical machine has a series of two motor driven spindles, and over each spindle, an oscillating arm to move the work piece or tool. The overarm mechanism is designed to oscillate from side to side, with fixed adjustment back and forth. On most of these machines, the work or tool mounted in the top unit is rotated by its contact with the tool or work that is mounted on the power-driven spindle.

If the top work piece oscillates, it must be adjusted so that the path of oscillation of the axis of the pin intersects the projected axis of rotation of the spindle. In addition, the top tool must be designed so that pressure can be applied to the work piece it is driving. The work spindle is placed near the front of the bench, which rotates in the center of a pan (used for collecting any spillage of water or abrasive) and carries either the block or the tool. The speed of this spindle can be varied by belt-driven pulleys and a variable speed



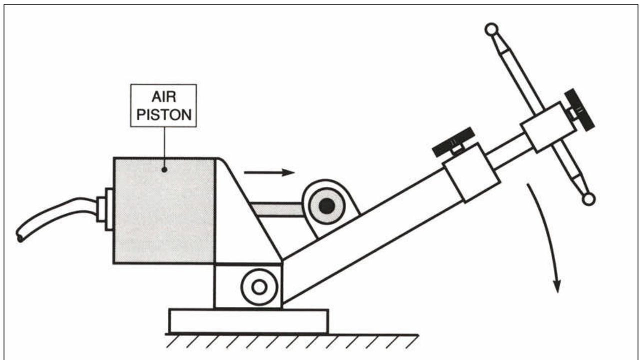
controller. The top end of the work spindle is provided with a hub adapter, which is screwed on the spindle. The upper end of the adapter is machined to receive the tools and blocks, which may be equipped with threads or tapers. In all fine grinding and polishing, the larger part, whether a lapping tool or workpiece is placed on the spindle.

The upper tool and overarm are hinged and mounted on a sturdy bearing. An auxiliary spindle in the rear rotates the stroke regulator cam. The length of the stroke or sweep is set by moving the stroke regulator arm, which is held in place by the clamping screw in the T-slot of the stoke regulator cam.

As the stroke regulator cam revolves, it moves the stroke regulator arm back and forth. The oscillation is transmitted in turn to the overarm, which holds the quill holder and the quill shaft. The quill shaft has a spherical pin which will drives the tool or the work block, whichever is on top. The hinge in the overarm permits the quill pin and tool to track a spherical curve a or slight variation in the runout of the lower platen. The location of the center of the oscillation is controlled by the offcenter or "eccentric"

position of the regulator arm shaft. The oscillating arm should be approximately horizontal when the machine is in operation. This position can be obtained by adjusting the length of the pin and locking it with the pin lock knob. The pin is kept in close contact with the tool by Strasbaugh's air-polish-pressure system, or by placing circular drilled weights on the pin above the clamping point. In addition to the adjustments mentioned above, the distance of the pin from the center of the lower work surface may be varied front to back by sliding the rod which carries the pin in or out of the overarm casting. In practice this setting should always be at zero (center-over-center) or slightly forward of center.

The polishing or lapping pressure is adjusted by means of a regulator and is monitored on an air pressure gauge. The air piston also responds to a lift switch that raises and lowers the over arm. The switch that activates the valve is mounted on the easily accessible control panel of the machine.



Pneumatic down pressure.

Overarm Machine Adjustments During Grinding or Polishing

Spherical Surfaces

In this example, the lower work piece is a convex spherical part being fine ground and whose surface has become too convex. The tool is above and is usually smaller in diameter by 10%. This convex error may be corrected during the grinding operation by making one or more of several adjustments. These adjustments are:

1. decrease the speed of the spindle
2. increase the speed of the oscillating arm
3. adjust the center of oscillation so that it is directly over the axis of the spindle; and
4. decrease the length of stroke so that the upper work piece sweeps only a very short distance beyond the outer edge of the lower work piece.

On the other hand, it the surface of the lower workpiece is concave, the required adjustments are:

1. increase the speed of the spindle
2. decrease the speed of the arm
3. move the center of oscillation further to the left of center, and
4. increase the length of the stoke

The primary factors governing the adjustment of the oscillating arm for fine grinding and polishing are:

1. the diameter of the lower part
2. the length of the stroke, and
3. the location of the center of oscillation

Flat Surfaces

In this example we wish to set the oscillating arm to maintain a flat surface on a smaller block of parts being lapped or polished face down on the larger process table. First the center of oscillation is offset to the left of center by 25% of the diameter of the process table. Then the stroke length is set so that the work will oscillate from the right edge of the table towards the center of the table. The amount of overhang off the edge of the table should be kept to a minimum. The work block should also not cross to far to the left, past the center of the lap to avoid non-uniformity of wear and flatness control.

If a concave curvature develops, the length of oscillation should be adjusted slightly longer. With this setting, the greatest polishing is at the edges and the edges are flattened. If a change in the length of oscillation of the arm does not produce sufficient correction, the next step is to decrease the stroke speeds and increase the speed of the table. If the parts become convex, then the stroke could be shortened and the table speed reduced. It is important to remember that too short a stroke tends to produce holes or irregularities in the smaller work block, while a stroke that is too long will bevel the outer edge of it.

Bearing this fact in mind, the stroke should be lengthened to correct a concave surface of an upper work piece, and shortened to improve a convex one. The stroke should not be changed without first trying the subtle table and stroke speed corrections. The normal speed of the lower spindle is about 35 rpm with the oscillating arm making approximately 15-20 strokes per minute.

Selecting Abrasives for Fine Grinding

Abrasives with a particle sizes of 30, 12 and 5 microns are used for fine grinding. The 30 um abrasive is used to reduce the elements to within 0.003 or 0.002 inch of the finished thickness and the finer abrasive, such as 12 and 5 um , is used to complete fine grinding. However, if the surfaces have been hand-corrected with the 12 um abrasive at the close of the rough-grinding operation the use of the final 5 or 3 um abrasive can be omitted. It should be noted that the removal of surface also reduces any pits remaining after the rough-grinding operation. However, since the removal of more than 0.004 inch of surface depth should be done with a coarser abrasive than 30 um, pits of greater depth should be reduced to this depth or less at the close of the rough-grinding operation, or in any event, before the blanks are blocked for fine grinding.

Hand Grinding

Assuming the tool is the lower work piece, after the selected abrasive and water have been blended to a fluid consistency, the mixture is applied to the surface of the tool with a squirt bottle or by some other suitable means. The care needed when working with the finer abrasives is greater than when the coarser ones are used, because of the closer contact maintained between the glass and grinding tool. After inverting the block, it is placed on the tool slowly, and in such a manner that the surfaces of all the elements on the block touch the tool at the same time. Next it is moved by hand across the rotating tool surface for approximately 12 strokes until grinding has started on all glass surfaces of the block. The block is then ready for machine grinding.

Machine Grinding

Before using a machine for fine grinding, some adjustments are necessary. These are the pressure of the arm on the work, the speed of the lower spindle, the frequency of oscillation, the length of stroke, and the location of the center of oscillation. For the initial setting: (1) the speed of the spindle and the frequency of oscillation should be at a medium rate; (2) the stroke should be one quarter of the diameter of the larger table or part, and (3) the center of oscillation should be to the left of the center of rotation of the spindle, at a distance equal to 10-20% of the diameter of the table or tool. The abrasive should be allowed to break down completely during the last few minutes of grinding. Just enough water should be added to keep the surface moist. However, it must not be allowed to over-expend itself or to become dry, as numerous scratches will result.

Machine Polishing

Polishing involves many variables, often with multiple steps, each with a specific set of process parameters such as polishing speed, pressure, time, temperature, as well as slurry particle size, hardness, suspension density and Ph. A typical flat polishing system consists of the rotating lower platen that is covered with a polyurethane polishing pad or a cast visco-elastic pitch lap, in combination with a polishing liquid or slurry containing abrasive particles that produce wear on the polished surface, thereby creating the desired surface qualities. This liquid slurry can be combined with purified water or made chemically active by changing the Ph, causing the surface of the component being polished to be chemically modified, accelerating and improving the polishing process. Pressure can then be added to accelerate or decelerate the desired process. The work piece is usually mounted face down on the polishing table. However, many small and larger lens polishing application are performed face up with a polishing tool orbiting over the part.

The combination of chemical action from the acidic or alkaline slurry and mechanical action from the slurry particles is used to produce a variety of surface finishes on glass optics, silicon wafers, opto-electronic crystals, thin film memory disk media, as well as a variety of telecom-switch and semiconductor devices.

Typical polishing pressure when using conventional pitch laps are: 0.25 to 1 PSI; and when using synthetic polyurethane or porometric polishing pads, the pressure can be increased to 3 PSI or even greater. However, global surface planarity is always degraded over time unless advanced CMP systems are employed.

The traditional pitch polishing process can and does improve the flatness of an optical surface better than any other synthetic media process. Precision polishing to flatness of 1/4 lightband (1/10 th micron) is considered standard in the optics industry. Some high precision applications require local flatness ten times smaller than that, which are produced on overarm systems with the proper pitch, slurries and settings.

A surface finish tolerance of “10/5” (20 Angstroms Ra) is routine. 5 Angstroms is possible, and sub-angstrom “super-polish” surfaces can be achieved with special colloidal slurries and the use of submerged polishing bowl techniques.

For more information, or to discuss your application, please contact Strasbaugh's application engineering team: optics@strasbaugh.com • Tel: 805-782-6208