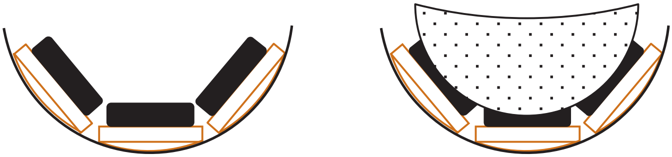
Pitch Pickup Blocking

Since **spot tools** are expensive, and singly working parts is inefficient, small to moderate quantities of lenses are often made with temporary tooling such as the pitch pickup blocking method, in which spherical surfaces can be blocked by individually generating or grinding them, sticking pitch to their back sides, wringing them directly against their grinding tool, sinking a hot backer into the pitch to a predetermined depth, then removing the parts and backer. Because it uses the surface to be worked as a reference (unlike the spot tool, which uses the edge of the opposite side and thus demands a specific thickness), this method also allows rework of scratched parts.



The pitch should be a few millimeters thick at its thinnest point and relatively equal in the inner and outer zones.

Accurately calculating the backer tool radius is a bit more complicated than described in the available literature. Taking convex radii and convex sags (and all thickness) as positive, R_1 as the radius being blocked and R_2 as the opposing radius, if $R_1 + R_2 - t_c > 0$

then $R_{pick\,up} = \sqrt{(R_1 - t_c + h_2)^2 + \left(\frac{\phi_{eff}}{2}\right)^2} - t_{least\,pitch}$

while if $R_1 + R_2 - t_c < 0$

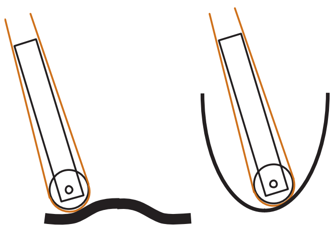
then $R_{pick\,up} = R_1 - t_c - t_{least\,pitch}$

These expressions work for both concave and convex tools.

Since pitch flows over time, it is good practice to press the block onto its test plate for overnight breaks in work.

CNC Belt Style Machine

The tool head is an elastomeric wheel with a driven belt wrapped around it. The interchangeable belts contain bound particles of diamond, zirconia, ceria, or alumina, or are uncharged for slurry feed. The wheel is a toroid with diameter ranging upward from 8 mm, and durometer ratings from 30 to 80 Shore D. It is a full five-axis machine with the wheel's rotational axis perpendicular to and offset from the workpiece axis.



- Small and interchangeable wheels allow sharp inflections and short concave radii.
- The long arm is capable of reaching deep into concave ogives.
- Various wheel hardness and abrasive styles enable its use on soft crystals and hard ceramics.
- Rapid volumetric removal is possible with aggressive belts.
- With the relatively small and simple contact patch, free-form shapes can be created.

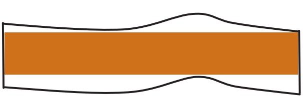
On-board metrology is by confocal, white light, chromatic imaging. The effective removal function of the tool is mapped by measuring a test dimple. A dwell program is created by convolving this removal function with the difference between the interim workpiece shape and the desired shape.

This type of machine is currently capable of surface form error in the range of $\lambda/2$ to $\lambda/4$ visible in some configurations. It can be followed by MRF or fluid-jet for a finer finish.

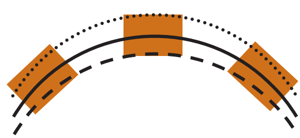
Starting Material Dimensions

When planning a job, one must ensure that the starting material stock dimensions are capable of yielding the final dimensions.

- Sheet material may have surface defects or a warp. Remember that warp affects both sides.
- Molded blanks have skin stress that must be removed.
- Sawn surfaces are not strictly plane.
- Curve-generated surfaces are not exactly spherical, and may need radius adjustment.
- Cores usually need fine edging.
- All shaping and lapping operations leave subsurface damage that must be fully removed by polishing.
- To achieve surface figure, it may be necessary to polish opposing sides for stress relief before reworking one or both sides to a lesser thickness.
- Plan for adequate removal across the block: When grinding a spherical surface, grinding depth is proportional to the cosine of the angle between the local surface normal and the block axis.
- Plan for wedge variability in lenses mounted in a block: It may be necessary to start them over diameter and center after polishing.
- If possible, plan to finish with enough thickness to rework in case of rejection for surface quality, figure, or coating.



Maximum available plane material from warped sheet (exaggerated)



Each colored lens blank starts at same size. Initial removal is greatest, final removal least, and wedge is constantly changing on outer parts of block at constant radius.

Sag and Spherometers

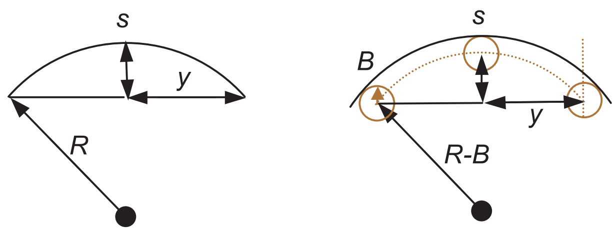
Sag (short for sagitta) is calculated by several formulae, each having its place.

Contact points or balls do not have to be equally spaced, and a narrow span can be useful. In any case, y is the half-span of the circle formed by the three points contacting a plane perpendicular to and centered on the probe gauge.

When using a linear gauge with two pins and an in-line centered probe, rock the gauge to find the true reading.

Accurate for all spheres: $s = \left(\frac{y^2}{R}\right) \Big/ \left[1 + \sqrt{\left(1 - \frac{y^2}{R^2}\right)}\right]$

Note: A simpler version of this equation, $s = R - \sqrt{(R^2 - y^2)}$, assumes R to always be a positive number.



When using a **spherometer** with ball feet:

$$s = \left(\frac{y^2}{(R-B)}\right) \Big/ \left[1 + \sqrt{\left(1 - \frac{y^2}{(R-B)}\right)}\right]$$

where R is entered as positive for concave surfaces and negative for convex, and B is the half-diameter of the contact balls.

An excellent approximation for shallow spheres with fewer chances for input error is

$$s \cong \frac{y^2}{2R} \qquad \text{or} \qquad s \cong \frac{\phi^2}{8R}$$