# SECTION A

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# Selected Problems in Surfacing Optical Elements Using Diamond Tools by Milling, Lapping and Polishing on Hard Base

In the present-day techniques of mechanical working of optical elements such as all types of lenses, the dominant role is played by the operations of premilling, rough and fine grinding and polishing. The first attemps to simplify processes of this type are introduced by specialized optical establishments and in the last few years marked improvements have been made in this respect. In the process of manufacturing of elements for different types of camera, enlarger or projector objectives, as well as for other systems manufactured in medium or great quantities, there are introduced the following basic technological operations: milling, lapping and polishing.

The possibility of applying this type of mechanical processing occurs in the method of fixing the condensing elements in special shapers on a thin layer of glue, i. e. in the so called hard base method.

Milling as the first basic technological operation, when processing both sides of a lens is done by using a diamond pot mill. At present different granulations of diamond mills are used beginning from 50mμ to 200mμ. Proper diamond mill is chosen on the basis of the following parameters:

1) roughness number of the worked element,

2) grade of glass — its hardness,

3) design parameters of the detail, in particular its diameter, radius and final tolerance,

4) design-processing parameters of the millers used in optical industry.

By applying proper processing parameters and suitable gradation of the diamond mills the operations of pregrinding the lenses are eliminated. The surface quality is often achieved by proper choice of technological parameters only, such as: circumferential speed of the mills and in-feed that determines the depth of cutting per unit time. In practice, for the above reasons the most often used grain coarseness of the mill is from 90 to 100 mm.

The well-known European firms as DAMA LOH-Wetzal, CMV, Bothner, Optibel and Autoflow in their designs of optical mills use the range of in-feeds from 0.02 to 1.5 mm/min, and speed of the mill spindle from 5,000 to 18,000 revs/min. The wide range of processing parameters used recently allows to carry out the milling operation with great precision.

Owing to the interdependence of the milling and lapping as the next technological process, the following parameters are obviously required after working on optical millers:

1) deviation of the radius from its final value in the range from 20 do 30 Newton fringes,

2) off-sphere deviation from 2 to 4 Newton fringes,

3) thickness tolerance dependent on the final tolerance in the range 0.01 to 0.1 mm,

4) roughness number between 8 and 10 according to ISO.

The design of optical millers by the above firms,

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owing to automatic and semi-automatic processing, allows simultaneous servicing of 3 to 9 machines, resulting in considerable efficiency of the milling operation. Lapping is after milling the next technological operation that is done by using convex and concave tools. On spherical surfaces of these tools there are milled round seats of various diameters, in which diamond discs are fixed with the help of special glue. A lapping tool thus shaped eliminates the grinding from most processes applied nowadays. The discs used for lapping tools have standard gradation applied by the majority of European optical manufacturers which is in microns 0.5, 2.5, 10, 20 and 50.

Before lapping operation the lapping tools undergo fitting on cast iron countertools by using electro-corundum grinding powder nos. 240, 320 and 400.

Depending on the successive gradation of the diamond of the lapping tools, used in a particular technological process, the deviations of radius of a finished detail is determined by the number of Newton fringes or in microns when using the stereometric method of measurement. The lapping operation of milled elements is done on semi-automatic lapping machines. Machines of this type have the range of vertical spindle rotation from 2000 to 3500 revs/min, with the upper tool being simultaneously guided by a guide-bar system of horizontal pressures up to 20 kg/cm$^2$.

The surface quality after lapping operation is very high and reaches the 12 class acc. to ISO, when using diamond of grain coarseness 10m$\mu$ and it looks like a polished surface. With the same type of the lapping tool the surface quality depends on glass grade and the parameters of processing.

Substituting lapping operation for the traditional fine grinding gives good economical effects, despite high costs of the diamond tools.

For example:

Fine grinding of lenses 25 mm in diameter and radius of 32 mm, sticked on by 6 pieces, is done using grinding powder No. M14 during 20 minutes and using grinding powder No. M7 during about 20 min. — total 40 min.

When using lapping tools of two kinds of grain coarsenes, e. g. 20 mm and 10 mm, the total operation time is about 40 s, if operating one semi-automatic spindle (in normal manufacturing process one worker operates two spindles). High quality gained in lapping operation allows to shorten the polishing time 2 or 3 times.

The application of lapping operation enables us to obtain very precise deviations in the curvature radii expressed by the Newton fringes depending on technological and design requirements. This advantage of lapping allows a precise determination of the polishing parameters and, as a result, to eliminate polishing tars.

At present in the discussed type of technological process based on milling and lapping, polishing operation is to conform with optical requirements of the radius tolerance of the order of three Newton fringes and the ovalization of 0.5 fringes, using thermoplastic materials in the form of plastic waveform.

The discussed technological process can also be applied for making microoptics by using shaped diamond tools for each operation, in particular for lapping.

The application of this type of modern technolo-. gical processes, despite considerable costs of the machinery and diamond tools and equipment, gives good economical effects.