Setting up a teaching surfacing workshop – *a view from Spain*

Santiago Royo and Jesus Caum report on establishing a lens surfacing workshop for teaching purposes in a Spanish College

THE OPTICIANRY and Optometry School in Terrassa, Spain (EUOOT) has recently acquired the equipment required for performing ophthalmic surfacing procedures. This article describes the objectives and present capabilities of the ophthalmic surfacing workshop in the EUOOT, but mainly deals with the setting-up process of a surfacing workshop for teaching purposes.

The main steps of the fabrication process are briefly outlined, and the relevant parameters to be adjusted in the systems performing each of the steps to yield a proper fabrication procedure are discussed at length, presenting their effect in the surfacing process. In the final part, an example of the teaching activities to which the workshop is presently devoted is presented.

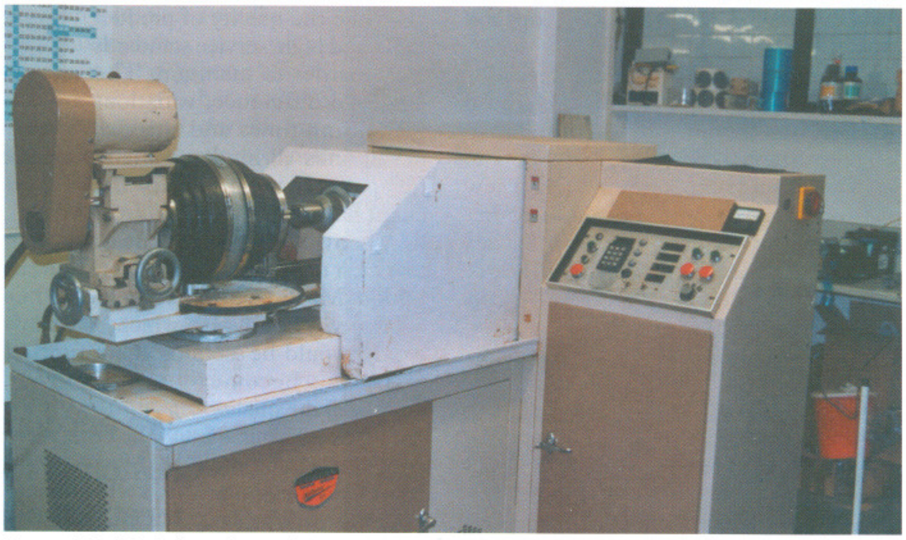

FIGURE 1. Ophthalmic surface grinder

Recent tendencies in the ophthalmic lens market are moving towards a more complete formation in ophthalmic lens manufacturing. An increasing number of students in our schools are finding jobs either in the surfacing workshops of high-production manufacturers, or in low production workshops which allow a quick response to customer's demands. More and more opticians and optometrists are offering quick surfacing services, some of them even with public surfacing workshops where the patient may follow the complete surfacing procedure of his lenses while waiting for his spectacles to be delivered.

As this market tendency increases, the demand for prepared technicians is subsequently rising in order to preserve the quality of the service offered. Opticianry and optometry schools are pushed to respond to this demand by enhancing the training of their students in such subjects. However, the setting-up of a surfacing workshop is not a simple matter, having important requirements both in the installation, in the machinery, and in the skills of the people in charge. This paper intends to address such issues, pointing out the key steps in the setting up of the laboratory and presenting an example of the teaching practices which may be developed in a surfacing workshop.

A SHORT GUIDE TO OPHTHALMIC SURFACING

A paper like this cannot describe to any great extent the complex issue of ophthalmic surfacing, with its many options, possibilities and workshop organisations, widely described in other references.[1-3] However, a short description of the steps in ophthalmic surfacing is necessary to understand the setting-up process described in the following paragraphs.

First, the type of workshop machinery to be used should be considered. We have selected machinery using semi-finished lens blanks, as this is the most commonly used in small surfacing workshops, allowing the fabrication of the different lens types (single vision, bifocal, progressive). This means only surfacing of the concave surface of the lens will be required. Starting from a completely uncut blank gives few learning benefits (the procedure of surfacing a convex surface is almost identical to the concave one), plus it does not represent the conditions the students may find in the workshops they are most likely to be employed in. Machinery for serial fabrication is avoided in our workshop for the same reason.

The type of surfacing workshop presented requires a set of processes in order to yield the finished lens and these are outlined in Table 1. Once the power to be obtained in the final lens is known, the combination of semi-finished lens blank (determining P_1, the power of the convex surface) index and diameter and

TABLE 1
Processes required to yield the finished lens

Calculation	Selection of the combination of available semifinished lens (P_1) and tool (P_2)
Protection	Protective covering of the surface to be preserved
Blocking	Adhesion of the surface to a metal cylinder used for subjection
Grinding	A diamond grindstone generates the rough curvature (P_2)
Fining	Erosion by friction with a tool of curvature opposite to P_2
Polishing	Reduction of roughness and sub-surface damage up to optical quality
Control	Validation of the parameters of the obtained lens

lens fining and polishing tool (determining P_2, the power of the concave surface) has to be calculated, including specifying the desired thickness or prismatic power distribution to be added to the lens. Once the blank and tool are selected, we need to protect the finished surface of the lens blank by covering it with an adhesive plastic film. Blocking, allowing the fixation of the uncut lens to the different surfacing machinery, follows by attachment of a mount. Usually, this involves fixing an appropriate metal cylinder to the surface, using a low-temperature metal alloy which fills the cavity formed by the metal cylinder and the convex surface of the lens.

Next, the concave surface is ground using an abrasive diamond grindstone, yielding a rough surface (roughness 10μm rms) with almost the desired curvature. The fining step is intended to adjust this curvature to exactly the desired one and reduce the micro roughness of the surface by friction against a convex tool covered with an abrasive pad. The tool has exactly the curvature to be obtained on the concave surface of the lens. Finally, the polishing process takes the surface to its final optical quality, both through thermal, chemical and abrasion processes, in a process mechanically equivalent to the fining one, although modified from the simple abrasion of the fining process by the use of cerium oxide in suspension in the lens-mould interface. Different fining and polishing processes are possible, involving different numbers of steps along the surfacing procedure. For the sake of simplicity (only one process is enough for our teaching purposes) and economy (reducing the number of consumables), one-step fining and polishing procedures are selected for our workshop.

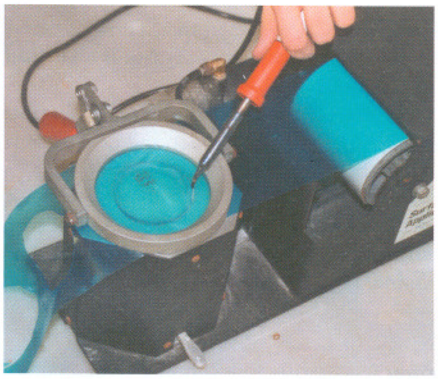

FIGURE 2. Convex surface protection

STEPS IN SETTING UP A SURFACING WORKSHOP

Setting up a surfacing workshop adequately allows a proper performance of the machinery and the calibration of the free parameters in the instrumentation.

In a surfacing workshop a high level of protection of the electric power sources and systems is a must, due to the nature of the jobs being carried out involving power electrical motors and water-based refrigeration systems. Four lines of independent electrical protection were set up, covering the surface protector and blocker, in one of the lines, and the surface grinding, fining and polishing machinery in each of the remaining three lines. The amount of electrical power required for the hydraulic grinder (Figure 1) purchased required special arrangements in the power supplies to the workshop.

An additional requirement was a compressed air circuit allowing the operation of both the surface protector, and the fining and polishing machines, which use compressed air to adjust the pressure of the surface against the convex tool with the abrasive pad. An ABAC Pole Position 24 pump with pressure sensor was purchased and connected to the compressed air circuits of the mentioned systems.

Water supplies are also required, although they are very simple systems. The refrigeration pumps for the grinder, finer and polisher work in closed water circuits, so only low-level maintenance is required to keep an adequate water level, to maintain the right concentrations for the additives, and to ensure the amount of liquid is enough for the functioning of the machinery. An open circuit water supply for the refrigeration of the alloy in the blocker was also provided.

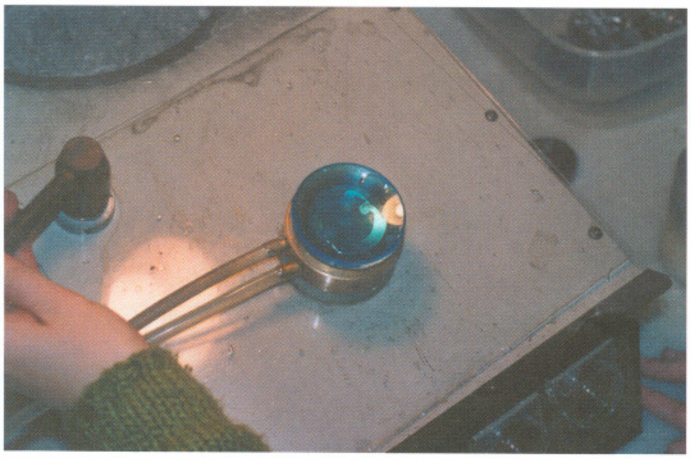

FIGURE 3. Blocking of the semi-finished lens blank

For calibration, one different machine is required for each of the steps of the surfacing procedure. As each of the systems has its own requirements for setting up and calibration, we will point out the main details which need to be addressed in each instrument.

With the available surface protector (a 3M surface Saver Applicator) and blocker (a Coburn 990 Alloy Blocker), the setting-up problems were minimal, once the electrical power, water and compressed air supplies were ensured. It is worth mentioning the simple idea of using a solder to cut the protection plastic film stuck to the convex surface, which allows a better adhesion of the film close to the edges of the semi-finished lens blank than the adhesion obtained using a simple cutter (Figure 2).

For the blocker, a metal cylinder for the different fabrication bases (typically 4.00D, 6.00D and 8.00D) are required, taking into account the number of lenses to be used simultaneously in process.

Figure 3 shows the blocking process, with the melted alloy flowing into the space between the metal cylinders and the protected surface of the lens. Recycling the low-temperature alloy once the finished lens is deblocked is easily accomplished using a 70°C water bath, where the set of metal cylinder plus solid alloy is placed in a sieve and immersed in hot water, quickly melting the alloy, which pours through the sieve down to the bottom of the water bath.

The adjustment of the grinder is somewhat more complex. Further to the required supplies to the machine, calibration of the parameters of the machine is required. In our case, both curvature of the concave surface curves and the central thickness values needed to be adjusted by generating a nominal surface, measuring its curvature and adjusting the screws controlling the servo valves governing the hydraulic circuits in the grinder. Once the curvature is adjusted and the thickness error shown to be constant and independent from the surface being processed, a simple adjustment of the lens-grindstone distance is enough. Once adjusted, the error in curvature values was around ±0.05D for lower powers, rising to +0.10D for surfaces over 8.00D, representing the difference caused by a change in the functioning mode of the grinder.

The finer and polisher proved to be harder to adjust, due to the different intervening elements: concentration of the abrasive solutions, pressure of the surface against the curved mould, and processing time. Only a finer and a polisher were available, so a choice between mineral and organic material processes was required at this point. In our case, the deciding factor was the availability of a large stock of mineral semi-finished lens blanks for the workshop.

FIGURE 4. Polishing procedure

The concentration of abrasives required for fining was set, from experience, to 350g/lt of MicroGrit WCA-20T, while for the polisher a 300g/lt water suspension of Rodhia Cerox was used (Figure 4).

The process time and pressure were adjusted without the need for optimising performance, as the workshop has been set up for educative rather than production purposes. Using a tool with known curvature, pressure and time trials were performed. A 24psi pressure along six minutes for the fining, and 16psi along 12 minutes for the polishing steps proved to be enough for all the available lens materials. Finally, calibration of the available convex tools was performed through a complete surfacing procedure: the curvature of the tool was taken to be that of the perfectly polished surface obtained using that tool.

If the surface was more curved than the tool, the centre of the surface was not polished, while if the lens was flatter than the tool the surface was polished only at its centre. The procedure was repeated to validate the curvature of the set of moulds available in the workshop, both for spherically and toroidally shaped tools.

Finally, a batch of different lens powers was processed in order to test the accuracy and repeatability of the surfacing procedure, with the results in concave surface power, thickness and back vertex power shown in Table 2. Expected values, obtained values and deviations were calculated and measured for each parameter, showing good accordance between real and expected values.

DESCRIPTION OF ONGOING TEACHING ACTIVITIES

The workshop is, at present, prepared for providing otherwise hard to obtain lenses for the spectacle mounting and dispensing practices in EUOOT (progressive addition lenses, for instance), and to illustrate the principle of surfacing to the students.

One typical use of our surfacing workshop involves a first-year workshop in ophthalmic lenses, where the students are asked to calculate an ophthalmic lens of given power from the stock of semi-finished lens blanks and tools available in the workshop. The students have the detailed stock list available prior to the session, and they are asked to find the combination of powers (lens blank and tool) required to obtain a lens of a certain power. They must also obtain the main parameters (thicknesses, sags, powers and so on) of the lens.

The students are asked to verify their calculations on the workshop computer, where a simple Visual Basic application confirms the values they propose for their lens. In case of error, a revision of the calculations is compulsory. In the practical session which follows, the students perform the quality control procedures for the whole process, and indicate each step in the setting up of the lens and in the adjustment of the machinery to yield the desired lens.

Although ideally they should manipulate the machinery, it is power-driven equipment not intended to be used by non-expert hands, so in the interests of the safety of the students and maintenance of the equipment, direct manipulation is performed only by the teacher.

At the end of the workshop, students have seen, controlled and taken part in each of the steps in the creation of an ophthalmic surface, and some of them proudly taking home the lens they have calculated and (indirectly) processed.

REFERENCES

1 Mancusi RJ. *Ophthalmic surfacing for plastic and glass lenses*, Chicago: Professional Press, 1982.

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TABLE 2

Power of the convex surface (P_1), concave surface (P_2), central thickness (t) and back vertex power (P_{VP}), expected from the calculations and obtained as final after the surfacing process

P_1 (D)	$P_{2Expected}$ (D)	$P_{2\,Final}$ (D)	ΔP_2 (D)	$t_{Expected}$ (mm)	t_{Final} (mm)	Δt (mm)	$P_{VP\,Theoretical}$ (D)	$P_{VP\,Final}$ (D)	ΔP_{VP} (D)
6.12	5.50	5.493	0.007	4.70	4.66	0.04	0.740	0.744	0.004
6.12	5.75	5.790	0.040	4.41	4.26	0.15	0.480	0.436	0.044
6.12	2.00	1.990	0.010	5.40	5.31	0.09	4.255	4.250	0.005
6.15	0.00	0.000	0.000	6.45	6.36	0.09	6.310	6.312	0.002
6.15	1.00	0.960	0.040	5.44	5.20	0.24	5.288	5.320	0.032
6.15	5.00	5.030	0.030	4.20	4.19	0.01	1.250	1.226	0.024
6.12	0.96	0.958	0.002	5.45	5.21	0.24	5.297	5.300	0.003
6.12	5.03	5.090	0.060	2.20	2.05	0.15	1.140	1.080	0.060
6.12	3.00	2.984	0.016	4.36	4.17	0.19	3.170	3.240	0.070
6.15	1.50	1.497	0.003	5.90	5.73	0.17	4.800	4.798	0.002
9.61	2.92	2.930	0.010	7.03	6.42	0.61	7.136	7.090	0.046
9.61	3.95	3.927	0.023	6.57	6.54	0.03	6.000	6.070	0.070