THE ART OF GENERATING

A TECHNOLOGICAL CHALLENGE

The ability to see clearly is one of the most important aspects of our lives. Whether that's to work, play, read or perform everyday activities – and for many this means wearing glasses. There are more than seven billion people on our planet and an estimated 4.6 billion of them need glasses, regardless of gender, age, or ethnicity. For these people, finding the right pair of glasses means visiting a trusted optician who then typically orders the lenses from an ophthalmic manufacturing lab.

By Mark Hollmann

Over the last 15-20 years, the ophthalmic industry has changed considerably, due to new developments, technologies, and conditions in lens manufacturing.

CHANGES IN MATERIAL

Until the 1960's, only mineral glass was processed. Today organic is the primary material used for lenses. Only 10-15 percent of today's lenses are mineral glass. Wearer comfort, time savings, more technological options and also aesthetic reasons are main factors for the domination of organic material today.

PROPORTION OF CORRECTIVE NEEDS

Besides the need of single-vison lenses (correcting myopia, hyperopia or astigmatism), lenses needed for additionally correcting presbyopia have increased substantially. Here, opticians can offer bifocal, trifocal and progressive lenses. While all of them correct presbyopia, progressive lenses eliminate the visible lines of traditional bifocals and trifocals and hide the fact that the wearer needs reading glasses. In the field of progressive lenses, technology has evolved tremendously.

Almost twenty years ago, all presbyopia correction with progressives was done on the front side of the lens. This offered limited technological options and required semi-finished progressive lenses in large inventories. Today, by using 'freeform technology' (also called digital surfacing), all corrections – including the ones for presbyopia – can be done on the backside of the lens. Freeform is becoming the preferred way to make lenses, using revolutionary digital manufacturing process and advanced digital lens design and surfacing equipment to create high-quality, customized eyeglass lenses with a unique prescription.

During lens manufacturing a series of steps are carried out – from blocking, through generating, polishing, deblocking, cleaning, coating up to finishing. The process that adds the 'correction' on the lens is generating.

WHAT HAPPENS DURING GENERATING AND HOW DOES IT WORK?

After blocking, the lens goes to the generator which can produce prescriptions at 1/100th of a diopter accuracy. In the generator, the blank (raw lens), undergoes two different steps – milling and turning. The lens backside is processed and receives the corrective information. The entire process only takes about 35-140 seconds, depending on the machine and the prescription which needs to be manufactured.

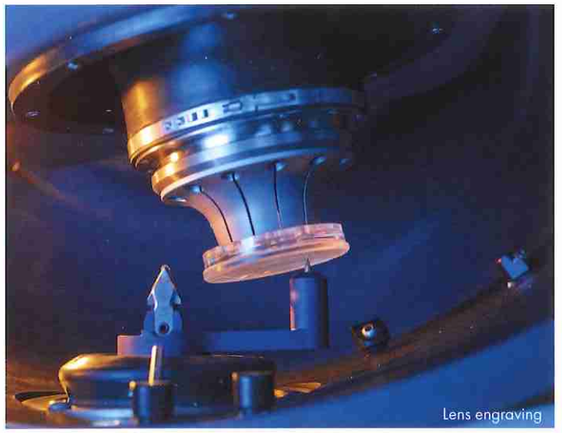
GENERATING – MILLING PROCESS

During high-speed milling (cribbing and rough surfacing), the lens surface is roughly prepared. Within seconds, the milling cutter removes the majority of the material, reduces diameter, bevels the lens and creates the initial shape of the surface. The fastest milling spindle on the market removes material with 35,000 rpm and completes the process in about 7-10 seconds. After milling, a turning process is necessary to smooth the surface with one final cut.

Working chamber

High-speed milling

Fine-turning



Lens engraving

GENERATING – TURNING PROCESS

The turning process, also called high-speed cutting, prepares the surface so that only light polishing (buffing) is required afterwards. The process of turning differs from manufacturer to manufacturer and machine to machine. Special turning tools with high speed control systems provide maximum speed as well as unprecedented form accuracy and surface smoothness.

A diamond, located on the turning tool holder, is used to remove material. Depending on the lens material, either an MCD (Mono Crystalline Diamond) or a PCD (Poly Crystalline Diamond) is used. The tool holder carrying the diamond moves back and forth to generate the lens surface. The lens itself also turns with up to 4,500 rpm. Another infeed axis moves the turning axis with the lens towards the tools' cutting edge.

During this process, an acceleration of up to 200 m/s² can be reached. This corresponds to twenty times the earth's acceleration due to earth's gravitational force (known as 'g')! Traditional generators cut in three axes simultaneously, whereas digital surfacing requires at least four axes. There is a huge technological challenge, to best handle the positioning of the axes during the high-speed turning process ensuring a surface accuracy in the µm -range.

TECHNIQUE BEHIND THE TECHNIQUE

To ensure the best results in the shortest time, machine settings in both, milling and turning are required. And the keyword here is 'spiral distance' which determines the distance between the spiral turns of the final cuts (during both milling and turning). The smaller this distance is, the better the surface smoothness for polishing. However, something that needs to be taken into account is that the smaller the distance between the spiral turns, the longer the generating process takes.

OPTIONAL FEATURES FOR GENERATING

Depending on the lab's requirement or lens specification, some additional, optional machinery features might be necessary. The auto-calibration option safeguards the machine manufacturing quality.

To validate the lenses after surfacing, some generators are equipped with an integrated topography measurement option. This guarantees superior lens quality and simplifies the operator's work. A special sensor tool reads the lens surface and measures about 300 points. The actual values are then compared to reference values and the operator receives the lens quality information, which enables him to adapt the machine axis configuration or the tool geometry.

Some lenses might require semi-visible markings on the surface. There are different marking methods: a separate machine (laser engraver) after polishing, or marking done within the generator.

Because generators' throughput, features, and automation levels vary, labs should choose a generator based on their specific needs. The market offers machines with production throughputs from approximately 25 lenses/hour up to 100 lenses/hour.

A MASTER DISCIPLINE IN LENS MANUFACTURING

Finally, from a technological and mathematical perspective, generating can be considered a master discipline in lens manufacturing. But without full integration and optimal linkage to all other lens manufacturing processes it would be useless. As technology continues developing, the generating process will continue to change as well. The industry will push technological advancements and the consumer will ultimately benefit from them.

Mark Hollmann

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Mark completed his apprenticeship as mechatronic engineer at Satisloh in 2004. After studying Mechatronic Engineering at the University of Applied Sciences (THM) in Giessen/Friedberg, Germany, he worked as Service Engineer for Satisloh. He then entered in the field of Application Engineering where he gained further experiences for about four years. In 2015 became Manager of Customer Engineering and moved to North America where he was responsible for surfacing. He came back in 2017 and started working as Product Manager.