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Technical Paper

Dynamic Kinematics & Universal Polishing Tools in the Multi-FLEX polishing machine

Mark Hollmann, Product Manager
Surfacing and Industrial Finishing
Satisloh GmbH
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Soft-Tool Polishing

The spherical and the tangential process:

The introduction of soft-tools was a revolutionary step in polishing of ophthalmic lenses. Together with the capability to produce backside progressive surfaces on all-format generators, it launched the optical industry into the “digital age”.

In contrast to hard-lap polishing with more than 1000 different tools, soft-tool polishing was able to cover a wide working range with only 15 different tools using a spherical process. This process applies a tumble movement of tool axis to lens: the tool follows the lens radius. This results in a very uniform stock removal but the polishing times are relatively long. Also, 15 different tool curves still mean a rather large number of tools, even though the amount is drastically reduced in comparison to hard-lap polishing.

Seeking for easier, faster and cheaper solutions, the next evolution in polishing was the tangential process.

With the first tangential process development on Toro-FLEX and Duo-FLEX, Satisloh was able to reduce the number of required polishing tools to 3 to 7 tools with different curves; another big step in reducing tool inventory. Furthermore, the tangential process allowed to reduce polishing times, while maintaining the high stock removal uniformity of the spherical process. The tangential polishing process works with a calculated base angle (ϕ0) and a stroke. Both parameters are calculated upfront and will not change during the polishing of a specific lens.

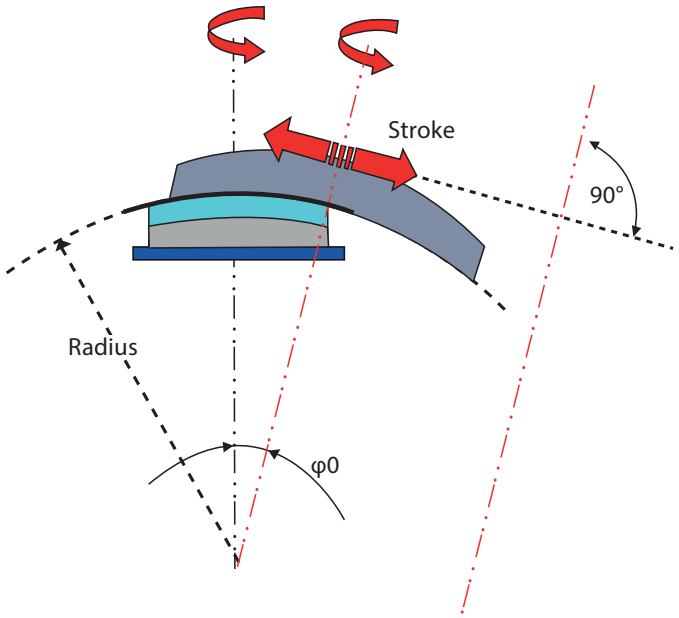

Figure 1: Theoretical kinematic model of tangential polishing process

Tangential polishing is used in the Toro-FLEX, the Duo-FLEX and in the newest Satisloh polisher, the Multi-FLEX. On all three machines the basic arrangements of the degrees of freedom (relative movement between tool and lens) are the same. One obvious, big difference is the amount of polishing tools. While Toro-FLEX and Duo-FLEX are using 3 to 7 tools with different base curves, the Multi-FLEX uses only one universal curve, which results in one tool for its standard polishing process. This development is yet another major step in the evolution of soft-tools, and reduces tool inventories and complexity to the absolute minimum possible.

All Satisloh soft-tool polishers control the process with the same parameters: polishing force, oscillation speed (speed of linear movement of the tool from centre of the lens to its edge and back) and RPM´s of tool and lens rotations. And all start the polishing process with a calculated position of the tool to the lens.

The main difference, other than the amount of tool curves, is the kinematic model. On both Toro-FLEX and Duo-FLEX a static kinematic model is used, whereas Multi-FLEX employs a dynamic kinematic model, which is much more complex and requires extensive know-how and development time, but also leads to much more accurate results.

Duo-FLEX and the static kinematic model:

The Duo-FLEX polishing process is based on static process macros without analysis of the lens surface file. Duo-FLEX utilizes 7 different tool curves. Every single tool has a defined Rx working range and one fixed base angle (angle of the tool to the lens) regardless of job data. Duo-FLEX has to control the process with a large number of macros and settings. A distinct macro is needed for each material, each diameter range and each one of its 7 tool curves. Each macro includes a static polishing time, a static polishing force, static RPM´s for tool and lens, a static oscillation speed and static overrun factors for the centre and the edge of the lens. This results in approximately 200 macro combinations. But since macros and base angles are static for a range of lenses, compromises are inevitable, and the majority of lenses are polished with parameters that are approximately, yet not exactly, right for them.

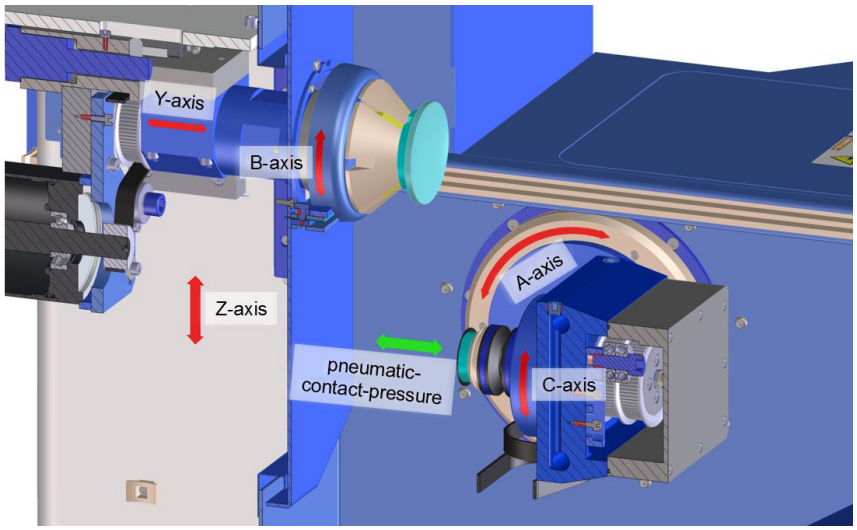

Figure 2: The configuration of axes in the Duo-FLEX polisher was designed for the tangential polishing process with static kinematics

Multi-FLEX and the Dynamic kinematic model

Multi-FLEX is using one universal tool curve. Satisloh offers different processes, which in some cases require specialized tool materials or diameters but still the same tool curve. The dynamic kinematic model uses complex math and analysis of the lens surface file to calculate the optimum polishing tool path. The job parameters GBASE and GCROSS plus the diameter of the lens are the basic values which are considered in this calculation. Depending on the polishing force, the dynamic kinematic model calculates a “polishing spot” (contact surface between tool and lens) and, using the information from the surface file, determines an individual base angle and starting point for the polishing process for each lens. This results in millions of possible combinations creating unique dynamic kinematics.

Multi-FLEX only uses a very small number of macros: one per material and process. Yet the parameters in each macro (polishing force, polishing time, oscillation speed and RPM´s of tool and lens) are specifically calculated for each lens. This means that Multi-FLEX, due to its dynamic kinematics, polishes every lens with an individually optimized process, resulting in the most accurate optics for the wearer.

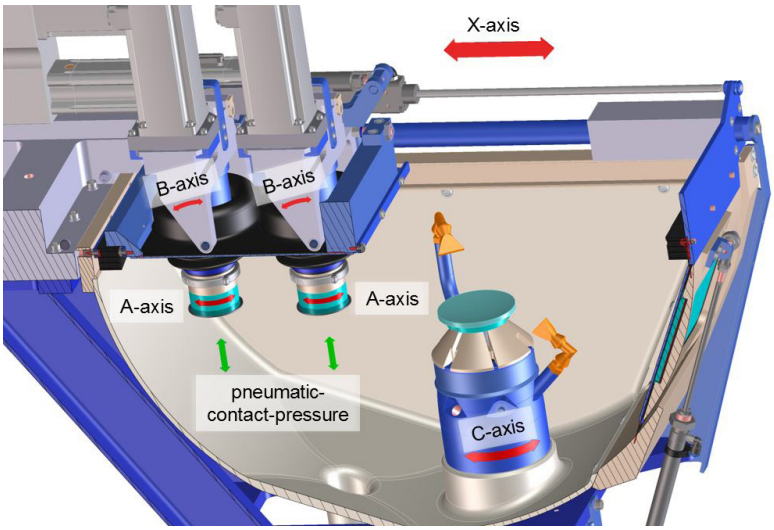

Figure 3: The advanced configuration of axes in the Multi-FLEX polisher is designed for the tangential polishing process with dynamic kinematics

SUMMARY:
Spherical soft-tool polishing together with all-format generating launched optical manufacturing into the digital age and meant the end of huge hard lap tool inventories. Tangential polishing was the next development step. Satisloh’s universal tool polishing reduces complexity and tool inventory to the absolute minimum while at the same time introducing a highly sophisticated calculation model for the optimum polishing tool path: dynamic kinematics. Traditional soft tool polishers calculate parameters for a range of lenses resulting in approximations and compromises. Only Multi-FLEX’ dynamic kinematics calculate optimized parameters for each individual lens resulting in most accurate optics and best vision for the wearer.