

Universal Tool Polishing

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22.02.2016

Version 1.4

The aim of this document is to provide information about a new simplified yet powerful lens polishing technology. Any information given is not binding and can and will be changed without further notice.

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1. INTRODUCTION

The science of polishing a lens is all about bringing high sheen and better transparency to a generated surface in multiple materials, curvatures and complex geometries, without compromising the generated shape, RX and complex design.

Flexible tool polishing was introduced, together with free-form generating technology, to manufacture lenses more efficiently and cost effectively and produce both complex and traditional toric surfaces. Automation has been progressively integrated into this process, resulting in multiple options that can be included in one system to monitor, control, and verify different sets of parameters enabling repeatable results with higher throughput numbers and exceptional yields not reached before.

Combining flexible polishing and automation opens a wide range of possibilities for working with different indexes, shapes, and surfaces while minimizing resources, efforts, costs and time.

There have been many advancements in polishing kinematics, as well as in the reduction of the number of polishing tools used in the process. Traditionally, an Rx lab used approximately 5,000 hard lap tools to fine and polish its jobs, and incurred additional costs and labor associated with the re-work of those tools. The introduction of digital generating and flexible tool polishing changed this number dramatically; polishers were introduced by various manufacturers that required 14, 7 and even as few as 3 tool curvatures. Then a breakthrough occurred in 2015, where it is now possible to use only one specific curve on the tool (a Universal Tool) for both standard and extended Rx working ranges, without compromising short polishing process times. Moreover, a tool life of up to 14,000 seconds means that tools have to be changed only once per shift, ideal for multi-shift operation without constant monitoring.

This revolutionary Universal Tool concept combined with the long tool life eliminates the need for tool exchange automation, saving space inside a polishing machine. Also, by only handling lenses (and not tools) with optimized movements, the automation becomes much simpler and faster, which reduces process times.

The Universal Tool process reduces logistics efforts and costs, optimizes all features in a smart footprint, and significantly increases machine productivity to up to 100 lenses/ hour.

“First came the breakthrough of Universal Tool polishing, and now new automated equipment to take advantage of that breakthrough.”

After developing a Universal Tool that lasts up to 14,000 seconds and processes standard and extended working ranges, Satisloh has embarked upon creating a new polishing system far more efficient, faster and simpler than any other polishing machine built today.

This new machine is called Multi-FLEX, a complete polishing system including:

- Independently-controlled chambers: it's like having 3 machines in one.
- Optimum kinematics for every lens type and prescription.
- Eliminates non-productive process steps like tool changes, which saves time.
- Multiple process options for versatility.

2. Multi-FLEX: Universal Tool Approach

The kinematics of previous Satisloh flexible tool polishers were based on having each tool curvature available in every system to best fit the prescription and achieving minimum polishing process times. This created the need for many different tools. Multi-FLEX's revolutionary concept focuses on the lens surface geometry rather than the tool to polish, influencing all parameters of the kinematics of the machine.

The Universal Tool approach delivers higher throughput without needing extremely short polishing times. This is achieved by eliminating frequent tool exchanges, which is the process step that requires the longest time.

Without tool exchanges (even for a two-step process) there must always be a polishing tool present and available in every chamber, and the lifetime of the tool should be very long to avoid interruptions for manual tool exchange.

2.1 Description Universal Polishing Tool and Working Range

The standard Multi-FLEX polishing tool is the Universal Premium Tool, a Satisloh multi-layer soft conformable tool with a hard base cap.

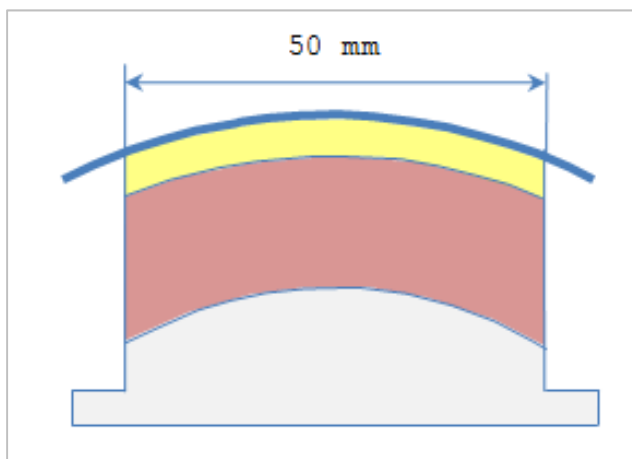


Figure 1.
Universal Premium Tool

This tool is designed for the standard working range of 0-14 diopters (index. 1,523), and for lens diameters from 55mm to 85mm. The tool geometry had to be modified to fit this complete range.

On one hand, to polish back curves between 0 and 14 diopters, the tool height had to be considered (thickness of the foam). Lenses with different curvatures, like a plano lens versus a high minus lens,

show a very significant difference in their seg height, yet the tool needs to be in constant contact with the lens in both scenarios.

Due to this requirement for constant contact for a wide variety of lens back curves, the curvature of the newly developed tool is a value close to the average curvature of its working range.

On the other hand, using one curvature to polish all different lens geometries and a wide range of diameters while maintaining the short polishing times of its predecessor Duo-FLEX, requires an optimized tool diameter for compensation: big enough to cover as much lens surface as possible even for large lens diameters, yet small enough to allow sufficient room for polishing slurry to be delivered to the lens surface during the process.

The tool diameter dictates the minimum lens diameter that can be polished on the machine. The diameter of the Universal Premium Tool is 58 mm, resulting in a minimum lens diameter requirement of 55 mm. The maximum lens diameter is 85 mm, 10 mm more than with the Duo-FLEX polisher.

As mentioned above, there is no automatic tool handling/exchange needed on the Multi-FLEX (not even for a two-step process), reducing complexity and improving machine cycle times and ultimately leading to increased productivity. However, this requires a tool with an extraordinarily long life.

The life of the Universal Premium Tool is up to 14,000 seconds. This means that if the chamber is equipped with two Universal Premium Tools, only one short interruption per shift is needed to replace them. The drastically reduced number of tool exchanges is easily executed by hand in less than one minute.

The Universal Premium Tool, as well as other Multi-FLEX tool types (as mentioned in section 3), are held in the spindle's tool reception by a plastic ring. This plastic ring works also as an indicator for the operator, showing that the tool has been placed correctly in the tool reception. The ring only closes if the tool is properly positioned.



Figure 2.
Universal Premium Tool and ring

2.2 Process Description

The Universal Tool polishing processes are based on a one-step tangential process.

The polishing kinematics are created by a CNC-controlled tool movement that takes the lens geometry into consideration. Tool and workpiece spindle rotation speeds are selectable. In the tangential polishing process the tool spindle rotates at a different speed than the workpiece spindle. All axes in all different chambers are controlled individually for simultaneous operation.

There are two different process options available for each chamber: one-step or two-step polishing process. This is possible because two tool spindles are present in each chamber (explained in section 2.1.1.).

3. Process Stations

Due to the reduced hardware complexity of Multi-FLEX (only lens handling, one tool curve, gantry loader with linear disposition), space has been freed up for more components, allowing 3 individual polishing stations and two single washing stations in the machine.

3.1 Polishing Chambers

Each polishing chamber has its own control unit, making it completely independent from the other chambers and allowing Multi-FLEX to polish up to 3 different lenses simultaneously.

With that, Multi-FLEX is truly like 3 separate polishing machines ALL in ONE (3 in 1). The machine saves time by avoiding tool changes, considerable floor space due to its compact design, and labor cost due to its automation.

The 3-chamber feature also results in maximum utilization of the machine's resources as well as continuous operation, even if one chamber is out of service.

The polishing chambers are made of plastic to avoid corrosion and are inclined 20° to let the polishing slurry drain to the recirculating system. The machine is designed with fewer corners to avoid solid polishing slurry deposits, providing more effective automatic cleaning and reduced polishing slurry costs. Its smart chamber design means that the recirculating polishing system does not get blocked, even if a large item (deblocked lens or destroyed tool) falls into the chamber.

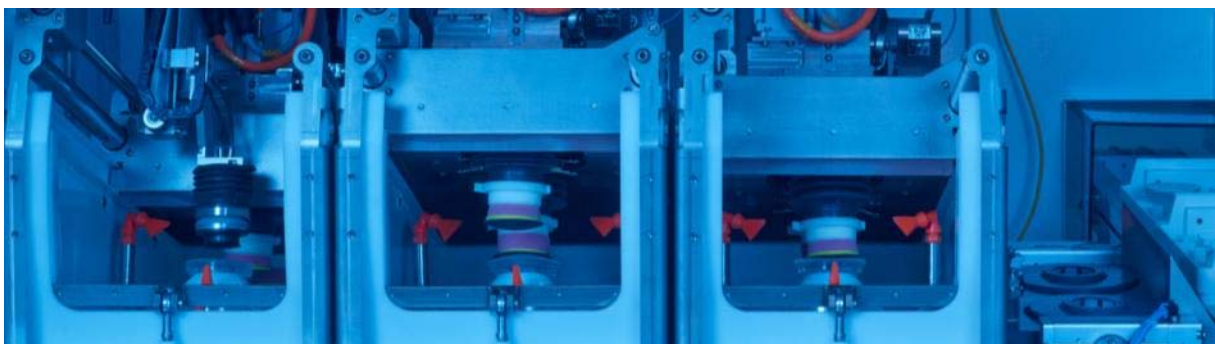


Figure 3.
Multi-FLEX polishing chambers

Each polishing chamber includes:

- 1 set of 2 spindles to support 1 tool each, called “tool spindles”.
- 1 spindle that holds 1 blocked lens, called “workpiece spindle”.
- 1 individual polishing recirculation unit.

3.1.1 Tool Spindles

The set of two tool spindles is not interconnected between chambers. The polishing chambers, as previously explained, are completely independent from each other.

The tool spindles provide the correct angle for the process (between 0 and 45°) and apply the proper pressure to the tool.

During the polishing process, the tool spindles approach the lens. Their movement is synchronized, although they are never used at the same time. Each tool travels to the one lens in the chamber when required.

As mentioned above, each chamber is equipped with two tool spindles, each holding one tool. Both tools are always present and available until they reach their lifetime and are manually exchanged.



Figure 4.
Multi-FLEX tool spindles

Process wise, this allows multiple options:

- Universal Premium Process: One-step process for standard range jobs; uses Universal Premium Tool
- Universal Premium ER Process: One-step process for extended range with the Universal Premium ER/HS Tool
- Universal Premium HS Process: Two-step process for standard range jobs for high sheen, with two different types of tools (Universal Premium and Universal Premium ER/HS)
- Universal Speed Process: Two-step process for maximum productivity, with two different types of tools (Universal Speed and Universal Premium)

These options are explained in detail in Sections 3 and 4.

The Multi-FLEX spindle configurations, as well as the spacious polishing chambers, reduce complexity regarding the number of axes: the Multi-FLEX has one fewer axis than the Duo-FLEX.

3.1.2 Workpiece Spindle

The workpiece spindle (one per chamber) holds the lens. Each lens is polished with its own set of parameters, independent from the lenses in the other chambers.

During the polishing process the blocked lens remains in a fixed position and the tool spindles approach the lens. The fact that the lens does not move to a different position (it only rotates) eliminates the risk of damage from hitting polishing nozzles inside the chamber.

The tool spindles are at the top of the chamber while the workpiece spindle is at the bottom. This configuration allows the lens to receive the maximum amount of polishing slurry. Polishing slurry does not stay on the lens surface due to the chamber's 20° decline. At the end of the process the lens is therefore free of polishing slurry residue, which avoids contamination of the handling system. This reduces polishing slurry costs as well.



Figure 5.
Multi-FLEX tool spindles and workpiece spindle

3.1.3 Individual Polishing Recirculating System

The most important parts of the polishing recirculating system are the polishing tank that contains and supplies the polishing slurry at certain temperatures and flow rates, and the polishing nozzles inside the chambers that eject the slurry onto the tool and the lens.

The nozzles are in fixed positions and deliver enough polishing slurry to lens and tool for every lens surface and diameter.

Since the 3 chambers operate simultaneously but are independent from each other, every chamber needs its own polishing fluid supply at different times. It is very important that both, a constant flow rate and the correct polishing fluid temperature, are maintained in all circumstances, regardless if only one chamber is working or all three. Unexpected variations of any of these parameters can alter the results. For these reasons the Multi-FLEX requires an intelligent polish slurry tank system.

The Multi-FLEX intelligent slurry system controls all of these different parameters for each chamber.

Satisloh is also developing an automated intelligent central slurry tank system with its partner Bazell Technologies.

3.2 Washing Stations

There are two single washing stations in the machine.

After the lens has been polished, the remaining polishing slurry residue needs to be rinsed off as soon as possible. Dried polishing slurry can cause scratches during cleaning, stains that are difficult to remove, coating defects and many other issues. This can be avoided by simply rinsing the lenses for only a few seconds after the process finishes.

The washing station not only rinses, but also dries the lens, delivering a dry lens back side free of polishing slurry. After the blocked lens reaches the washing station, the plate holding it turns by 180°, which means the surface that needs to be cleaned faces down inside the station. A pressurized jet ejects water through nozzles inside the washing station. Next, the plate (and lens) turns 180° again to its original position and compressed air is blown onto the lens surface to dry it.

This “washing” process is a pre-cleaning step for the lenses that prepares them for transportation to the next process station, such as lens marking or final cleaning before coating.

Multi-FLEX features two independent washing stations, each handling one lens and working in parallel with other processes in the machine, which optimizes process cycle time.



Figure 6.
Multi-FLEX washing station

4. Different Tool Types



Universal Premium Tool

- Standard working range:
 - Curvature: 0-14dpt (index. 1,523)
 - Lens diameters: 55mm to 85mm
- Standard materials
- Optimal surface for subsequent hard coating
- Used in one and two step processes
- Tool diameter (at pad): 58 mm
- Life: 14,000 seconds



Universal Premium ER/HS Tool

- For extended working range in a 1-step process:
 - Curvature: 14-18dpt (index. 1,523)
 - Lens diameters: 48 mm to 90 mm
- For creating a high sheen surface in a 2-step process
- Standard materials
- Best tool for use on CR-39 lenses that won't be back side hard coated
- Used in one and two step processes
- Tool diameter (at pad): 42 mm
- Life: To be determined (process in testing)



Universal Speed Tool

- Standard working range:
 - Curvature: 0-14dpt index. 1,523
 - Lens diameters: 55 mm to 85 mm
- Standard materials
- Faster polishing process times
- Used only in two step process, as first step
- Tool diameter (at pad): 58 mm
- Life: To be determined (process in testing)

5. Multiple Process Options

Universal Tool approach + independent polishing chambers + different tool types

The Universal Tool approach, 3 independent polishing chambers, and the set of 2 spindles present in each chamber make the Multi-FLEX not only a flexible, but also a high volume system for the varied mix of lens characteristics in an Rx lab. Following is an explanation about how every one of these features can be used to achieve maximum usability of the machine fulfilling every Rx production need.

5.1 Universal Tool Approach

Using the Universal Tool eliminates the need to exchange tools for every processed lens, thus removing the complexity and expense associated with such exchanges. It also allows reduced machine size since no tool magazine is required.

Tools are exchanged manually, once per shift for the one- and two-step processes. After the tool has been replaced there is always a long lifetime tool available in the chamber.

The time and space savings from eliminating tool exchanges after every lens result in maximum utilization of the machine's resources, allow continuous operation and increased productivity, and make a third chamber possible in a very compact footprint.

5.2 Three Independent Polishing Chambers

The three independent polishing chambers allow optimum kinematics for every lens geometry.

There is no need for batching, and continuous production of every lab's product mix becomes a reality.

This is possible since every chamber acts like an independent machine with different sets of tools and/or parameters.

With Multi-FLEX the lab can mix and simultaneously polish a wide variety of lenses without process interruptions:

- Single eye jobs
- Different back curves in one job
- Lenses with different cosmetic requirements
- Different lens types in one job (e.g., freeform vs. compensation on single vision)
- Different lens geometries in one job (e.g., big and small diameters, elliptical and round shapes)

5.3 Set of Two Spindles in Each Chamber

Multi-FLEX can mix and process various types of lenses at the same time not only due to its independently controlled polishing chambers, but also because each chamber has 2 spindles that can be equipped with different tool types (or one type) creating the below configuration scenarios for each chamber.

It is important to note that the machine's capability of changing between spindles within seconds saves considerable time in the two step processes.

- Two Universal Premium Tools => Universal Premium Process:
 - Two tools of the same type extend the time between exchanges: when one tool's lifetime expires, the second one can be used, reducing the frequency of manual tool exchanges to once per shift.
 - Avoids interruptions if one tool can't be used anymore; maximum uptime.
 - One step process
 - Estimated throughput: Up to 90 lph

- One Universal Speed Tool and one Universal Premium Tool => Universal Speed Process:
 - Faster process times
 - Two step process (Step 1 Universal Speed / Step 2 Universal Premium)
 - Estimated throughput: Up to 100 lph

- Two Universal Premium ER/HS Tools or one Universal Premium Tool and one Universal Premium ER/HS Tool:
 - One step process with the Universal Premium ER/HS Tool for special geometries and jobs outside of the standard range => Universal Premium ER process.
 - Two step process for high sheen on standard range jobs (Step 1 Universal Premium Tool / Step 2 Universal Premium ER/HS Tool) => Universal Premium HS process
 - Estimated throughput: Up to 90 lph

6. Overview Machine Configurations for Versatility and Throughput

It is critical to analyze the needs of each lab and based on this analysis choose the optimum machine configuration for the best combination of throughput, quality and job logistics.

Please refer to the following table for configuration examples:

Multi-FLEX – a new level of versatility

Process	Polishing Chamber	Tool Spindle	Tool	One/ Two- Step Process	Working Range	Diameter
Universal Premium	1	1	Universal Premium	One-Step process	0-14 diopt	55-85 mm
		2	Universal Premium	One-Step process	0-14 diopt	55-85 mm
	2	1	Universal Premium	One-Step process	0-14 diopt	55-85 mm
		2	Universal Premium	One-Step process	0-14 diopt	55-85 mm
	3	1	Universal Premium	One-Step process	0-14 diopt	55-85 mm
		2	Universal Premium	One-Step process	0-14 diopt	55-85 mm
Multi-FLEX Config. 1/ Estimated Throughput: up to 90 lph						
Universal Speed	1	1	Universal Speed	Two-Step process	0-14 diopt	55-85 mm
		2	Universal Premium		0-14 diopt	55-85 mm
	2	1	Universal Speed	Two-Step process	0-14 diopt	55-85 mm
		2	Universal Premium		0-14 diopt	55-85 mm
	3	1	Universal Speed	Two-Step process	0-14 diopt	55-85 mm
		2	Universal Premium		0-14 diopt	55-85 mm
Multi-FLEX Config.2/ Estimated Throughput: up to 100 lph						
Universal Premium ER and Universal Premium HS	1	1	Universal Premium ER/HS	One-Step ER or Two-Step HS	14-18 diopt	48-90 mm
		2	Universal Premium ER/HS or Universal Premium (step 1)		14-18 diopt or 0-14 diopt	48-90 mm or 55-85 mm
	2	1	Universal Premium ER/HS	One-Step ER or Two-Step HS	14-18 diopt	48-90 mm
		2	Universal Premium ER/HS or Universal Premium (step 1)		14-18 diopt or 0-14 diopt	48-90 mm or 55-85 mm
	3	1	Universal Premium ER/HS	One-Step ER or Two-Step HS	14-18 diopt	48-90 mm
		2	Universal Premium ER/HS or Universal Premium (step 1)		14-18 diopt or 0-14 diopt	48-90 mm or 55-85 mm
Multi-FLEX Config. 3/ Estimated Throughput: up to 90 lph						

Note: it is possible to mix processes between polishing chambers creating a huge number of additional configuration possibilities.

Benefits of all configurations (within the standard working range)

All configurations can process in parallel:



- Single eye jobs
- Different lens curvatures in one job
- Different lens types in one job
- Different lens geometries in one job
- Continuous operation, even with one chamber out of service

Exclusive benefit for configuration with One Step Processes:



- Maximum uptime

Exclusive benefits for configuration with Universal Speed Process:



- Maximum throughput with a two-step process
- Faster process times
- Highest productivity

Exclusive benefits for configuration with Universal Premium ER and Universal Premium HS Processes:



- Process standard and extended range jobs
- Process special geometries
- High sheen

7. Intelligent Tool System (available Fall 2016)

Part 1 – Intelligent Tools (included in price of tools)

Each tool contains information on a data matrix code about type of tool, intended use and macros, and tracks usage in seconds. This is very important in order to make sure that tools on each spindle are known and never mixed up.

Part 2 – Tool Recognition System (separately priced option available 3rd Q 2016)

Special Imaging system on the loading arm that checks to ensure that there are tools on the spindles and checks for wear and rips in the carrier material on the tool each time a lens is being loaded into a chamber.

8. CONCLUSION

The Multi-FLEX polisher is a powerful system with greatly reduced complexity. Multi-FLEX takes polishing to the next level offering the highest throughput in the industry, a broad variety of process options using Universal Tool Polishing and the most advanced automation.

All these features come in one machine with 3 independent chambers and an integrated washing system. This saves floor space and reduces costs. Multi-FLEX can fulfill the high demands of a modern Rx lab, with versatile production options, throughput of up to 100 lenses per hour and top quality results.

“Like having 3 machines with automation, all in one compact footprint”

**Document information subject to changes; Multi-FLEX is now in the testing phase.*