SURFACE FINISHING GUIDEBOOK

medical instruments

EXECUTIVE SUMMARY

Among the various technologies used for finishing the surface of medical instruments, mass finishing and shot blasting play a key role, not only as intermediate steps but also for placing the final, finishing touch on these components.

Besides the right material selection, surface treatment is an essential component of the overall manufacturing process of medical instruments. Only high-quality surface finishes guarantee the required functionality, high sterility, corrosion resistance, and absolute reliability that most medical components require, while also providing a satin, non-glare appearance.

In this guidebook, we will discuss the types of medical instruments that can be treated with mass finishing and shot blasting methods and the wide spectrum of finishing goals that must be achieved on different materials ranging from high-strength metal alloys, like titanium, to 3D printed components made from different metals and plastic. Specifically, we will describe mass finishing and shot blasting treatment processes for medical instruments along with the type of equipment and media used for such applications.

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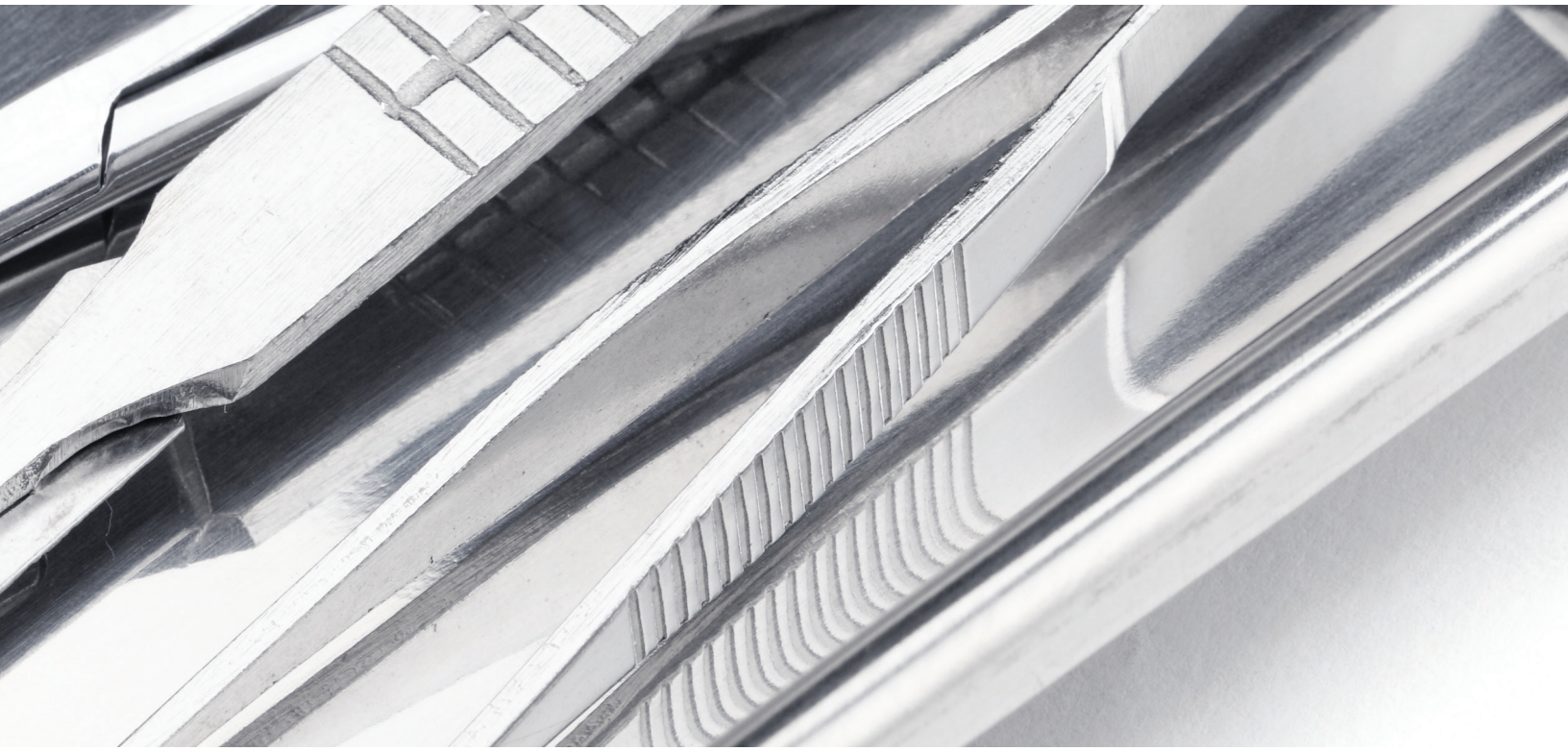


MEDICAL INSTRUMENTS ARE SUBJECT TO THE MOST STRINGENT PERFORMANCE STANDARDS

There isn't another industry where performance and reliability standards are higher than in the field of medical devices. This not only applies to implants, but also to medical instruments, all kinds of equipment, and other devices like orthodontics.

Biocompatibility	Most medical instruments need a very smooth surface to limit the risk of bacterial contamination. This is especially critical for invasive instruments.
Excellent functionality and long service life	With lives at stake, medical instruments must be able to reliably serve their purpose, 24/7, for an extended period of time, without ever impairing functionality.
Cosmetic appearance	Many instruments must have a satin, non-glare finish without jeopardizing their biocompatibility. A non-glare finish prevents distraction during surgical procedures.
Excellent corrosion resistance	Medical instruments must not get stained or corrode. They must be able to withstand frequent autoclave sterilization and exposure to harsh chemicals like chlorine wipes, ultrasonic cleaning, etc.

MATERIALS THAT CAN MEET THE TOUGHEST OPERATING CONDITIONS

Once implanted, medical instruments are exposed to frequent use, but even before then, they are subject to highly corrosive atmospheres caused by frequent sterilization in a steam pressure chamber, exposure to chlorine wipes, and ultrasonic cleaning. They must never fail. To minimize wear and prevent corrosion most medical instruments, especially surgical tools, are made from tough, slow wearing, corrosion-resistant, high-performance metal alloys like austenitic stainless steel, titanium, or cobalt chrome.

Some surgical instruments may even have tungsten carbide tips and edges for better resistance against pitting or scratching. For some medical components, as well as in orthodontics, lower-grade metals like aluminum and plastic may be utilized, but never for invasive instruments.

Some instruments may even have to be plated for better thermal conductivity (taking away heat from the body), electrical conductivity (for electrical equipment), higher strength, or absorbing light from lasers.

HIGH-QUALITY SURFACE FINISHES – A MUST FOR MEDICAL INSTRUMENTS

Besides the right material selection, surface treatment is the other key factor influencing the functionality, performance, and longevity of medical instruments. During the manufacturing process, medical instruments can undergo multiple finishing operations.

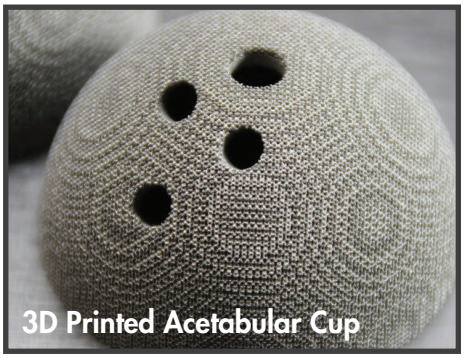
After the initial shaping process by forging, casting, machining, 3D printing, welding, heat treatment, etc. The surface of the raw components may have to be treated for deburring/edge radiusing, general surface cleaning, or initial surface smoothing. The latter is especially critical for 3D printed components.

Along the production chain, intermediate finishing steps in the form of surface smoothing and polishing may be required as preparation for plating or electro-polishing. The final surface finishing stages for medical instruments may include passivation, high-gloss polishing, or placing a matte, non-glare finish on the surface of components and frequently incorporate plating and electro-polishing.

The medical device industry is constantly looking for better, more suitable materials that will offer greater performance and last longer, while simultaneously searching for more efficient manufacturing technologies. When it comes to surface finishing, such newly developed materials and manufacturing processes can pose considerable technical challenges. That's why close cooperation between the medical device manufacturers and qualified surface treatment experts is essential, not after the fact, but during the development and prototyping phase.

A SPECIAL CHALLENGE – POST PROCESSING FOR 3D PRINTED COMPONENTS

To date 3D printing has been mainly a prototyping method. For example, scientists developed a computer model of the stinger of bees to produce a 3D printed prototype of an innovative hypodermic needle. However, 3D printing has evolved into a manufacturing technology for low volumes of standard products.



3D Printed Acetabular Cup

Unfortunately, printed parts have a much higher initial surface roughness than, for example, forged or cast components:

Initial surface roughness of 3D printed parts, Ra = up to 2,000 micro in.
Initial surface roughness of forged or cast parts, Ra = 120 – 320 micro in.

To go from an Ra of 2,000 micro inches down to 10 or lower can be a daunting task!

MASS FINISHING AND SHOT BLASTING – TWO ESSENTIAL FINISHING TECHNOLOGIES FOR MEDICAL INSTRUMENTS

Numerous surface finishing methods are utilized for the treatment of medical instruments. Among them are belt and wheel grinding, washing, electro-chemical machining (ECM), thermal deburring, electro-polishing, all kinds of plating, passivation, etc. However, because of their numerous economic and functional benefits, mass finishing and shot blasting are the most widely used treatment systems for surface preparation and finishing of medical components.

MASS FINISHING IS A GRINDING SYSTEM

The pressure between the media and work pieces creates a constant "rubbing" and generates a grinding and polishing effect!

Generally, mass finishing makes parts smoother.

Surface finishes can be as low as
Ra = 0.8 micro inches (0.02 micron)

SHOT BLASTING IS AN IMPACT SYSTEM

Small metal or mineral pellets are thrown onto the surface of a work piece at speeds of 200 – 800 feet/second.

The impact on the work piece surface produces the desired cleaning, peening or texturing effect.

For medical applications, mainly air blast systems are used.

Generally, shot blasting makes a surface rougher.

The smoothest finishes achieved with shot blasting are about
Ra = 32 – 16 micro inches

WHY MASS FINISHING AND SHOT BLASTING ARE SO POPULAR FOR FINISHING MEDICAL COMPONENTS

Even though their technical characteristics are quite different, mass finishing and shot blasting share common features:

- They create homogeneous, all-around "isotropic" finishes as opposed to "anisotropic" surface appearances produced by machining, belt and wheel grinding, rolling, drawing, or extrusion.
- Both can handle practically any type of material, from very tough metals like titanium, cobalt-chrome, and even tungsten carbide to softer metals like aluminum and magnesium, but also plastic and even ceramic.
- Mass finishing and shot blasting produce a wide spectrum of consistent, absolutely repeatable finishing results with easy-to-control mechanical processes. They completely eliminate quality fluctuations inherent in manual finishing operations!
- Users can select from a wide spectrum of equipment, from simple, low-cost, stand-alone machines to fully automated finishing systems.

MASS FINISHING AND SHOT BLASTING MACHINES USED FOR MEDICAL INSTRUMENTS	
MASS FINISHING	**SHOT BLASTING**
• Small to mid-size standard rotary vibrators • Special rotary vibrators without inner dome • Small tub vibrators • Small to mid-size centrifugal disk finishing machines • Compact drag finishers	**Dry shot blast systems** • Semi-automatic blast cabinets • Compact, fully automatic, indexing satellite table machines • Small, swing table machines **Wet blast systems** • Semi-automatic wet blast cabinets • Compact, fully automatic, indexing satellite table machines **Wide variety of robotic blast systems**

- Mass finishing and shot blasting are eco-friendly. Their operation does not pose any health hazards, and the sludge from mass finishing or metal dust from shot blasting can be disposed of in normal sanitary landfills or recycled.

- Both are used at various manufacturing stages. For example, for general cleaning, deburring/edge radiusing immediately after casting, forging, machining, welding, 3D printing, and intermediate finishing as preparation for coating, plating, or electro-polishing all the way to placing the final, finishing touch in the form of high-gloss polishing, or very smooth, non-glare finishes.

MASS FINISHING AND SHOT BLASTING GO HAND-IN-HAND

For example, shot blasting is used as a preparatory cleaning or peening step followed by a mass finishing process for surface smoothing and polishing or the other way around.

Certain medical instruments like tweezers, scissors, and scalpels must be polished by mass finishing and then blasted to place a matte, non-glare surface finish on the components. Consider the finishing process medical medical pliers:

FORGING

DESCALING BY BLASTING

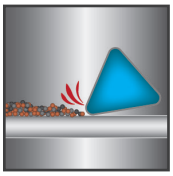
GRINDING/MACHINING

POLISHING BY MASS FINISHING

BLASTING FOR A NON-GLARE FINISH

THE FINISHING TASKS FOR MASS FINISHING

DEBURRING/EDGE RADIUSING
Sharp burs are ground off and edges are rounded.

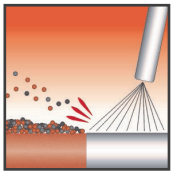


SURFACE CLEANING
Surface impurities like scale from forging, heat treatment, or castings are removed as well. Oil, coolant, and shavings from the part surface. The surface usually becomes smoother!

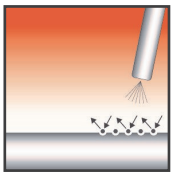
SURFACE SMOOTHING
Surface grinding creates smoothing frequently as preparation for polishing, plating, and electro-polishing.

POLISHING
High gloss polishing can be achieved down to Ra = 0.8 micro inches (0.02 micron).

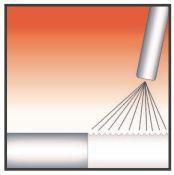
THE FINISHING TASKS FOR SHOT BLASTING



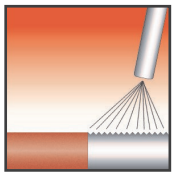
SURFACE CLEANING
Descaling after forging, casting, or heat treatment often produces a rougher surface.



PEENING
Inducing a compressive stress in a component surface makes it more resistant against general wear and corrosion stress cracking.

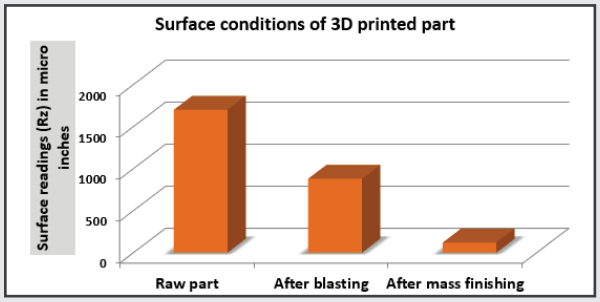


COSMETIC BLASTING/TEXTURING
Placing a very fine, matte, anti-glare finish is produced on components, for example, surgical instruments.



SURFACE PREPARATION FOR COATING
Surface texturing creates better adhesion of the coating material.

A SPECIAL CASE – PRE-SMOOTHING OF 3D PRINTED COMPONENTS BY BLASTING
Shot blasting normally makes a surface rougher, but since 3D printed parts have a very rough initial surface, shot blasting has a smoothing effect. It is used for pre-smoothing prior to mass finishing.

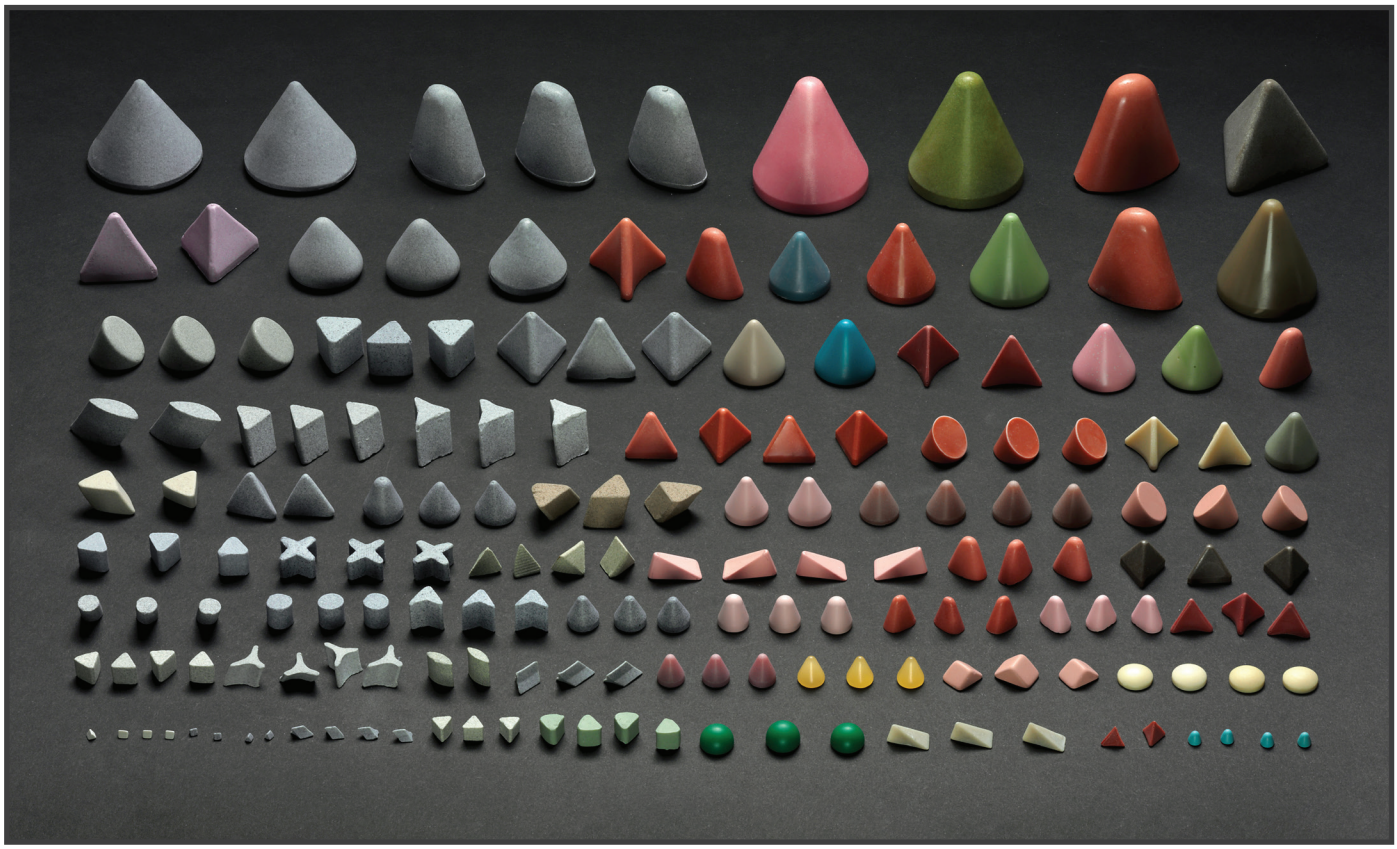


Roughness readings
Raw part: Rz = 1,700 micro in.
After shot blasting: Rz = 880 micro in.
After mass finishing: Rz = 120 micro in.

MASS FINISHING MEDIA – THE ESSENTIAL TOOLS FOR HIGH-QUALITY FINISHING RESULTS

In any machining operation good tooling is essential for producing quality parts. For mass finishing processes, the media are the "precision" tools that guarantee the specified finishing results. Especially in the field of medical devices with its zero-defect requirements, only top-of-the-line media and, for that matter, compounds, will ensure that the quality requirements, are met. The rapid development of tougher and more wear-resistant materials for medical devices frequently demands the development of new, innovative mass finishing media and processes that can cope with the surface finishing challenges of these new materials.

Good examples for these challenges are the increased use of ceramic materials in the medical field and components made with 3D printing.



HOW ECONOMICAL ARE MASS FINISHING AND SHOT BLASTING?

Both technologies are highly adaptive to customer needs and offer flexible, modular solutions. The equipment spectrum ranges from small manual or semi-automatic machines for low production volumes to fully automatic systems for high volume.

The customer decides how much they want to spend and what degree of automation they desire. The costs for work piece fixtures – if required – are manageable, and due to the high degree of mechanization, the personnel costs are only a small percentage of the total costs.

For relatively simple processes, the costs per piece can be as low as a few cents. With more complex, multi-step finishing operations for high-value components like orthopedic implants the costs for cut-down after casting/forging, followed by surface smoothing and polishing may amount to several dollars, a small fraction of the total component costs!

The big savings are, however, achieved by the stability of the finishing processes, ensuring absolutely repeatable, high-quality finishing results with zero scrap rates!

TYPICAL COST STRUCTURE FOR A 3-STEP MASS FINISHING PROCESS FOR KNEE FEMORALS IN A COMPACT DRAG FINISHER:

(1) Cut down after CNC grinding
(2) Surface smoothing
(3) High gloss polishing

- Depreciation	20 - 25%
- Personnel	10 - 15%
- Energy	< 3%
- Consumables (water, compound, grinding, and polishing media)	45 - 55%
- Maintenance and waste disposal	Less than 5%

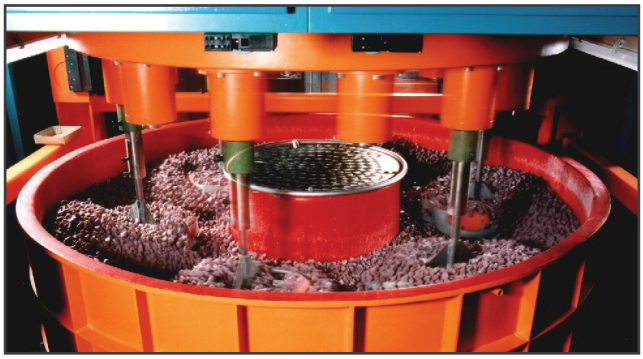
Total costs for all three steps: Less than $10!

MEDICAL INSTRUMENT CASE STUDIES

Let's look at some practical examples of mass finishing and shot blasting applications for medical instruments…

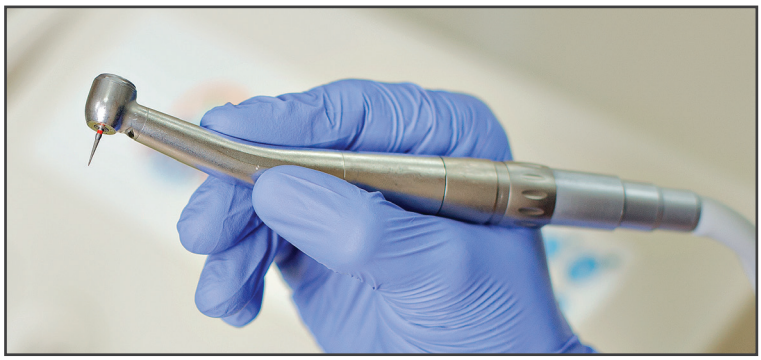
FINISHING DOORS FOR HEAVY-DUTY AUTOCLAVES

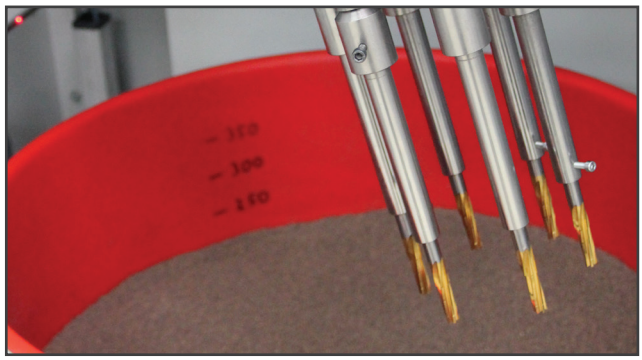
Finishing task	Deburring/smoothing and polishing of the work pieces after fabrication from Ra = 20 down to 4 micro inches
Mass finishing solution	Two-step, drag finishing process: (1) Deburring and surface smoothing (2) Polishing
Finishing equipment	Compact drag finisher with 4 work stations
Capacity	4 work pieces/hour
Economics	Costs per piece about $2.50



FINISHING OF STAINLESS STEEL DENTAL DRILL HEADS

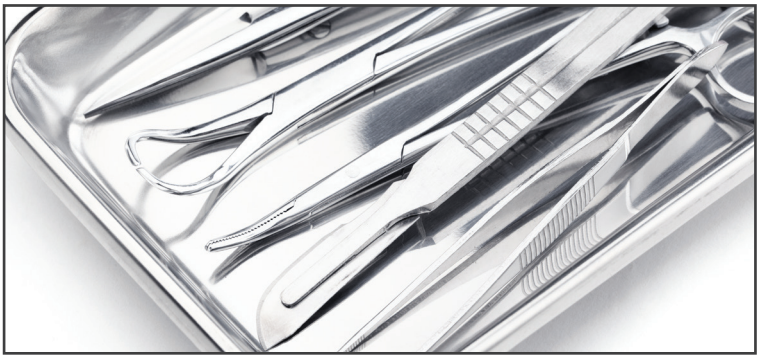
Finishing task	Deburring and surface smoothing of dental drill heads after milling from Ra = 40 - 60 down to 8 - 10 micro inches
Mass finishing solution	Two step drag finishing process: (1) Deburring and cut down (2) Surface smoothing
Finishing equipment	Compact drag finisher with 4 workstations; each workstation equipped with a 6-spindle head, allows 24 work pieces in a single batch
Capacity	About 42 work pieces/hour
Economics	Costs per piece about 20 cents





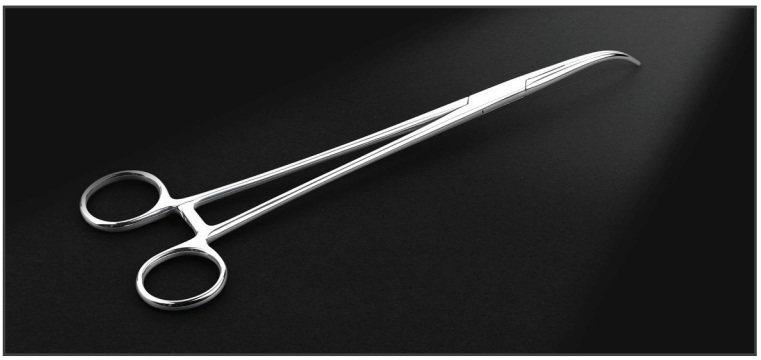
SURFACE CLEANING/TEXTURING OF STAINLESS STEEL TWEEZERS

Finishing task	Surface cleaning and texturing of the work pieces after forging/grinding and induction welding
Shot blasting solution	Treating the work pieces in a special air blast cabinet
Finishing equipment	Suction air blast cabinet equipped with turntable with crate holding the work pieces; automatic oscillation of the 4 blast guns
Capacity	About 850 pieces/hour
Economics	Costs per piece about 4 cents



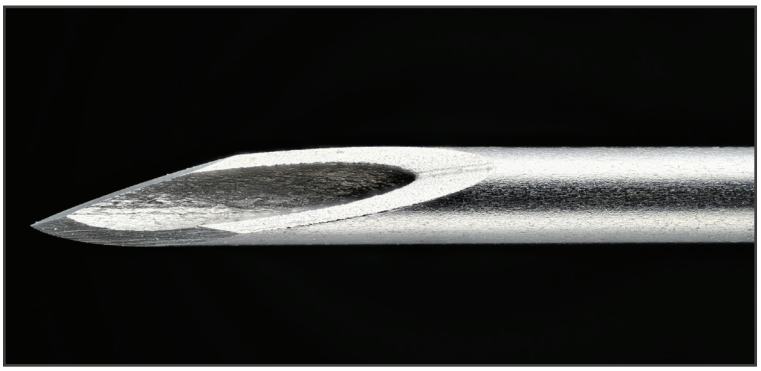
FINISHING OF STAINLESS STEEL SURGICAL SCISSOR SEGMENTS

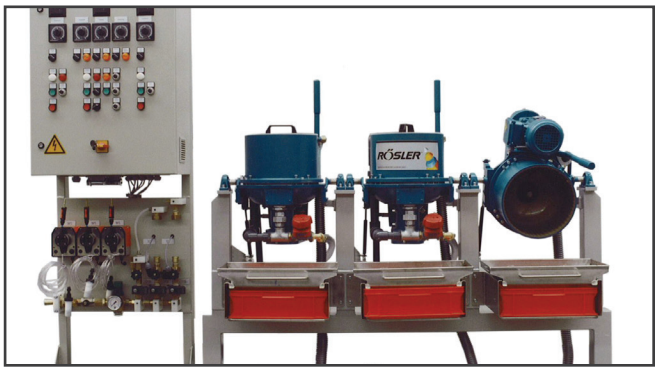
Finishing task	Deburring/surface smoothing after belt grinding and high-gloss polishing of the work pieces
Mass finishing solution	Two-step, vibratory finishing process: (1) Deburring and surface smoothing (2) Paste polishing
Finishing equipment	Special, flat bottom, rotary vibrator for gentle processing to prevent nicking of the parts
Capacity	About 30 work pieces/hour
Economics	Costs per piece about 40 cents



FINISHING OF CANNULAS AFTER TIP GRINDING

Finishing task	Deburring of the cannula tip and surface smoothing of the cannula body after grinding of the cannula tip
Mass finishing solution	Processing in a small, high-energy, centrifugal disk finishing machine
Finishing equipment	Semi-automatic centrifugal disk finishing machine with multiple work bowls allowing the treatment of small batches of a wide variety of different work pieces
Capacity	About 190 work pieces/hour
Economics	Costs per piece about 8 cents

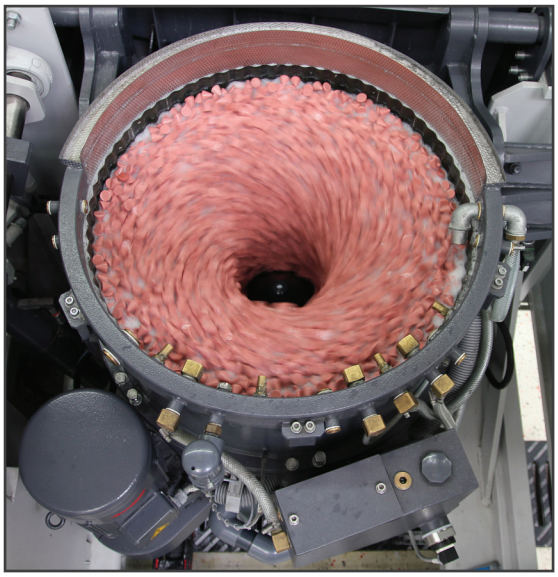




PLACING A MATTE FINISH ON STAINLESS STEEL SURGICAL PLIERS

Finishing task	Placing a non-reflective finish on pre-polished medical pliers. The surface must not become significantly rougher to prevent bacterial contamination
Shot blasting solution	Wet blasting with a slurry of glass beads and water
Finishing equipment	Wet blast cabinet with turntable; one manually operated blast gun
Capacity	About 30 pieces/hour
Economics	Costs per piece about $1.25

CONCLUSION AND OUTLOOK



Mass finishing and shot blasting have proven to become indispensable finishing tools for a wide variety of finishing tasks for medical instruments in different manufacturing stages, be it general cleaning, deburring, surface smoothing after casting, forging, stamping, machining, heat treatment, or surface preparation for plating, coating, or electro-polishing all the way up to placing the final finish on all kinds of implants and medical devices.

Medical instrument suppliers are continuously searching for product improvements. Their focus is equally shared between finding new, more reliable, and wear-resistant materials as well as new manufacturing technologies. Two examples are the increased use of ceramics as base material or coating and 3D printing.

The new materials are generally a lot tougher and harder than previously used materials. This makes the finishing tasks much more difficult. Especially with the increased use of 3D printed components, which have a much rougher surface than cast, forged or machined work pieces.

Suppliers of mass finishing and shot blasting equipment and consumables have met these challenges head-on by modifying existing equipment designs or developing brand-new machinery. However, the biggest progress has been made in the field of mass finishing media. There is now media on the market, which allow placing a high-gloss finish on components made from cobalt-chrome or titanium after CNC grinding. And these media even allow mirror polishing of ceramic work pieces. Likewise, 3D printed components can be finished from initial surface readings of >2,000 micro inches down to less than 10.

For more information on medical instrument finishing, mass finishing, or shot blasting, visit us at www.rosler.us.

If you would like to send in your parts for **FREE process development**, please contact us at 269-441-3000 or rosler-us@rosler.com.

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