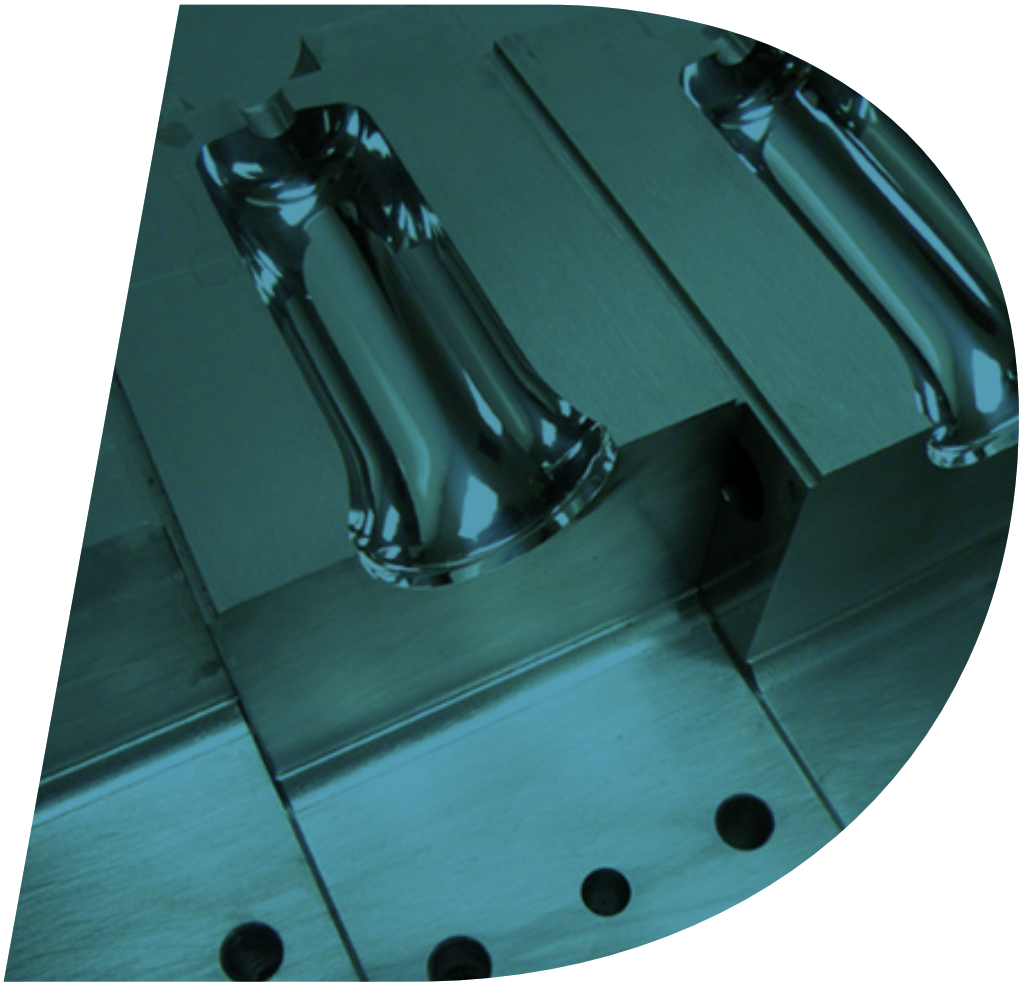
Injection Molding Polishing SC_V:1EN_10/2022

DLyte The metal surface finishing revolution



SUCCESS CASE.
INJECTION MOLDING POLISHING

For the mold and die industry

Powered by DryLyte® TECHNOLOGY

A brand of GPAINNOVA

INJECTION MOLDING POLISHING.
For the mold and die industry

THE COMPANY

GPAINNOVA's client is a company dedicated to design, manufacturing, maintenance and refurbishment of injection molds for high end industries such as medical device, optics or packaging, that require high gloss finishing.

"The surface quality of an injection mold affects productivity, quality and aesthetics of the end product."

THE PROBLEM

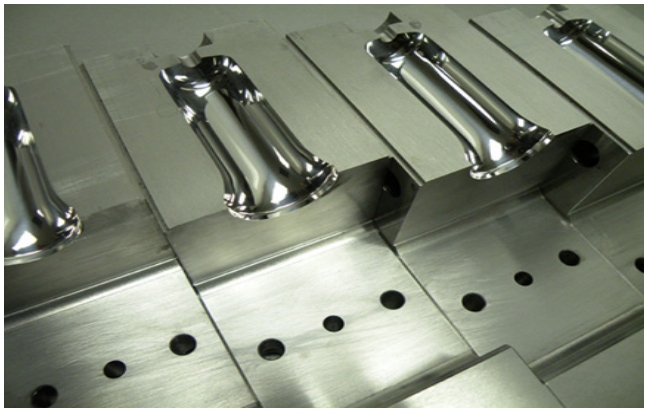
Injection molding manufacturing has evolved during the last years to improve throughput, quality of the manufactured parts and to extend useful life of the mold. The increased complexity in designs and materials has supposed a challenge for mold designers and manufacturers who are looking for new, more precise and reliable processes. The appearance of a product is dependent on the surface quality of the mold used in the manufacturing process.
Products with high gloss or extreme transparency require to be manufactured using a mold with high-end surface finishing. A good surface also reduces the risk of local corrosion and fracture or cracking due to temporary over loading or fatigue but it can lead to increased release forces and eventually sticking phenomena depending on the adhesion properties of the polymer used.
Despite the use of advanced tools in mold manufacturing, there is still need for a polishing final step, which tends to be manual, as there is no automatic process able to achieve a high gloss finishing keeping the tight tolerances of a free form mold.

The molds are carefully polished into mirror-like appearances, which is a cumbersome and time-consuming process that is dependent on individual polishers. This means that the polishing process is more a craft than a reliable production process, achieving consistent surface finishes from tool to tool. It is therefore of great interest within the industry to start using automated polishing techniques to overcome the mentioned drawbacks, and as a bonus, improve the working environment which today includes vibrating hand tools and monotonic work positions/operations.

The company identified that surface finishing of the injection mold slide insert could be automated to improve repeatability, quality and to lower production costs.

Until now, the company polished manually as there was no automated polishing method capable to polish with the requested quality and precision.

Manual polishing is an abrasive method that involves the use of sandpaper, oilstone, felt wheel, abrasive paste, alloy trowel, diamond grinding needle, bamboo, fiber whetstone, round rotary grinding machine, generating inconsistent finish across the mold and causing a higher tool deformation risk, as well as size or geometry deformation or others effects related to the polishing process. Additionally, this circumstance leads to high labor costs and excessive polishing time.



Why a good surface quality in molds is so important?

Because it prevents:

+ Imperfections on the final part's surface.
+ Performance reduction of the injection machine due to longer cycles.
+ Reduced lifespan of the tools.
+ Sticking of the part during release due to adhesion.
+ Corrosion of the mold.

Before adopting GPAINNOVA's solution, the customer applied a manual process using Sandpaper, oilstone, felt wheel, abrasive paste, alloy trowel, diamond grinding needle, bamboo, fiber whetstone, round rotary grinding machine in a manual workstation. Besides being significantly resource-demanding, these procedures were not cost-efficient and lead to a high rate of defective parts, tooling replacement and lack of quality of the final product.

What are the potential problems of the surface of a mold?

+ **Pitting**: Scattered (pin) holes dispersed over the majority of the surface.
+ **Comet tails**: Scattered holes with a tail, dispersed over the majority of the surface.
+ **Hole**: Smaller irregular or circular shaped cavity, e.g. pores, pinholes and imprints by abrasives.
+ **Groove (scratches)**: Longitudinal recession with rounded/flat bottom.
+ **Relief**: Hill-like formations in all kind of geometries covering the majority of the surface.
+ **Peak/Raising**: Small outwardly directed feature, often irregularly shaped, e.g. bare laid inclusions.
+ **Orange peel**: Randomly, smooth valleys and hills covering the majority of the surface.
+ **Waviness**: Longitudinal, smooth valleys and hills covering the majority of the surface.
+ **Discoloration/Staining**: Discoloured areas; e.g. "milkyspots".
+ **Haze**: Areas with lower gloss than the surrounding ("silvery frosted appearance").
+ **Burn mark**: Physical destruction due too high surface temp. during surface preparation.
+ **Crack**: Linear recession with a sharp bottom.

THE GOAL

The company was looking to improve production capacity and quality and to reduce cost of polishing slide insert molds for plastic injection. The customer needed to polish the molds to get higher quality and longer lifecycles, thus reducing refurbish and maintenance costs.

Concerning the polishing target, it consisted in mirror surface finishing and a significant roughness reduction to achieve an Ra goal of 0.05 micrometers including in narrow slots while preserving the radius of the external and internal sharp edges unaltered.

THE SOLUTION

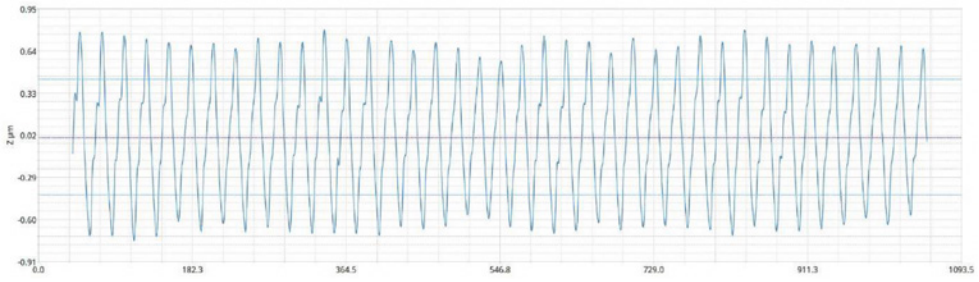
The customer prepared a batch of samples of stainless-steel molds produced stainless tool steel developed for cases where rust in production is unacceptable and where requirements for good hygiene are high, as within the medical industry, optical industry and for other high quality transparent parts.
The parts were produced by high-speed milling to a resulting roughness measured between 0.3- and 0.1-microns Ra (16 and 4 microinches). Targeted Ra was below 0.05 microns (2 microinches).

GPAINNOVA's Process Department defined the electrolyte based on material alloy, initial and targeted roughness and part geometry. After this, the Engineering Department developed a fixture to hold the pieces during the process specially prepared to avoid shadows, preventing part damage by impact and maximizing the capacity per cycle of the selected equipment. The equipment recommended by the Process Department was a **DLyte PRO500**, a compact machine with high output, specially designed for mass production (it can process up to **16 molds per cycle**). The movement and speed applied was defined to ensure a perfect media and electrical flow through the whole piece.

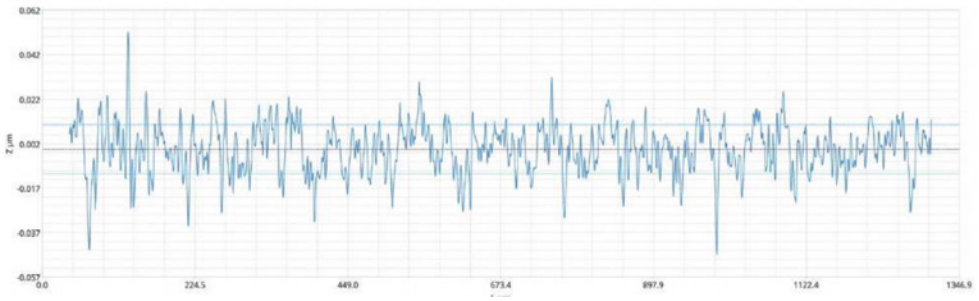
Main factors that determine the cost per piece are defined by CAPEX, which depends on the equipment required linked to the yearly production, the batch capacity, the process time per batch and the OPEX (which is defined by the weight removal per piece, media lifespan for the material and maintenance costs).

The media lifespan is determined by its metal absorption capacity, as the metal removed from the pieces is captured by the media particles. The way we use to calculate media's lifespan is linked to the quantity of metal that the consumable can absorb before losing effectiveness. This way, GPAINNOVA was able to calculate the number of pieces that we could treat with the media, based on average metal removal weighted on a sample badge. Metal absorption capacity of the media is different between materials, as material's density changes substantially for different metals. For heavy metals and alloys, metal extraction is higher than for light metals alloys.

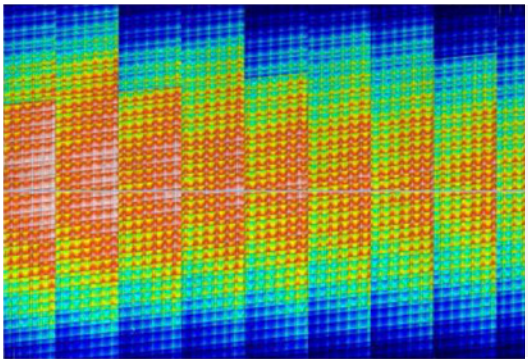
Different tests were performed in order to define the ideal combination of processes **to reach the technical specifications of the surface and lowest total process time and cost**. Technical specifications include high-gloss polishing of the mold to decrease surface texture of injected parts, premature failure and corrosion and to keep tight tolerances.



Rugosidad before DLyte



Rugosidad after DLyte



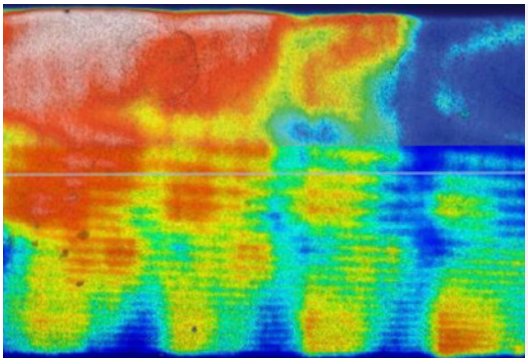
ISO 25178/Altura

Sa	2.1333 µm	Sq	2.5766 µm
Sku	2.5002	Ssk	-0.4744
Smean	1.5765 µm	Sv	9.3321 µm
Sp	6.3616 µm	Sz	15.694 µm

ISO 25178/Amplitud

Ra	0.4038 µm	Rsk	-0.0391
Rku	3.5122	Rt	3.5201 µm
Rmean	0.0033 µm	Rv	1.9071 µm
Rp	1.6131 µm	Rz	3.5201 µm
Rq	0.5030 µm		

Confocal roughness measurement before Dlyte® process



ISO 25178/Altura

Sa	0.5088 µm	Sq	1.2283 µm
Sku	54.2746	Ssk	-6.3824
Smean	-0.1585 µm	Sv	15.288 µm
Sp	2.8849 µm	Sz	18.173 µm

ISO 4287/Amplitud

Ra	26.404 nm	Rsk	-0.5531
Rku	4.5149	Rt	298.67 nm
Rmean	1.5570 nm	Rv	212.10 nm
Rp	86.576 nm	Rz	298.67 nm
Rq	33.920 nm		

Confocal roughness measurement after Dlyte® process

GPAINNOVA made trial runs applying different process times and parameters, and conducting roughness measurements with a profilometer and a microscope in different areas before and after the process.

Best results were achieved with dry suspension media, a solution based on gel particles and an electrically non-conductive liquid. The non-conductive liquid protects the surface of the piece against the oxidation created by oxygen present in the air. The processing time was 120 minutes for a 16 pieces batch, starting with an average roughness of 0.35 microns (14 microinches) after manufacturing process and a final roughness below 0.05 microns (1.2 microinches). The mass removal was 0.2 grams per piece.

Considering a weight removal of 0.2 grams per piece and the weight removal capacity of a full media work bowl of 210 liters –in the case of steel with dry suspension media is 4.04 kg–, GPAINNOVA, thanks to its DLyte solutions, can treat 20,000 parts per media lifecycle. Based on the processing time of 120 minutes and an estimated total time for loading and unloading the holders of 4 minutes, total process time is 124 minutes per batch of 16 pieces. The daily output considering 1 shift is 60 molds and the annual output assuming 250 working days is 15,000 units.

CURRENT STATE OF FINISHING

Manual Polishing

DLYTE FINISHING SYSTEM

***DLyte* (120 minutes)**

According to GPAINNOVA's experience, the achievable roughness values, material removal and process' time may change depending on the geometry and the initial state of the surface before being processed with DryLyte Technology.

Those are the costs per piece based on the material removal, process time and capacity:

- **OPEX cost per part: €1.41** (including media, maintenance cost, electricity and air consumption)

CAPEX: : €6 per piece for 5 years with 15,000 pieces/year (including equipment and customized holder investment)

BENEFITS

Among **the new DLyte surface finishing process' main technical benefits,** it is worth to highlight the following ones:

01. HOMOGENEOUS RESULTS ACROSS THE PIECE & GEOMETRY AND TOLERANCE PRESERVATION

DLyte is more precise and homogeneous than current abrasive processes as material removal is performed by an electrochemical process which depends on the number of impacts of the media against the surface, and the electrical field. The DryLyte Technology makes the polishing of molds without losing tolerances and radius precise and reliable. The biggest drawback of previously used manual polishing is that surface quality is dependent on the polishing operator's skills, that may generate inconsistent and undesired results to mold.

02. BEST-IN-CLASS CONCERNING SURFACE ROUGHNESS (RA UNDER 0.05 MICROMETERS)

DLyte can reduce the roughness over 80% in one step and without side effects. There is no other automated process able to process the parts defect free.

03. STABLE RESULTS AMONG DIFFERENT BATCHES WITHIN THE ELECTROLYTE MEDIA LIFESPAN

Dry electrolyte does not require maintenance, as the media absorbs the metal ions during the process and the cathode remains clean, thus achieving high-quality finishing results with zero scrap rates. The previous manual process was inconsistent.

04. LONGER LIFESPAN FOR TREATED PARTS

Improved corrosion resistances

+ Samples processed with DLyte corrode slower than parts treated with liquid electropolishing.

Corrosion Resistance Test Study.
The results of the study show that DLyte achieves better corrosion resistance than liquid electropolishing. The dry EP sample corrodes slower than the traditional EP sample.

QR - Download the Corrosion Resistance Study

Defect free and isotropic surfaces

+ DLyte process produces an isotropic non-directional finish improving the surface finish and providing repeatable, non-directional and uniform finish, as there is no surface abrasion. Instead, material removal of material is produced by ion transport. The previous abrasive flow machining process used abrasives with a high risk of metal inclusions.

05. BIOCOMPATIBILITY PROVED

DLyte is only using polymeric particles with acids to improve surfaces. DLyte has proven the biocompatibility of the products processed with its systems.

Among **the new DLyte surface finishing process main operational, economic and environmental benefits**, it is worth to highlight the following ones:

06. REDUCE PROCESS COMPLEXITY

DLyte replaces manual finishing improving lead time and ensuring quality consistence.

07. REDUCED FOOTPRINT

DLyte process features high output in a very compact footprint. Manual polishing required several stations which means 10 times more space for the same production.

08. COST AND TIME REDUCTION

The new process supposes a production cost reduction over 80%, including process, logistics, improved quality, and reduction of rejection and scrap of molds. The automated process is able to process 16 units per batch in 2 hours, this supposes a process time reduction per piece over 90%.

09. REDUCTION OF COST OF POOR QUALITY

The new process supposes an improvement of quality.

10. EASY WASTE MANAGEMENT

The dry electrolyte waste management can be easily handled by standard services. At its turn, all the metal removed from the workpieces remains in the media. As it is solid there is no risk of discharge in waterways or drains.

11. EXPOSURE OF WORKERS DURING PROCESS AND MAINTENANCE

DLyte process does not generate dust, heavy noise. Metals removed from the workpieces remain in the media, so workers are not exposed to the noise or dust. Manual polishing involves exposure to dust, noise and toxic particles to workers.

12. HANDLING AND STORAGE OF MEDIA

DLyte only uses solid electrolyte media with a low acid concentration, which can be handled and stored without additional safety measures. It is not harmful for workers and, since it is solid waste, its handling reduces the probability of discharge in drains and waterways.

Traditional industrial process

Industrial process with DLyte

> How to know when the electrolyte needs to be replaced?

DLyte Technology incorporates a software that calculates the electrical charge accumulated during the polishing cycles, a parameter that is directly proportional to the mass extracted during the cycle. The system enables the operator to adapt the parameters during the lifespan of the media to compensate the age of the electrolyte and to guarantee repeatability and performance. Once the media arrives at the end of its lifespan, the machine indicates that the consumable needs to be replaced by a new one.

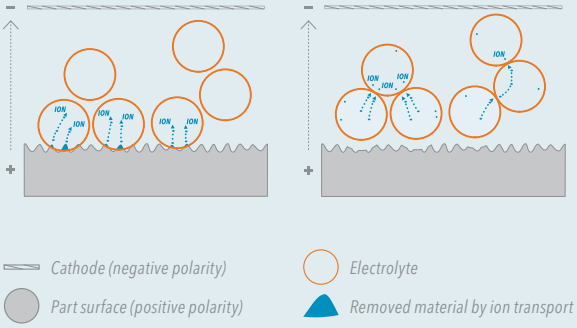
> How does the DryLyte Technology work?

The technology combines the mechanical surface finishing and liquid electropolishing processes, being able to reduce the surface roughness without impacting on the original geometry as the removal is based on ion transport instead of abrasion of the surface.

The equipment uses electricity with specific electrical parameters and moves the parts fixed by fixtures inside a tank full of media. Every time an electrolyte particle impacts the metal surface, there is an ion transport that removes irregularities from the peaks of the surface.

DRYLYTE TECHNOLOGY PROCESS

DryLyte is a patented technology for grinding and polishing metals by ion transport using free solid bodies. DryLyte Technology works by combining the electrical flow created by the high-precision rectifier with the movement of the pieces through the electropolishing media. This results in an ion exchange, **removing material only from the peaks of roughness. The process does not round edges** and can access internal corners that are not easily accessed mechanically.



> Why trust GPAINNOVA and DLyte?

A personalized assistance for GPAINNOVA's clients is assured during all the DLyte journey, thanks to our experienced teams that:

+ Advise customers to find the most suitable polishing process
+ Design and customize the best solution for the customer
+ Ensure a proper production performance (achieving target cost, lead time and surface quality results)
+ Train customers to take the most of the DLyte Technology
+ Solve any doubt about the technology and the equipment
+ Promptly assess any maintenance service needed

Thanks to this, we count on:

+ More than 600 satisfied customers worldwide
+ More than 800 machines installed
+ 55 distributors in 5 continents
+ More than 10 years of expertise in surface finishing processes

DLyte

Powered by DryLyte® Technology

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