3DEO

ENGINEERING FUNDAMENTALS

METAL
3D PRINTED
SURFACE FINISH

AN INTRODUCTION TO SURFACE FINISH

The nature of a surface is defined by the three characteristics of lay, surface roughness, and waviness. It comprises the small, local deviations of a surface from the perfectly flat ideal, or a true plane. Surface finish is an important aspect of a part's material property that affects the part's friction and layers.

For some applications and projects, the surface finish of a component can be a crucial parameter. Typically, it can be important to ensure quality, negate corrosive effects, or reduce friction for mating components. Because of this, manufacturers making parts in production need to understand how to evaluate the quality of a part's surface texture and understand its associated implications.

In general, more post processing often leads to a more refined surface finish, or smoother surface roughness. Different types of post processing can yield greater anti-corrosive properties, smoothness, and aesthetics. For example, a consumer product manufacturer may seek a durable matte black nitride finish to fit with their small consumer product that needs high density and a dark aesthetic.

SURFACE ROUGHNESS

Surface roughness is a measure of the variance in a part's surface topology. The engineering requirements for most parts include surface roughness specifications. Roughness affects part aesthetics (e.g. shiny or matte) and mechanical behavior like crack initiation, wear resistance, fatigue life, marine, sealing, bearing, and fluid dynamics.

Reducing roughness, or friction, is critical in mechanical parts like pistons, bearings, and seal surfaces where too much contact between moving surfaces can lead to rapid wear-and-tear. The rougher the surfaces in an integrated dynamic machine, the less quietly, efficiently, and safely it will operate. The specifications will differ case by case, but the smoothness required of an end-use part can be an important factor to weigh in costing it.

Surface roughness analysis includes the use of parameters to inspect and determine if the part manufactured meets quality control standards. Because of today's need to measure for quality control, the manufacturing industry is seeing a rise in high tech measuring equipment needs. Surface roughness analysis helps manufacturers and designers quantify the roughness of the surface finish they select.

MEASURING SURFACE ROUGHNESS

A surface's profile is measured using a profilometer which detects and records a surface's step, curvature, and flatness. This data is then used to calculate the roughness of the surface, typically using one of the parameters below.

Ra	Ra, Roughness Average, is the arithmetic average of surface heights measured across an entire surface. Simply put, it's the average height of the microscopic peaks and valleys on any given surface. *This is most commonly used in North America.
Rz	Rz, Mean Roughness depth, is calculated by measuring the vertical distance from the highest peak to the lowest valley within five sampling lengths, then averaging these distances. *This is most commonly used in Europe.
RMS	RMS, Root Mean Square, is calculated as the Root Mean Square of a surface's measured microscopic peaks and valleys.

SURFACE FINISH OPTIONS IN METAL 3D PRINTING

Metal 3D printing is quickly making a name for itself as an up-and-coming manufacturing technology. The shift in transitioning from traditional manufacturing to metal 3D printing is being driven by a variety of advantages, including product development flexibility, design freedom, and low-supply chain risk. While these are significant advantages, surface finish has historically been a difficult challenge for end-use applications.

Rather than manufacturing parts conventionally through MIM or CNC, Metal 3D printers build parts layer-by-layer to produce complete objects.

3DEO's 17-4 PH Stainless Steel Material Specifications in the As-Printed State

Relative Density	99.5%
As Printed Surface Roughness	**100-120 µin (2.5-3.1 µm) Ra**
Hardness	34-42 HRC

High volume metal 3D printing has been held back for years, in part, by the surface finishes yielded in the as-printed state. As such, it makes post processing a big opportunity for high volume 3D printers in the long run. Over the past few years, additive manufacturers turned their attention to surface finishes and have seen remarkable results with the likes of polishing, black nitriding, bead blasting, and a few other options, some of which (like 3DEO) can achieve a surface roughness of 10 µin (0.3 µm) Ra.

While metal 3D Printing brings with it a host of surface finishing options, the “right” finish depends on the part’s application. Because each case is different, there is no “best-finish.” Also, a designer or engineer needs to understand the benefits associated with each surface finish before deciding which is the best choice.

This understanding will help design and engineering teams grasp the costs and benefits associated with bringing 3D printed parts to a suitable finish and thus meet the goals of the project. 3DEO offers options for almost every use case and has production parts in a wide variety of industries today.

DIFFERENT METAL SURFACE FINISH PROCESSES

There are five main categories of surface finishing processes and each deliver a different aesthetic, feel, and part properties.

SURFACE FINISH TYPE	FINISHING PROCESS
Standard finish	Parts are “as sintered” out of the standard 3DEO 3D printing process
Undefined cutting edge finish	Abrasive Blasting Vibratory Finishing
Chemical additive finish	Isotropic Superfinishing Vibratory Finishing
Electric power finish	Electropolishing Metal DryLyte
Solidification by plastic deformation	Shot Peening

3DEO offers a variety of surface finishing options to customers.

To further detail this, we will select 7 of these processes to expand on with more detail.

Bead Blasting Finish

Finishing process to smooth surface without affecting tolerances. MIM-like surface finish, great for non-reflective applications, 32-64 µin (0.8-1.6 µm) Ra surface roughness.

Vibratory Finish

Machining process with an undefined cutting edge. The goal is to improve surface quality for small parts. This is done by rounding edges, smoothing processes, and grinding.

Polished Finish

Mirror finish with a unique production polishing process. Ideal for aesthetic and functional requirements, 10 µin (0.3 µm) Ra surface roughness.

Centrifugal Finish

Fully automated surface finishing which deburrs and polishes large metal parts.

Black Nitride Finish

Chemical hardening of steel that produces a black finish. Harder, more durable surface quality. Ideal for applications requiring a black finish.

Shot Peening Finish

The goal of shot peening is to strengthen the surface and solidify it through plastic deformation, thus modifying the mechanical properties of the surface.

As-Printed Finish

Surface finish in the “as printed” state with no secondary ops. Includes a matte finish that is comparable to investment casting with 100 µin (2.5 µm) Ra surface roughness. The surface can be polished to a glossier finish with some simple carbide tooling.

3DEO SURFACE FINISH OPTIONS

3DEO offers the following finishing options: polished finish, bead blasting, black nitride, electroless nickel, cerakote, and matte finish.

As printed: Surface finish in the "as printed" state with no secondary ops.

- Matte finish
- Compared to investment casting
- 100 µin (2.5 µm) Ra surface roughness

Polished: Mirror finish with a unique production polishing process.

- Ideal for aesthetic and functional requirements
- 10 µin (0.3 µm) Ra surface roughness

Bead Blast: Finishing process to smooth surface without affecting tolerances.

- MIM-like surface finish
- Great for non-reflective applications
- 32-64 µin (0.8-1.6 µm) Ra surface roughness

Black Nitride: Chemical hardening of steel that produces a black finish.

- Harder, more durable surface quality
- Ideal for applications requiring a black finish

CONCLUSION

When it comes to surface finish, there are many options available to you. Which option depends on the part's application and performance requirements. Of course, different finishing options come with different costs and so this must also be factored into the equation.

3DEO has a team of engineers and material scientists that can help you understand our surface finish options and which might be best suited for your particular application. We are always able to take an introductory meeting, so don't hesitate to reach out if you would like to learn more about our processes or discuss your application.

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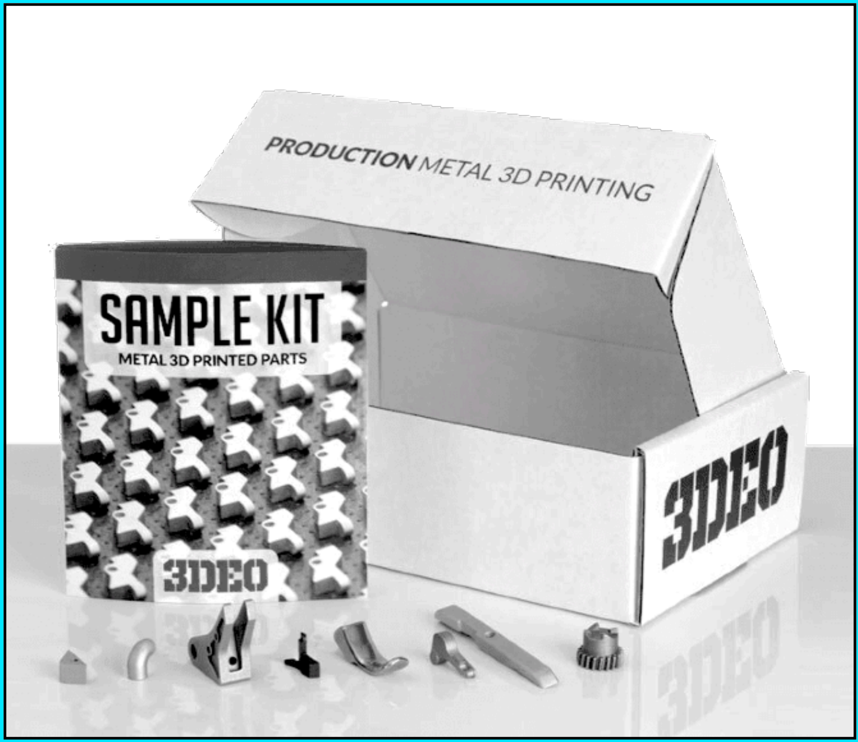

ABOUT 3DEO

Based in Los Angeles, California, 3DEO invented and patented several industrial technologies, including metal 3D printing, which is the core of its next generation manufacturing platform. The company supplies complex stainless-steel components in high volumes to customers in the medical, defense, aerospace, and other industrial markets. By working with 3DEO, customers get access to cutting edge manufacturing technologies in 3D printing, machine learning, and robotics.

For more information, visit www.3deo.co.

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