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Surface Finishing in Stainless Steel

White Paper

Surface finishing in stainless steel

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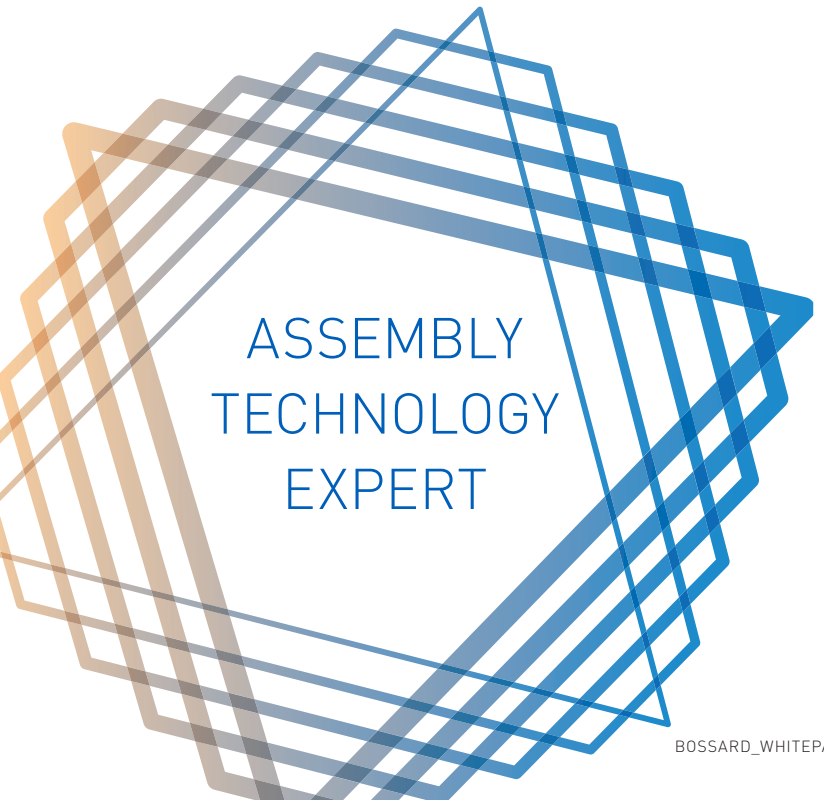


SURFACE FINISHING IN STAINLESS STEEL

Preface

In the fast-moving pace of the fastener world, we might hear things like: “The stainless steel you supplied has gone rusty. This can't be stainless. What's gone wrong? How can we fix it? Can we check if the material chemical composition is correct?"

Although the common objective of stainless steel applications is to work perfectly as intended by the designer and end user, there are a significant number of instances where one could be disappointed by the performance of the material. These disappointments tend to fall into only a few basic categories, but it is critical that we understand the possible causes which lead to such a situation. In most cases, a little basic knowledge would have prevented or significantly improved the situation.

The definition of stainless is known as without stain or blemish in general. For this case, the stainless steel has a function which builds around a certain resistance to stain or corrosion as a primary function. The most common stainless steel contains both chromium (between 18–20%) and nickel (between 8–10.5%) as the main non-iron constituents. It is less electrically and thermally conductive than carbon steel and is essentially non-magnetic. It has a higher corrosion resistance than regular steel and is widely used because of the ease in which it is formed into various shapes. In the industry, there are also many different types of effect of surface finishes on the corrosion resistance of stainless steel.

This paper will show the importance of passivation, polishing medium and surface profile on the corrosion resistance of stainless steel. In addition, it will also demonstrate the importance in obtaining a correct specification of architectural features where cosmetic appearance is a dominant factor.

For the purpose of understanding the topic in depth, we will focus on two key areas of discussion:

- Is passivation in stainless steel necessary?
- Importance of surface finish in stainless steel

Stainless steels are called "stainless" because in the presence of oxygen they develop a thin, hard adherent film of chromium oxide that protects the metal from corrosion. In the event that the surface is scratched, this protective layer develops again. It has been recognized that surface finish in stainless steel plays an important role in the corrosion resistance. Despite such emphasis on this topic, people have to be reminded from time to time so that we can find ways to enhance the performance of different stainless steel grade material.

The main requirement for stainless steels is that they should be corrosion resistant for a specified application or environment. The selection of a particular "type" and "grade" of stainless steel must initially meet the corrosion resistance requirements. Additional mechanical or physical properties may also need to be considered to achieve the overall service performance requirements.

Figure 1: Surface before passivation

Figure 2: Surface after passivation and polish

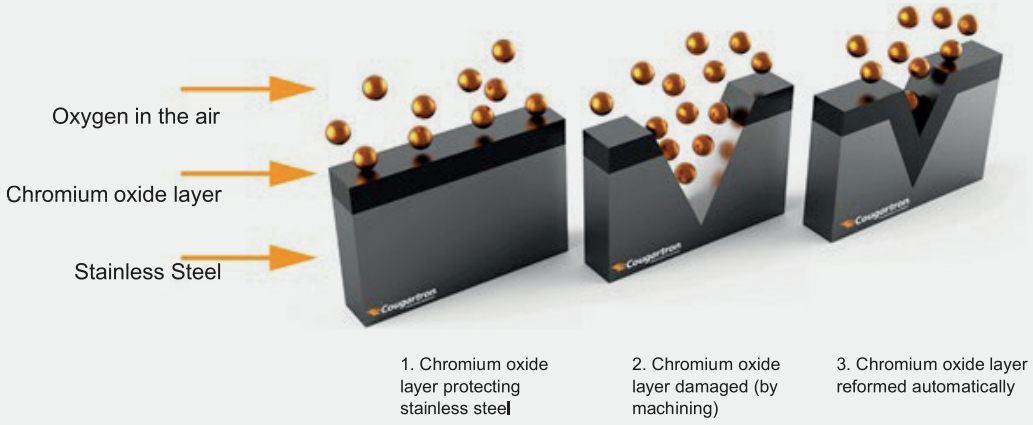


Figure 3: Shows the process how chromium oxide layer is formed

SURFACE FINISHING IN STAINLESS STEEL

Is passivation in stainless steel necessary?

During handling and processing operations such as forming, machining, and tumbling, particles of iron or tool steel may be embedded in or smeared on the surfaces of the stainless steel component. Although stainless steel is highly corrosion resistant, the iron contamination induced during fabrication is subject to rust and corrosion. If this contamination is allowed to remain in the material, these particles may corrode and produce rust spots or stains on the surface of the stainless steel.

While these particles might cause surface blemishes, the base material remains unchanged, and it maintains its basic mechanical performance characteristics. However, even if the base material is mechanically unchanged, the stainless steel material will not be able to generate the passivation where there is spot corrosion. It has been traditionally thought that passivation is the standard method of cleaning stainless steel; when in fact passivation is not a cleaning process at all.

The passivation process removes any residual iron from the surface of the part by the use of nitric and citric acids. In ISO16048, special attention has been given to the fundamental fact that a surface film of chromium oxide is immediately formed when producing stainless steel or products made of stainless steel. It is this very thin oxide film which can be thickened by passivation.

The thickness of the layer is about 0.002µm. Technically, passivation will not remove any oils or other non-ferrous contaminates. These other contaminates are removed through a vigorous clean water cleaning process, prior to the actual passivation process.

March 1983 issue of Plating/Anodizing Forum in Industrial Finishing: "Thousands of dollars are wasted every month by manufactures going through complete passivation cycles when all they need is a proper cleaning." In addition to proper cleaning, the use of carbide tooling minimizes iron contaminates in the stainless steel. Suppliers in the industry may implement many carbide tools in-order to reduce tool wear, and this has a side benefit of minimizing the particles of embedded tool steel.

Bossard application engineering is dedicated to helping our customers reduce component costs. One way to reduce costs is to eliminate non-value-added processes; and passivation tends to be one of these. Passivation is a costly operation and is not environmentally friendly. We recommend that a review of the customer's application requirements be done in order to determine whether or not passivation is really necessary for each particular application.

Some typical applications where passivation is appropriate is in medical implants or instruments, components used in the food or drug industry, sensor system or any application that is requiring a clean environment. Excluding the above-mentioned applications, and others where the user deems it appropriate, there are thousands of applications in which passivation is not necessary.

It is important to remember that any residual carbon may cause superficial blemishing, however this should not impede the corrosion resistance of the base metal or impact the basic performance of the part. The cost differential between a passivated and non-passivated part is approximately 15% to 20%. If the customer's application does not require passivation, you may recommend a part with a plain finish versus a passivated finish.

The main requirement for stainless steels is that they should be corrosion resistant for a specified application or environment. The selection of a particular "type" and "grade" of stainless steel must initially meet the corrosion resistance requirements. The corrosion resistance of stainless steels is derived from the alloying element chromium.

A chromium-rich oxide film forms naturally on the surface of the steel. If damaged, the film will normally repair itself. In this condition the steel is in the passive state. If the film is destroyed, then the surface is in the active state.

Figure 4: Passivated Sensor Housing

SURFACE FINISHING IN STAINLESS STEEL

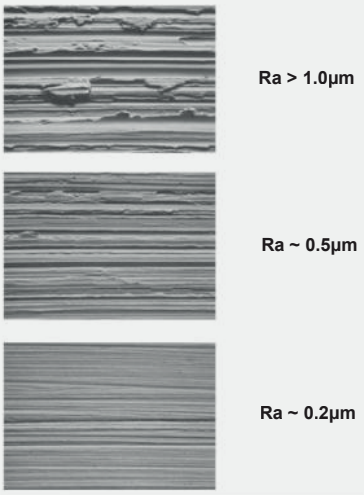
Importance of surface finish in stainless steel

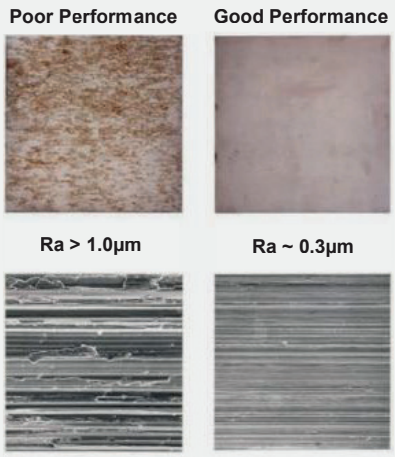
Next, we focus on the importance of polishing with reference to EN10088-2. This standard defines Ra values that will present a direct impact to the corrosion resistance.

Directional coarse polished finishes with Ra values >1.0 micron will show deep dull groves where chloride ions can accumulate. This presents a potential risk of destroying the passive film which can initiate corrosion. On the contrary, Ra values < 0.5 microns will exhibit clean-cut surfaces with few sites where chloride ions can accumulate. A simple process of satin polish is a good solution to provide an overall fine polished surface with reasonable corrosion resistance.

With variation in surface finish, we also discover that roughness has a controlling influence on the level of staining. Rougher surfaces (Ra >1.0 micron) are more susceptible to staining whereas the smoother surfaces (Ra <0.5 micron) show little staining.

SEM examination of stainless steel samples of various roughness after accelerated corrosion testing confirms that smoother surfaces exhibit less staining (see figures 5 and 6 below)





When addressing the concern of surface roughness and staining, especially on large exterior surfaces, it is common to try different polishing grits and belt types to achieve the desired result. In addition to this, there are other three considerations that should be kept in mind:

Orientation

With a vertical direction of polish, we can minimize entrapment of harmful species and at the same time a natural washing effect is maximized as rain and condensation occur. Sometimes called a line finish, this finish is achieved by sanding in a vertical direction using approximately a 150-180 grit abrasive sandpaper. This is one of the most common stainless steel finishes used in architectural metal work.

Surface reflectivity

A smoother surface will appear brighter and in some cases almost mirror like, which may be desired in some designs. In such cases, we will need to specify a "matt" non-directional polishing method such as glass bead blasted finishing.

Large scale effects

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Summary

There are many different types of surface finish on stainless steel. Some of these originate from the mill but many are applied later during processing, for example polished, brushed, blasted and etched finishes. In the application of using the same grade of stainless steel, polishing or different finishing will affect the corrosion resistance. The EN10088-2 2K standard provides the understanding that the Ra value should not exceed 0.5 microns and this would be easily achieved by using 240 grit silicon carbide polishing belts. In general, ISO 3506 standard fasteners may be used with most assemblies while additional requests can be made for special parts with a different surface finish.

Passivation on the other hand is performed after the surface of the stainless steel has been thoroughly cleaned or descaled. Since the term "passivation" is used to describe distinctly different operations or processes relating to stainless steels, it is necessary to ensure that it is correctly carried out to give a desirable improved corrosion resistant stainless steel.

If you need further assistance or have special finish requirements, please check out our contact page at **www.bossard.com** and talk to your nearest Bossard customer service representative.