## Surface Finishing


Untreated Valve


Mechanical Polishing


Electropolishing


Finished Valve

### Why treat stainless steel surfaces?

In order to obtain desirable aesthetic and technically functional surfaces  finishes on stainless steel the following processes are carried out:-

- Mechanical
- Chemical
- Electro-chemical

### *Stainless Steel or Not?*

As referred to in the Stainless Steel section the name “Corrosion Resistant Steel” would be a more appropriate name used for this group of materials. The stainless steel section details methods in which the materials are formed, alloying elements and applications.  In particular, the methods of fabrication, manipulation and induced heat treatment greatly affect the material in its performance, especially when referring to the supplier technical data for any specific material, many of which are surface properties.

When heat or stress is put upon a material surface the characteristics of that surface is often changed and therefore the properties and performance of the material are change, usually reducing the performance below the desired levels as required when specifying a particular grade.

Materials are chosen for their specific performance data, which is often critical to the application of the end product. Therefore should this performance be reduced than the product may not be “fit for its purpose”. In this section we try to show you how these changes are made within the manipulation, fabrication and welding processes.

### Manipulation & Fabrication

By bending, forming, pressing, drilling and cutting we are introducing cold working, tearing, shearing and stress that change the surface properties of the surface. Care must be taken not to cut the material too quickly, inducing too much heat and not to over manipulated through fabrication techniques.

## Welding & Heat Treatment

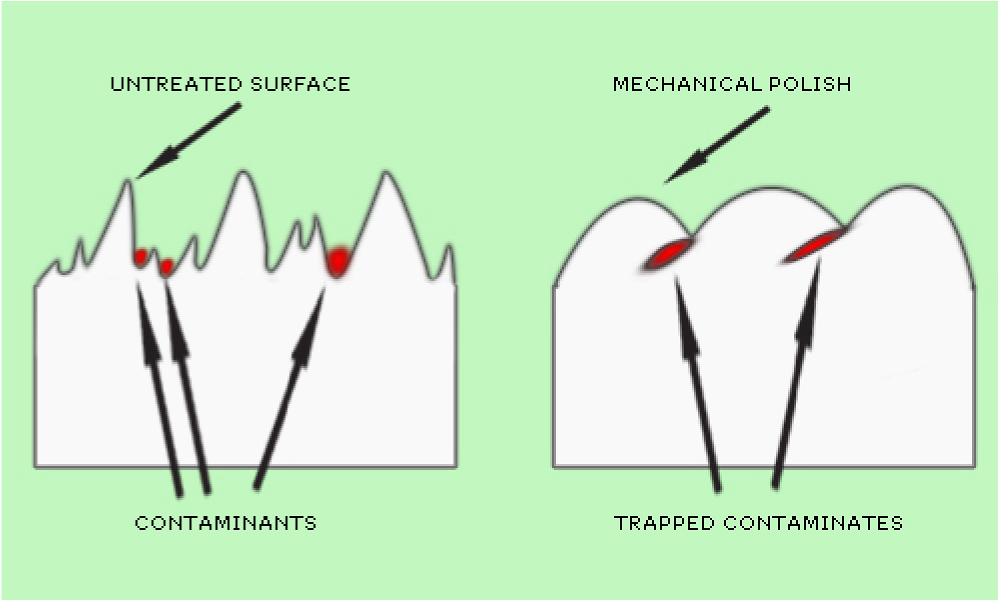
When welding and heat treatment takes place many things occur in the structure of the material, depending on the temperature achieved through the process. The material local to the weld site is taken into the full melting stage and the surface is oxidised, forming a scale depending on the atmosphere or shielding method. These surface oxides do not have the surface properties of the base materiel and subject to attack and corrosion. Often non metallic elements within the alloy do not fully re-dissolve back into the base material. A remarkable loss of the original properties may be encountered by this process.

We must remember that most of the materials within the group none as "Stainless Steel" contain at least 70% iron and therefore surface oxides containing iron readily corrode within most atmospheres. These oxides should be removed by methods that do not induce further

## Mechanical Treatments

Whilst mechanical treatments often remove the bulk of surface damage, they often add further complications and hide underlying problems.

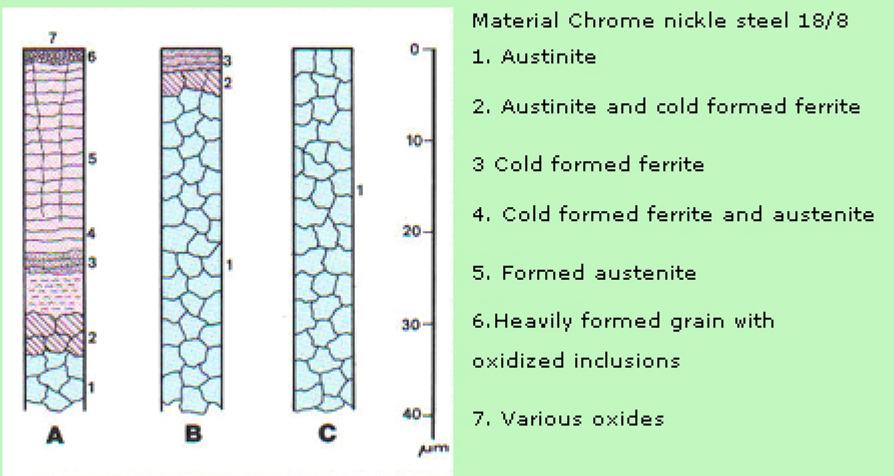
Metals are crystalline structures and when looking closely at such surfaces, the crystal structure should be easily seen. Once again, going back to how the original material is formed, this group of materials easily plasticize at 500ºC, allowing the upper layer to be pushed over damaged sites and for inclusions, debris and contaminates to be trapped within the upper surface layer




Mechanical treatments can also induce heat that far exceeds the phase changes of the material, taking them into the molten stages at local sites and enables cold quenching to take place with the material behind the local sites that remains within the stable phase, leading to local phase changes to take place.

Below details a typical phase change and oxide generation with applying various mechanical treatments

Influence of surface Treatment on the depth of the mechanically modified layer




acc. to J Wuff, The Metallurgy of Surface Finish Cambridge/Mass

## Cleaning Degreasing

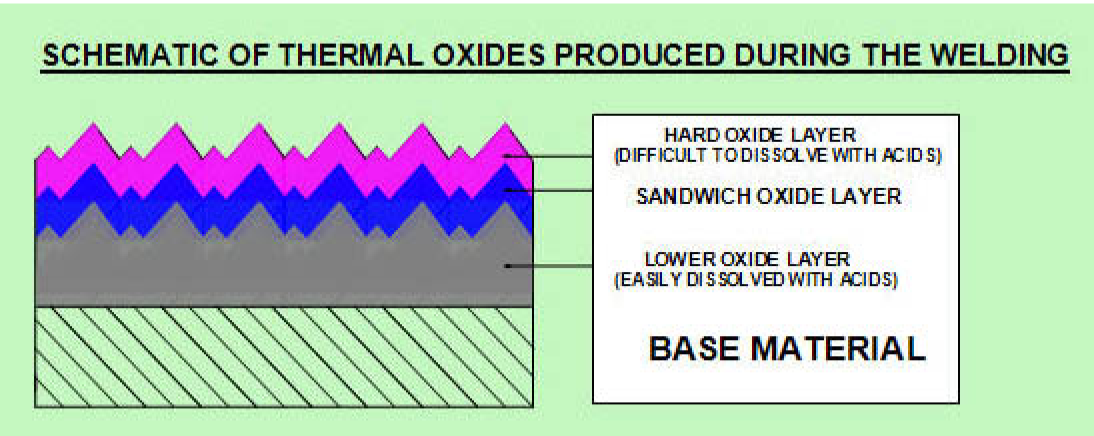
Materials from mills and stockist are often stored for long periods of time and transported within areas susceptible to contamination. So from the outset, materials should be cleaned before fabrication process takes place, especially when the material is to undergo heat treatment processes such as welding. Such contaminants are absorbed into the material when taken into the molten state that greatly affect the performance of the surface properties, making it difficult to obtain uniform aesthetic surfaces finishes.

Throughout the manufacturing process components are subjected to handling, coolants and localised grease from numerous sources. Before any chemical processing takes place the components should be fully cleaned and degreased.

## Pickling & Decaling

When stainless steel alloys are introduced to heat treatment processes, oxides are produce that reduce the surfaces ability to maintain its passivity thought the thin inert oxide protective layer. The oxides not only affect the appearance of the component but greatly reduce their corrosion resistance due to the oxides being mainly ferric oxides which are must less resistant. With these ferric oxides present it is not possible the material to produce its own natural uniform passive and leads it subject to various types of corrosion.

Below is an illustration of a typically welded surface




As mentioned in previous sections mechanical processes often hide contaminants. It is therefore crucial to remove these oxides layers to expose clean material. Standard pickling methods consist of aggressive mixed acids that dissolve these oxides in preference to the base material. Typically between 2 – 5 um are removed in this process leaving a matt etch appearance that is:-

- Metallically Pure

- Free of Discoloration
- Have Full Corrosion Resistance
- Have a Metallic Grey Etch Uniform Appearance

Acid pickling may be carried out in the following operations:-

- Immersion in a Solution
- Spray Solution Processing (within specialist enclosures)
- Brush or Roller on Paste
- Spray

### *Anodic Pickling*

This process employs the use of a direct current rectifier and using much less aggressive solutions but require much more equipment. Typically these processes are used within automatic high volume specialist installations.

## Electropolishing

When the ultimate surface finishing is required, electropolishing is the answer. All manufacturing processes expose the surface to some sort of degree of contamination or changes in the complex surface structure. Depending on the degree of machining, drilling, grinding, and polishing the structure of the material is changed through the introduction of heat from friction and quenching processes. In addition to metal structure changes, thin surface oxides are produced. All in all, these production methods deplete the performance of the base material in many ways. The mechanical section details illustrations that show influence of these processes and the depth of the surface that can be affected.

The Electropolishing process can be reproduced with a high degree of precision and consistency. Components that have tight tolerances made be processed safely under controlled conditions.

### *Optimising Surface Properties*

The Electropolishing process removes a layer of material, typically between 5 – 30 um by non impact methods, exposing pure chemically clean material that is free from contamination and exceptionally smooth. These key factors optimise the surface properties to their full potential. The surfaces tend to be slightly nickel and chromium enriched allowing full passivity and optimising the full corrosion resistance of the material.

***Roughness***

The roughness of a surface has a great affect on how it performs in service. In order to understand this fully the surface of the material must be look at very closely. Normal roughness stylus measures do not give enough information when requiring hi tech surfaces that are ultra clean, promote hi flow and reduce adhesion. Below shows a simple illustration that explains this:-

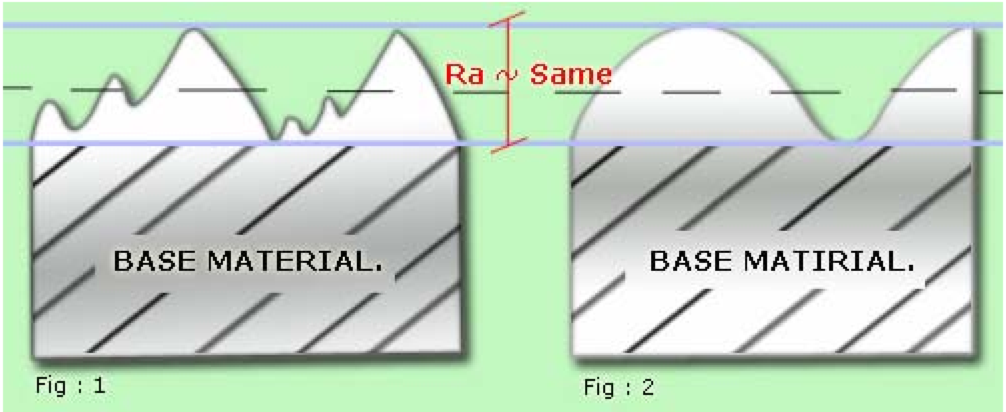


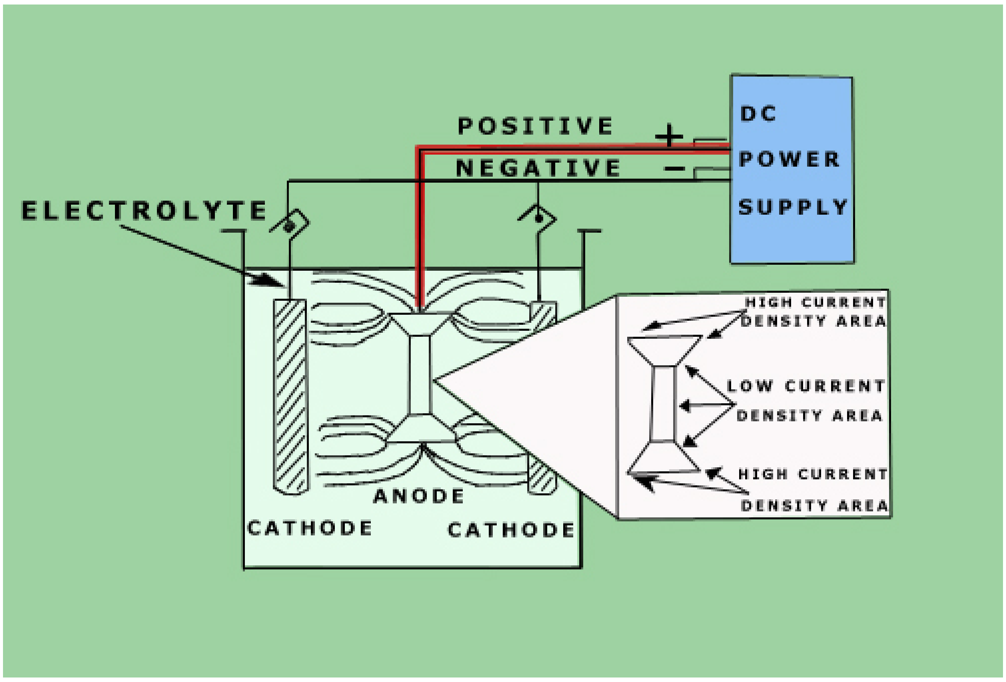

Fig1 shows a mechanically treated surface that has sharp peaks and troughs. Fig 2 shows a smooth flowing surface with the same Ra reading as Fig1. It is easy to see that Fig 2 has a much better surface finish that Fig 1.

A good example of this would be to have a 120 grit surface electropolished and compare it to a 400 grit mechanically treated. Both would show similar Ra reading, however the electropolished surface would have the optimum performance characteristics including:-

- Higher Corrosion Resistance
- Chemically Clean
- Low Surface Adhesion Properties (Non Stick)
- Aesthetically Pleasing (Shinny)

**Electropolishing Process**

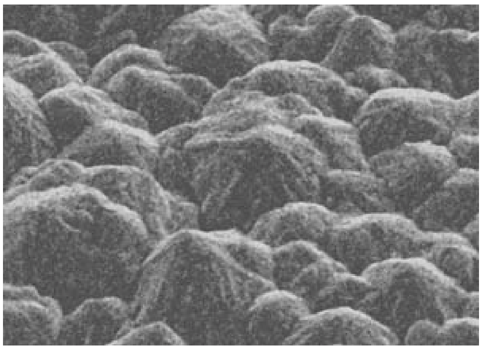
The electropolishing process is in principal the reverse of electroplating. Electropolishing removes a relatively thin layer of material from the surface by dissolution through and electrolyte and a DC transformer. Schematic Below:-




This is typical schematic of the electropolishing process as the peaks are removed at a faster rate that the troughs. This removes the micro roughness of the surface, leaving a very smooth surface. Illustration below show the process:-

## ***Surface Structure***

Fig 1 (Replicated SEM Picture 1 Pickled plate)

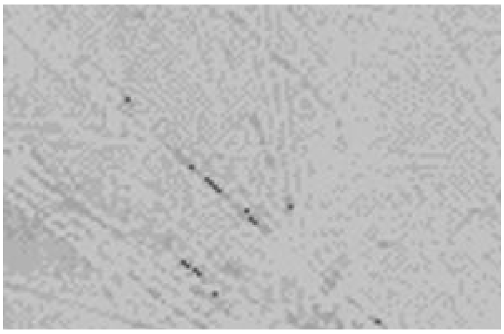


Metals are crystalline structures with relatively large grain boundaries and thus when looking closely as such surfaces these should be evident. Mechanically manipulated surfaces do not allow us to see the surface clearly and entrap multiple contaminants out of sight. Even when looking closely at raw mill pickled plate, it is easy to see the crystalline structure Fig 1.

Fig 2 (Replicated SEM Picture 2 400 grit surface)

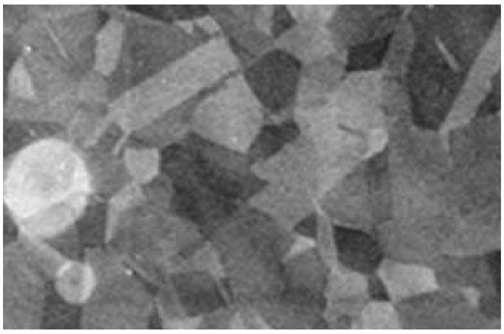
When the surfaces are mechanical treated to the desired level, whether that be 120, 240, 380, 400, 600 grit or mirror polished with mops they do not expose the true material and often have undesirable inclusions and contaminants. Fig 2 shows a 400 grit mechanically treated surface under 650 x magnification. This surface already is in abundance with contaminants and a perfect site for pyrogens (Germs) to grow. The roughness, especially the micro attracts the adhesion of small molecules. In service the surface would allow contaminants and substances to build, fester and create local entrapments growing exponentially to levels that affect the overall performance of the end product whether it be a surgical implant, polymer reactor, heat exchanger, or liquid / gas conveyance lines.

Fig 3 (Replicated SEM Picture 3 mirror polished surface)



When the surface is taken all the steps to a full mirror polish, the surface is perceived to be clean. On close examination, the surface does not show its natural crystalline structure and in fact shows a contaminant that has been dragged in by the mechnical mop.

Fig 4 (Replicated SEM Picture 4 Electropolished surface from 400 grit)



When the surface as shown in Fig 2 has been optimised by the electropolishing process a full crystalline structure is apparent. The upper damaged layers of material have been removed and lower undisturbed layers exposed. The material can now perform to its full potential, leading to a trouble free, low maintain service life of whatever component the original material has been specified for.

### ***Deburring & Edge Rounding***

The electropolishing process is also used for deburring, where mechanical means, especially when dealing with fine burrs, do not fully remove the burr by flapping it over one side or the other. As the process dissolves the peaks in preference the burrs are removed easily, creating desirable rounded smooth edges.

### ***Edge & Point Shaping***

In some applications, edges and tips of points (typically needles) require shaping. Under careful control of the parameters these profiles can often be shaped within a desired envelope.

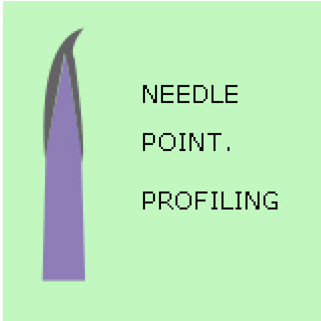
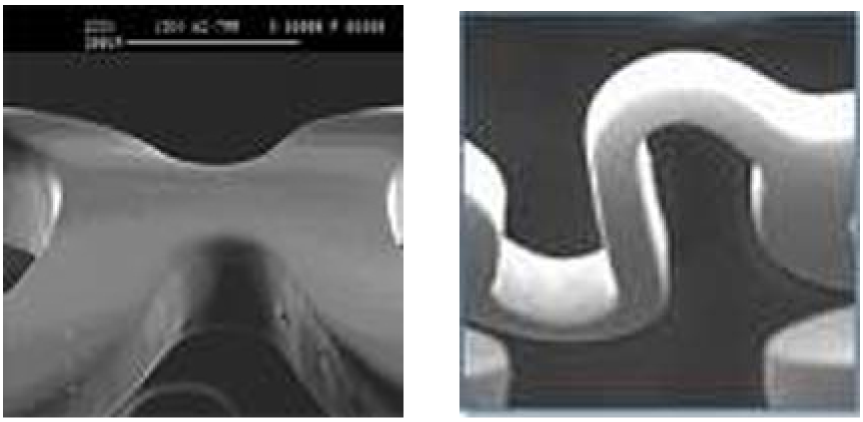



Fig 5 Shows Cardiovascular Stent Following Laser Cutting

Fig 6 - 7 Shows Cardiovascular Stent after Electropolishing with rounded edge profile



## Passivation & Desmuting

### *General Passivation*

Following drilling, grinding, punching and fabrication often the surface has not had sufficient time to create its own natural passive layer before the part is to be put in to service. It is therefore advisable to have a simple passivation step to be carried out. This may be done with a relatively short immersion in Willowchem 70 or 71.

### *Special Applications*

In special applications used for high purity fittings and conveyance lines high levels of passivation is required for full protection and reduce any contamination to the conveyance media. These processes use heated and high concentration passivation products and are measured by ratio's of iron oxide to chromium oxide through Auger spectrometry. This process should only be carried out by experience specialist companies. Further information may be obtained from a local Willowchem Technology partner.

### *Post Electropolishing*

Whilst electropolishing oxygen is liberated at the anode (Work piece) and therefore when removing from the process the components is almost at its full potential passivity. However, some complex metal salts are formed in the process that do not readily rinse in water. These metal salts can cause slight contamination and complications in some particular applications and also create staining. It is therefore advisable to carry out a simple immersion in a desmuting solution such as Willowchem 71.

Following any of the passivation or desmuting processing, the components should be fully rinsed  in clean freash water. It is often advisable to use a final hot water rinse with a a low conductivity (i.e deionised) which assist with flash drying and reduces water staining.