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GATEWAY SPECIAL FEATURE



A GATEWAY EDUCATIONAL ENLIGHTENMENT ARTICLE

Subject: ELECTROPOLISHING & PASSIVATION

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A GATEWAY EDUCATIONAL ENLIGHTENMENT ARTICLE

Subject: ELECTROPOLISHING & PASSIVATION

We have elected this month to run a special feature story with an educational theme.

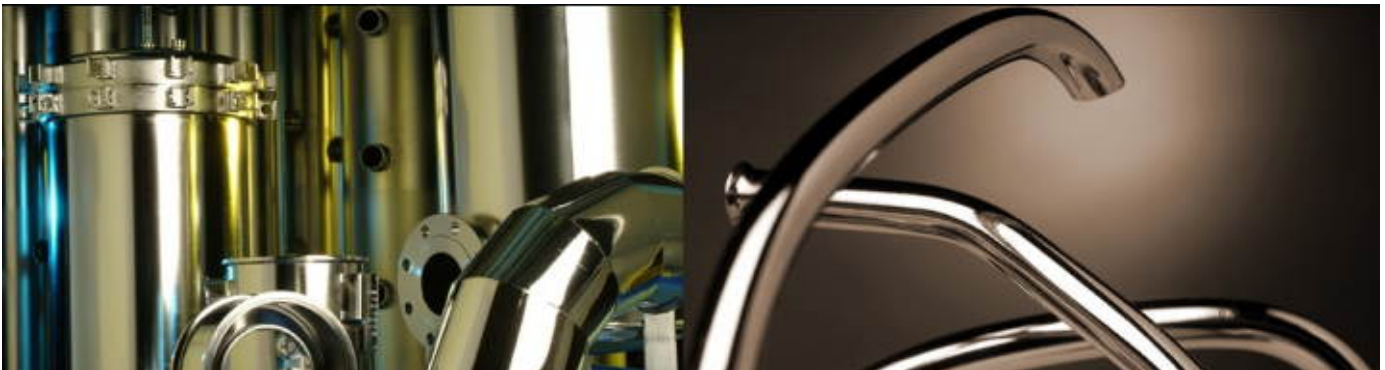
Buyers, Engineers and Shop Owners may use the electropolishing process, but few may realize all the benefits and areas where it may offer new solutions to old problems. Plus, passivation is also covered as it ties in with electropolishing. New England Electropolishing Co., Inc. from Fall River, MA offered this article to us and we thought it beneficial to our readers. Hope you enjoy.

Let us know if you'd like more of these types of features! gatewaybill@yahoo.com

WHAT IS ELECTROPOLISHING?

Electropolishing is the electrolytic removal of metal in a highly ionic solution by means of electrical potential and current. A less technical description of the process would be "reverse plating". Electropolishing is normally used to remove a very thin layer of material on the surface of a metal part or component. The process is of interest because of its ability to enhance the material properties of a work piece in addition to changing its physical dimensions. The amount of change to the metal is highly dependent upon the metal itself and how it has been processed up to the point where it is electropolished.

This smoothing effect results in leveling of the grain boundaries of the metal. In fact, the effect can be so pronounced at times, that visual identification of the boundaries can no longer be made. With the grain boundaries smoothed edge to edge, the usual sites for stress cracking have been removed. In most instances this will enhance a part's strength up to the value of its bulk material properties. It should be noted here that it is normally desirable to have all surfaces in the metal stress relieved to the point where the bulk properties of the material are characteristic throughout the part. There is an exception in the case of materials that require the additional fatigue strength. These materials may have had their surfaces purposely work hardened. This work hardening induces compressive stresses into



WHY ELECTROPOLISH?

Electropolishing is used for leveling the surface of most metals. It requires a minimum of labor and, if the conditions are right, can provide a spectacular surface finish. At first glance the leveling effect is important because it can improve the visual appearance of the part. Its real usefulness, however, is in the manner in which it smoothes the part.

the surface of the material. Be aware that electropolishing can easily remove this work hardened layer. It should also be noted that a uniform bead blasting of the material after electropolishing will normally restore the fatigue strength, in addition to letting the part retain the benefits of the electropolishing.

The important thing to remember about electropolishing is that it is versatile. You can improve almost anything that you can put in the tank. The better the part to begin with, the better the result.

Continued on page 7



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The benefits of electropolishing without the reflectivity

This removal of discontinuities in the edges of the grain boundaries will also remove sites for chemicals, dirt and microorganisms to be trapped. A third benefit of the leveling is the reduction of the total surface area of the grain boundaries exposed to the process. This significantly reduces the amount of material from the grain boundary areas exposed to chemical attack. In the areas of high vacuum work, the smoothing effect is useful because it reduces the total process surface area of the work piece. This reduces the gas load on the system allowing one to reach higher vacuums more easily.

Electropolishing also has a quality control and inspection aspect to its nature. Since the process is carried out in the presence of an aggressive chemical, when a defective part comes through the process line, the chemicals in the electropolishing solution tend to attack or uncover the defect in the part. This is a dramatic but effective way of double checking the quality of material being processed.

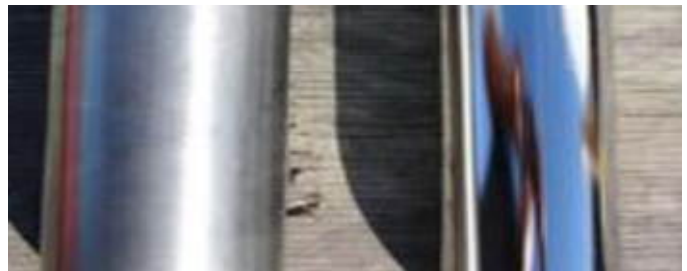
It should further be pointed out that the surfaces of stainless steel parts become passivated when they are electropolished. This passivation is useful in many processes related to the bio-genetic, pharmaceutical and semiconductor companies.

PRACTICAL LIMITATIONS

While it is possible to electropolish almost all metal, there are several metals and alloys that do not lend themselves to standard industrial processing. Some of the factors that determine suitability are related to the process chemistry, while others are related to the processing of the raw metals. Alloys that contain quantities of carbon, sulfur or silicon are quite difficult to electropolish. Most electropolishing solutions dissolve silver, limiting the process general use to the alloys of silver.

The best way to find out what can be done is to ask questions and to investigate. Sometimes the answer to your inquiry is already known. Many times the answer

is found through testing the material or parts. It is standard practice to try any new or unfamiliar part before any major processing is started. Electropolishing is very effective if something is wrong with the metallurgy of a part; electropolishing points it out by etching away the defective material. This etching is non-reversible and is almost always never repairable.



BEFORE

AFTER

HOW ELECTROPOLISHING WORKS ON STAINLESS STEEL

Electropolishing will occur when metal can dissolve anodically through a highly polarized film. Current theory also states that the highly polarized film can be a solid, fluid and/or gas. It is the steady state removal of metal ions that creates a desirable and practical electropolishing procedure.

The physical process starts with a tank filled with a phosphoric and sulfuric acid solution. The edges of the tank are lined with metal plates that function as the cathodes. Electrical connections are provided so that the leads from a rectifier can be connected to the work piece (anode) and the metal side plates (cathode). Next to the processing tank is a rinse tank filled with deionized water. Next to the rinse tank is a final rinse area where parts can be hosed down with fresh deionized water.

In electropolishing, the work piece is connected to the positive side of the rectifier and the cathode to the negative side. You adjust your current level, voltage level and tank temperature to the most desirable setting

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for the work piece. The work piece is then lowered into the processing tank and the power is turned on. After a suitable amount of time (actual length depends upon the part) you turn off the power and take the part out of the tank. The part is covered by a thick film or “drag out”. The electrical connection is removed from the part and it is taken to the drag out tank where the anode film is rinsed off by immersion. The part is taken to the rinse station and given a final rinse to remove all remaining traces of the anode film.



*(left) SST welded joint before electropolish.
(right) After electropolish, clean and improved.*

In electropolishing, there is a very significant preference to the removal of any high spots on the metal surface. This means that the dimensions of the lower spots are changed very little. This creates a smoothing effect to the metal surface. It also means that by the nature of the process, the total amount of dimensional change required to obtain the polish effect is very small.

PASSIVATION

Almost any stainless steel that you can buy has been rolled, machined and or manipulated with carbon or tempered steel instruments. This means that, in general, all of the stainless steel that you will purchase or re-manufacture will have an appreciable amount of steel worked into the surface.

In the industry this surface impregnated steel is referred to as “free-iron”. This free iron corrodes with no real difficulty. The corrosion process of iron is a very aggressive reaction. This reaction will in almost all cases start corrosion in the stainless steel. Once started, the corrosion of the stainless will continue to take place without the presence of free iron.

Most corrosion information uses a salt spray test as its basis for comparing corrosion rates. The corrosion of free iron in salt water creates both chemical and

electrical chemical reactions. It is believed that this reaction attacks the stainless steel at its grain boundaries and the corrosion propagates through the grain structure ungluing the grain structure. There is another well known chemical reaction that takes place when stainless steel is subjected to the effects of chlorine. In this reaction, the chlorine leaches out of the carbon and severely degrades the atomic structure of the metal. The result is that after removal of the carbon, the molecular grain structure will be very much like Swiss cheese.

Electropolishing of stainless steel has two significant benefits besides the leveling of the work piece surface. First, the electropolishing process will remove all free iron from the surface of the work piece. This has the obvious effect of eliminating the free iron corrosion up front. Second, electropolishing does not readily remove the carbon from the metal because carbon is very electrochemically neutral. Further, the process does not readily remove chromium or nickel. The chromium, nickel and carbon, for all practical purposes, become uncovered and remain sitting on the surface of the metal as the electropolishing process takes place.

If the carbon layer that is exposed is present in any significant quantities, it can be seen on the surface of the metal. This layer is referred to in the industry as “smut”. It is typically removed from the metal surface before it is used in service. Smutting is not a common problem associated with electropolishing.

If the carbon present is not a problem, as you electropolish a part you start enriching the surface with chromium and nickel. At some point, a chemical reaction takes place during the processing of the part. The chromium reacts and forms chromium oxide. Further, if the surface is very rich in chromium, the chromium oxide will form a thin layer over the metal surface. This is referred to as the chromium enriched surface oxidizing to form a chromium oxide passivation layer. This mechanism is referred to in the industry as “passivation”.

The term passivation is used widely in the stainless steel processing industry. In order to do good passivation, you must have a clean, active part. In some cases, you have to chemically strip the existing passive layer from the part before it can be re-passivated. However, electropolishing does not require any stripping of the existing passivation layer. The electromotive potential has more than enough energy to remove the outer layer of the part - enough to remove any passivation layer that may have previously existed.

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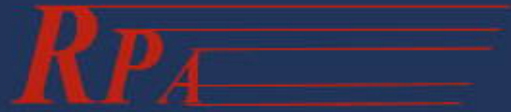
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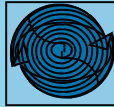
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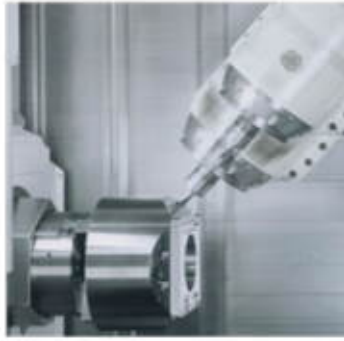


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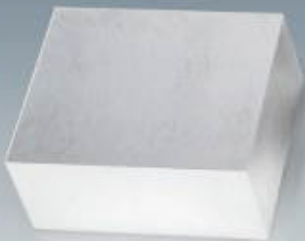
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