The benefits of electropolishing

- Corrosion resistance is improved by the elimination of surface contamination and stress.
- Smoothness is improved by the removal of micro and macro roughness.
- Plating behaviour is improved, giving a more homogeneous and adherent coat.
- Passivity is significantly improved.
- Cleaning properties are optimised with a low-stick surface and a drastic reduction in actual surface area.
- Fatigue resistance is increased by the elimination of crack initiating sites.
- Improved reflectivity increases the yield of reflectors and reduces losses in high-temperature and cryogenic applications.
- High-frequency conductivity is improved by the removal of defects in the surface area of the conductors.
- Rates of gassing under high vacuum are reduced by the elimination of gas-containing surface layers, the reduction of surface area and the reduction of the adhesive forces binding the gases to the surface.
- Friction is reduced and resistance to wear is increased by smoothing of the surface in the micro range and by the rounding of macro structures. Specifically, with a combination of materials of different hardness, electropolishing of the harder material can drastically reduce or even avoid wear on the softer material.
- Absence of particles in an electropolished surfaces means that during service nothing will be released from the surface which might lead to malfunction or contamination of the product.
- Cold emission of electrons under high voltage can be strongly reduced by rounding and smoothing of the surface profile.
- Contamination and decontamination in nuclear applications is improved.

In the pharmaceutical industry thorough cleaning of the contact surfaces of manufacturing plant is essential. Electropolished surfaces are widely used to reliably produce surfaces that meet the most stringent demands with regard to cleaning properties, cleanliness and corrosion resistance.

Electropolishing for the nuclear industry

In the nuclear industry, electropolishing is used to minimise the build-up of radioactive contamination on surfaces during operation and also as a reliable decontamination process to decontaminate surfaces for free release.

Investigations at the Batelle Institute show that with the use of an electropolished surface in comparison with a pickled surface, under the same conditions, the degree of contamination during operation can be reduced by about 90%.

Quality control with electropolishing

Electropolishing can be successfully used for material control and crack detection. Material defects which have their origin in alloy and structural inhomogeneities, will generally become visible after electropolishing.

Cracks are revealed by electropolishing even if smeared and deformed layers of material on the surface have previously covered them and, therefore, had not been visible or accessible for dye penetration testing SMI

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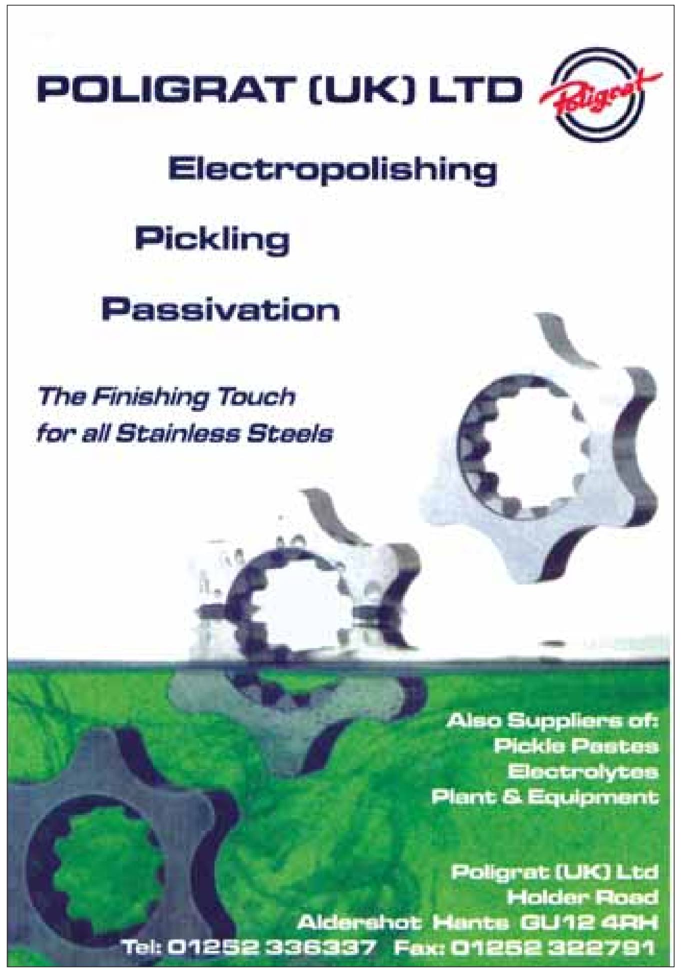

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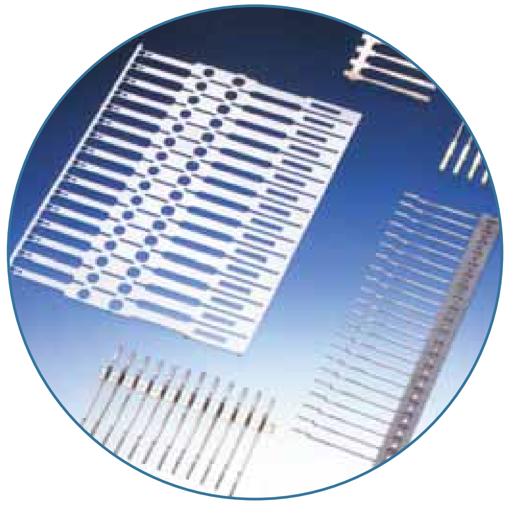
Stainless Polishing



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Stainless Polishing

The special properties of electropolished surfaces are explained and applications to solve different problems are also shown with practical examples by **Siegfried Piesslinger-Schweiger**, chairman of Poligrat GmbH.

The functional behaviour of a component and its interaction with the environment is mainly determined by its surface properties. These do not necessarily correspond to the optimum properties of the original base material because quite often they have been modified during the fabrication process. These mostly detrimental effects relate to corrosion resistance, passivity, hardness, smoothness, reflection, friction, wear, fatigue and adhesion.

When the quality of a surface does not meet the required specification, then electropolishing will very often give an option which is of great interest for both economic and technical reasons.

The applications for electropolishing are many and most easily explained by considering the effects achieved by the process and the properties of the surface produced. Electropolishing is the electrochemical erosion of the surface layers. Simplified, it can be called the 'reverse of plating'.

Full automated Poligrat plant type EK3500AS for electropolishing stainless steel drums for spin dryers

Electropolishing removes material from the surface of an anodic work piece by means of a DC current through an electrolyte specific to the material. The metal is dissolved into the electrolyte without any mechanical or thermal stress. Electropolishing will first affect the micro roughness (<1 micron) and with increased treatment time, the macro roughness (>1 micron). Electropolishing leads to a drastic reduction of the surface area.

Micro smoothing

During the electropolishing process, the electrolyte forms a viscous diffusion layer at the metal surface under the influence of the electrical field.

This 'polishing layer' will control the rate and the mechanism of material removal during electropolishing.

Macro smoothing

As well as electropolishing in the micro range, there is also the consequence of the different current densities caused by the Faraday Cage effect and the geometry of the surface.

Increased current density at corners and edges results in increased removal rates in these areas and gives a fine deburring of edges and corners. This fine deburring takes place over the total surface area, its efficiency being determined by the form and size of the burrs.

The effects of polishing and deburring always happen simultaneously, so that even if full electropolishing sometimes cannot be achieved, deburring is always still feasible.

PROPERTIES OF ELECTROPOLISHED SURFACES

The material removal by electropolishing occurs without any detrimental effect to the surface and no energy induced into the surface layer.

Electropolished surfaces show a number of characteristic properties which, in combination, cannot be achieved by any other process and which are the basis of the numerous applications within the technical field:

- The potential energy of electropolished surfaces is reduced to a minimum.
- Electropolished surfaces are predominantly free from surface related tensile or compressive stresses.
- Electropolished surfaces have minimum surface area.
- Sufficient electropolishing will remove all previously contaminated surface layers without creating new

Deburring/Surface Finishing Electropolishing techniques

Stainless steel valve body, internally electropolished to produce a clean, particle free surface

impurities or damage to the surface.

Electropolished surfaces are formed from the undisturbed crystalline structure of the base material and show its true properties. These are characterised by optimum corrosion resistance, high purity; the absence of particles, stresses and micro cracks; by high passivity, high reflectivity and very low adhesion.

TECHNICAL APPLICATIONS OF ELECTROPOLISHING

Materials

Modern industrial electropolishing processes are available for most of the commonly used metals and alloys. Electropolishing is used primarily for stainless steels followed by copper alloys, aluminium, carbon steels, nickel alloys and titanium.

Deburring

Electropolishing gives a reliable overall fine deburring. Its efficiency is determined by the size and shape of the burrs and their relation to the total dimensions of the workpiece. Ideal burrs have a thin base and large surface in relation to their volume such as grinding burrs. Burrs with a massive base are normally not fully removed.

If unfavourably-shaped or large burrs cannot be avoided, it is recommended that a pre-deburring process be used. The remaining burrs can then be removed economically and reliably by electropolishing.

Deburring forms a substantial part of the technical application of electropolishing. It is used on precision machine parts as well as optical, electromechanical and electronic components. Laser cut edges can effectively be deburred and smoothed by electropolishing.

A special application of electropolishing relates to the sharpening of cutting edges and needles. The combination of deburring and polishing results in extremely sharp blades and a significant reduction in cutting force

Electropolishing is particularly used for the deburring of mechanically sensitive parts and for the removal of burrs from inaccessible areas.

The improvement of fatigue resistance by electropolishing is based upon the removal of surface related crack-initiating sites such as micro cracks, embedded foreign material or tensile stresses in the surface.

The highest fatigue resistance can be achieved if compressive stresses are introduced into the stress-free electropolished surface by treatments such as bead blasting.

Electropolished stainless steel tubes

Improvements in corrosion resistance

The corrosion resistance of stainless steel is based on a passive layer consisting of chrome oxide. If the chromium content reaches at least 13%, the passive layer uniformly covers the whole surface of the workpiece. It is chemically very resistant and protects the stainless steel from corrosion. Local failure of this passive layer leads to deep corrosion damage such as pitting corrosion and stress corrosion cracking. The origin of failure of the passive layer can be multiple. Impurities in the surface such as ferrite from tools and residual grinding material; tensile stresses from mechanical treatment and oxide scale from heat treatment or welding are the most common defects initiating corrosion. Additionally, local chromium depletion caused by thermal or chemical effects should be mentioned.

Electropolishing produces optimal conditions for the uniform formation of a passive layer without defects. The electropolished surface shows the undisturbed base structure of the material and is free of impurities and local defects. In contrast with mechanical treatment, no depletion in chromium and nickel is caused. Due to the higher solubility of iron, electropolishing causes a slight enrichment of chromium and nickel, which is essential for the formation of a stable passive layer.

In the chemical, food and nuclear industries, electropolishing is used in all areas with high requirements for corrosion resistance. In the surgical industry, implants such as bone plates, nails and screws, pacemakers and cardiologic stents are required to be electropolished in order to make the surface corrosion resistant and biocompatible.

Improvement in cleaning properties and reduction of fouling

The cleaning properties of a surface are mainly determined by its adhesion behaviour, which is responsible for the sticking of a substance to the surface. On electropolished surfaces these active binding structures are minimised. Therefore growth layers are either generally suppressed or their adhesion to the surface is substantially reduced.

In the paper industry fouling by micro-organisms and resins frequently occurs. The partially formed debris breaks away and leads to inhomogeneities in the pulp causing tearing of the paper and costly shutdowns for cleaning of the papermaking machinery. Electropolishing of the relevant surfaces significantly reduces the build-up of contamination, increases the homogeneity of the paper and allows a significantly higher yield of paper per machine.

In tubular heat exchanges for the concentration for liquor in the pulp industry, fouling on pickled or mechanically-treated surfaces regularly occurs. The consequences are frequent shutdowns of plants for cleaning and increased energy costs for heating and pumping. Electropolished tubes show no build-up and therefore electropolishing will give real payback within a few weeks.