NEW METHODS OF SURFACE IMPROVEMENT ON STAINLESS STEEL

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Abstract
Stainless Steel is preferentially used in applications with increased demands to design and decorative aspects or to corrosion resistance and functional properties. Decorative surface finishes can be produced by a vast variety of mechanical, chemical or electrolytic treatments. Due to the specific mechanism of corrosion resistance based on the formation of a passive layer on the surface and the impact to structural and energetic conditions of the base material, each of these different methods for surface treatment has besides the visual aspect a distinct influence to corrosion resistance and functional behaviour like cleaning properties. Electropolishing provides a charcteristic shiny or satinfinish with best results in view of corrosion resistance, cleaning properties and passivity. It is a relatively complicated and costly process and the effects are limited to the inherent given properties of the actual material. New methods for surface treatment of Stainless Steel overcome these limits and provide significant improvements at low costs for a wide range of application.
POLINOX-Protect is a new and highly efficient passivation process with no impact to the visual aspect of the surface. A final treatment with POLINOX-Protect after production restores the corrosion resistance on all types of surface finish to a level close to electropolished surfaces. Application is cheap and easy by immersion or spraying. The chemicals used are purely organic, not hazardous or fuming and cause no environmental problems.
POLIANT and POLISEAL are inorganic and transparent coating of silicon dioxide based on a sol gel process. POLIANT is mainly applied for decorative purposes, and invisibly protects Stainless Steel surfaces against fingerprints, graffiti and contamination. It can be applied on all types of finish without changing the specific aspect or haptic properties. The coating is between 0,5 and 3 μm thick, water repellent, easy to clean and resistant to weathering and ageing by uv-radiation. It withstands temperatures up to 500°C and has the highest classification of fire protection. POLISEAL is a special variation of the coating for technical application. It can be used for high demands in view of cleaning and antifouling properties, biocompatibility and chemical resistance.

INTRODUCTION

Surface treatment of Stainless Steel for decorative or technical application can be done by mechanical, chemical or electrolytic ways. Mechanical treatment like grinding, polishing and blasting give an intense mechanic and thermal impact to the material causing detrimental changes in crystalline structure, energy level and chemical composition of a surface layer with a depth up to 30 μm.

These effects notably reduce corrosion resistance, cleaning properties, cleanness and passivity of the surface. Pickling removes oxides and contaminants from the surface and partially restores corrosion resistance and clean condition, but increases the roughness and mattens the surface by selective attack on the grain boundaries. It will not remove the deteriorated layer due to prior mechanical treatment.

Electropolishing is the only treatment, which reliably removes all faulty and damaged surface layers and provides metallically clean and smooth surfaces formed by the undisturbed base material characterised by high corrosion resistance, low surface energy and good cleaning properties. Electropolished surfaces show a distinctive glossy or satin finish depending on the electropolishing process which had been used.

PASSIVATION BY POLINOX-PROTECT

Compared to other types of surface finish electropolished surfaces show a superior corrosion resistance but electropolishing in many cases does not fulfil the demands in view of decorative surface finish or costs.

POLINOX-Protect is a new highly effective passivation process, which is applicable on all types of finish on Stainless Steel. Its application provides a superior corrosion resistance on all types of surface finish and overcomes the problem, that a special finish is desired for decorative reasons, but due to its fabrication it does not meet the requirements in view of corrosion resistance.

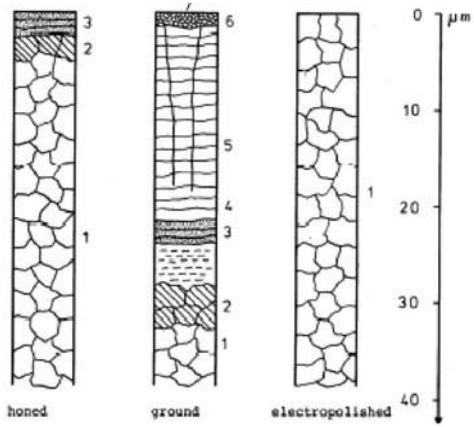

Figure 1. Depth of impact on material structure by surface treatment.

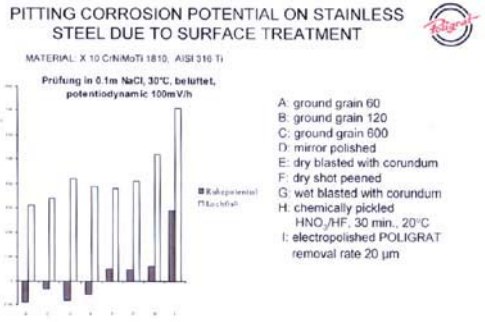

Figure 2. Pitting corrosion potential on stainless steel due to surface treatment.

The significant increase of corrosion resistance achieved by POLINOX-Protect is based on a special effect: Stainless Steel is corrosion resistant due to the presence of a homogeneous layer of chromium oxide covering its surface and protecting it against impact by corrosion. The quality of this „passive layer" decides the level of corrosion resistance of the surface. All defects and weaknesses of this layer, which is only about 10 nm thick, have direct influence to corrosion behavior. Besides local defects in structure, the iron content of the passive layer is an important factor regarding corrosion resistance.

Surface finishes produced mechanically by grinding, blasting, cold rolling, embossing or polishing show a ratio of Chrome/ Iron in their passive layer in the range of 0,8 to 1,1, that means, that the passive layer contains as much Iron as Chrome. Electropolishing increases this ratio into a range of 1,8 to 2,2, which is one of the reasons of the good corrosion resistance of electropolished surfaces. POLINOX-Protect has a strong affinity to Iron and selectively extracts Iron from the passive layer throughout its whole depth and increases the Chrome/Iron ratio values into the range from 6 to 8.

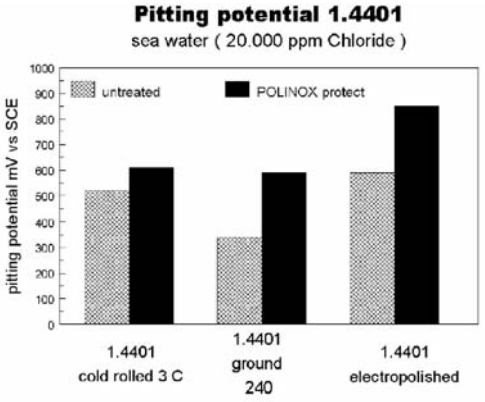

Figure 3. Pitting potentials of 1.4401 surface in sea water (DIN 50900) source: ALSTOM POWER Mannheim.

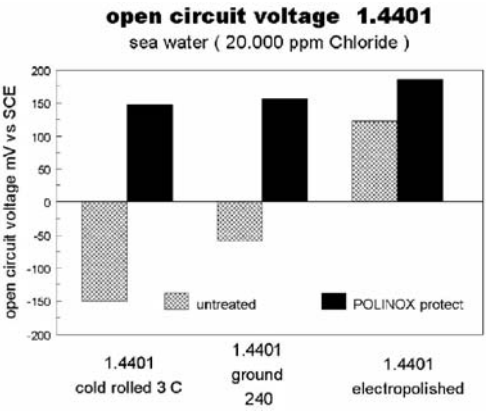

Figure 4. Pitting potentials of 1.4401 surface in sea water (DIN 50900) source: NASA, Abt. RTA 082, report: HLN-009-02MP.

The result is an increase of the corrosion potential up to 350 mV depending on alloy and surface finish.

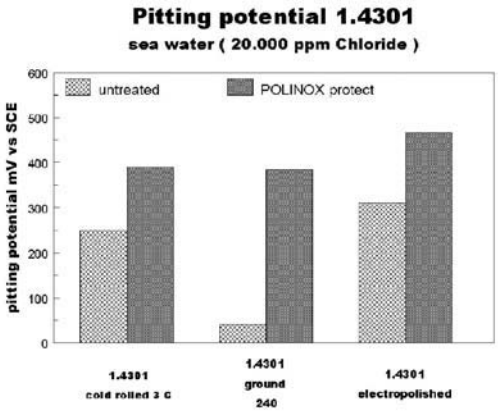

Figure 5. Pitting potentials of 1.4301 surface in sea water (DIN 50900) source: ALSTOM POWER Mannheim.

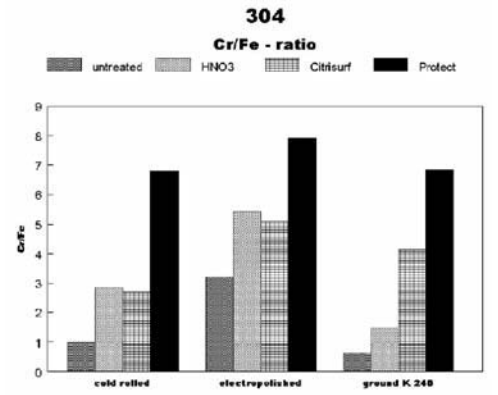

Figure 6. Chrome-Iron ratio on SS 304.

The application of POLINOX-Protect has no impact to visual aspect besides a slightly more silvery colour due to the higher concentration of Chrome. POLINOX-Protect also reliably removes ferrite contamination from the surface and has a strong cleaning effect. Also the problem of rouging in pharmaceutical plants can be overcome. Only heat discolorations will not be removed and require a pretreatment by grinding or pickling.

POLINOX-Protect contains a sophisticated mixture of chelating and complexing agents combined with detergents. All components are purely organic, not hazardous or toxic or fuming and smelling. POLINOX-Protect must be applied to existing passive layers. After pickling the surface of stainless steel is metallically clean and does not show a passive layer. This will be restored by the time under the influence of oxygen in the environment or by a treatment with oxidizing chemicals like nitric acid or peroxides. Passivation by POLINOX Protect is only possible after restoring the passive layer. Application is done by immersion or by spraying or brushing on of paste followed by a final rinsing with water. Treatment time is 3 - 5 hours depending on temperature (15-40 °C) due to the time necessary for the migration of the Iron ions out of the passive layer. Applications in pharmaceutical and food processing plants have met the expectations.

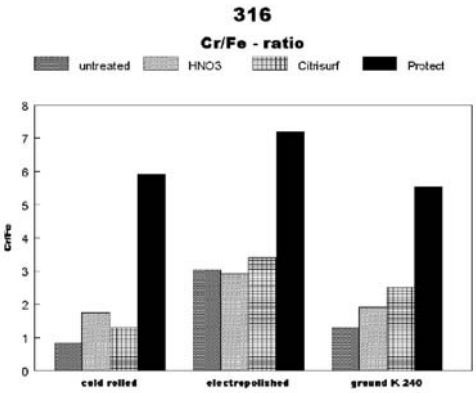

Figure 7. Chrome Iron ratio on SS 316.

Maintenance and repair of slightly corroded surfaces in buildings and architecture as well as in industrial process plants have shown, that POLINOX-Protect provides a new and additional potential to improve and restore the corrosion resistance of Stainless Steel at low costs.

SOL-GEL COATINGS

Sol-gel coatings are a new type of extremely thin and transparent coatings on surfaces, which provide a fascinating new spectrum of advantageous properties as well in view of decorative application (POLIANT) as also for functional purposes (POLISEAL). These coatings are based on silicon dioxide. They are applicable in industrial dimensions as well to large components as to small items.

The coatings show a glass like structure, are not organic and applicable with thickness in the range of 0,5 µm to 6,0 µm on all types of surface finish. They are resistant to most chemicals except strong caustic liquids and fluorides. The coatings are well bonded to the surface and do not break or peel off at blunt mechanical impact or deformation. They show a low level of surface

tension and excellent cleaning properties. The surface energy i.e. the energy necessary to remove a particle from the surface is on the sol-gel coatings about 3,5 times lower, than on electropolished stainless steel (0,008 nN: 0,028 nN) and 0,3 times higher, than PTFE with 0,006 nN.

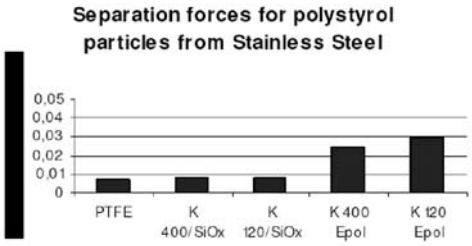

Figure 8. Separation forces for polystyrol particles from Stainless Steel.

The coatings are applied as liquid by dipping or spraying followed by a curing treatment at 190°C - 220°C for at least 30 minutes. POLIANT is a variation of coating used for decorative and architectural applications with a thickness of 0,5 to 2,0 μm. The coating does not affect the visual and haptic properties. Independent from surface finish including colouring Stainless Steel surfaces are invisibly but highly effective protected against fingerprints, graffiti, contamination and chemicals. POLIANT resists to temperatures up to 500°C and has the highest classification of fire protection. Overheated it does not produce fumes or toxic gases. POLIANT resists to weathering and ageing by ultra violet radiation. Small defects can be repaired locally. Typical applications of POLIANT are internal and external architecture, furniture, kitchen appliances, automotive parts, elevators, street and outdoor furniture, casings, marine applications and many more.

POLISEAL comprises a group of variations of coatings for functional purposes. Type and thickness of the coating is adapted to the demands of the actual application. These are for example in the area of heat exchangers, food processing, chemical and pharmaceutical plants, corrosion protection and medical application.
POLIANT and POLISEAL are trade names of POLIGRAT owning the exclusive sales rights for Europe and USA.

REFERENCES

Pießlinger-Schweiger, S. (2001) Electrochemical and chemical polishing of heat exchangers. In Heat Exchanger Fouling – Fundamental Approaches and Technical Solutions, Edited by H. Mueller- Steinhagen, P. Watkinson and M.R. Malayeri, Proceedings of UE Foundation Conference on HX Fouling held in Davos, Switzerland. Ulrich Bobe (2005) Forschungsvorhaben AiF-FV 13586, TU München (Lehrstuhl für Maschinen- und Apparatekunde)