Technical Bulletin

SURFACE TREATMENT OF STAINLESS STEEL FOR USE IN VACUUM APPLICATIONS

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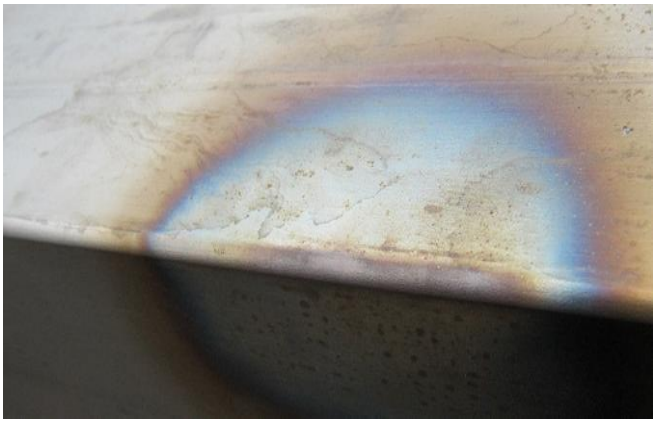
Introduction
There is a clear need in high-tech industry for materials that have the lowest possible levels of emission of gasses and/or shedding of (dust) particles into their environment. In applications where the production process is sensitive to contamination (particularly in relation to applications under vacuum conditions), part of the production occurs in clean room conditions. Examples of this are for the production of semiconductors, in the nuclear industry and for solar panels. Stainless steel is widely used as a raw material for components because of its corrosion resistance and ease of machining. The surface treatment chosen however can affect these characteristics.

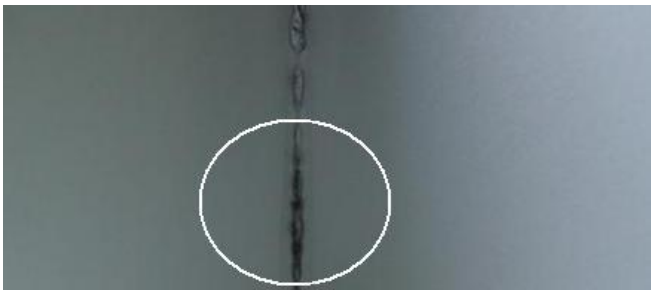
Accelerated oxidation occurs on and beside the weld seam when welding stainless steel. This occurs both on and inside the metal. This oxidation appears as a blue discoloured zone and results in a reduction in the corrosion resistance on the metal (see photograph 1).



Photograph 1: blue discoloured zone as result of welding

This oxide film can also contain various contaminants, which in high grade (vacuum) applications, could be released again, possibly in molecular form. Degreasing and then pickling and passivating with hydrofluoric acid and nitric acid is a well known method in the construction industry for removing discolouration, oxides and embedded contaminants and for restoring the corrosion resistance. In certain industrial sectors however, additional, often extremely high, demands are made on the cleanliness of surfaces. This necessitates additional surface treatments.

Stainless steel in high quality (vacuum) applications
In clean room environments contaminations such as finger prints, dry spots and carbon deposits in the weld seam can cause significant disruptions.



Photograph 2: carbon deposits in a weld seam (here 316L)

It is known that even just exposure of stainless steel to corrosive media at certain temperatures can cause cracks in the material which could release particles (metal dusting). This contamination is thus formed by the metal itself, even though it was supplied in a nearly contamination-free state.

Absorption of atomic hydrogen occurs in the stainless steel during the pickling process. This can lead to an extra level of gas emission in vacuum applications. While hydrogen is often seen as a harmless contaminant, there are enough examples in the industry where these contaminants lead to particle formation, (partial) separation of coatings and even unwanted chemical reactions at the surface. Atomic hydrogen is simply chemically reactive and thus increases the risk of contamination. An additional heat treatment can be helpful in handling this. The stainless steel to be heat treated should be completely pure, as heat treatment tends to fix contaminants on to the surface. Expelling the gasses out of a cleaned component in a vacuum environment is used as a measurement method. After chemical cleaning the expelled gas can be as much as $6*10^{-13}$torr•l/cm^2 s. By applying the correct heat treatment this can be reduced by a factor of about 600.

Electrolytic polishing is another method to prepare the surface of stainless steel for use in high quality vacuum applications. Electrolytic polishing makes the surface smoother (for example Ra < 0.05 µm), and this has three advantages. Firstly the lowering of the roughness greatly reduces the adhesion (absorption) of gasses, making it advantageous for vacuum applications. A lowering of the roughness also reduces in general the chances of new contaminants adhering to the surface.

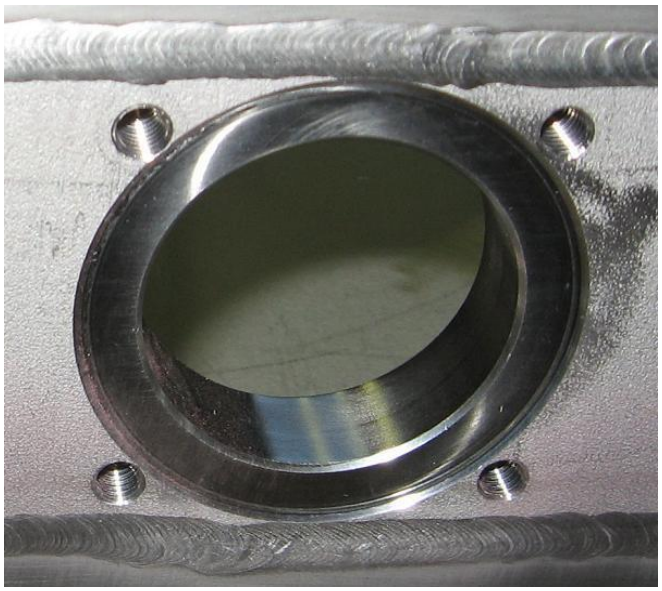
Secondly, electrolytic polishing is an anodic process, which of itself greatly suppresses the uptake of (atomic) hydrogen. Thirdly an enrichment of corrosion resistant metals such as chrome and nickel occurs during electrolytic polishing.

General recommendations

It is very important for every wet chemical treatment of stainless steel that the metal is treated with contaminant free etch, polish and rinse agents. A common mistake is, for example, to use the upper limit for the conductivity of demineralised water as a quality measure indicating that the demineralised water is of sufficient quality. Organic contamination in the demineralised water will, depending on its composition, not significantly increase the conductivity of the demineralised water. Especially in high-tech industries even a very small amount of organic contamination causes problems!

Vecom Group and RTC&P Consultancy, and Project Management

The Vecom Group has many years experience in the treatment of stainless steel for high-tech and vacuum applications. Vecom's added strength is that it can clean virtually any type of metal, tuning the process to the specific customer requirements. The purity of the product is guaranteed thanks to the analysis performed in one of Vecom's laboratories.
RTC&P is an independent technology advice bureau specializing in surface treatments (amongst others precision cleaning) and contamination issues. Their field of expertise includes materials and surfaces that are utilized in high quality vacuum environments.
Vecom and RTC&P regularly work together in the area of consultancy for high-tech cleaning.



Photograph 3: flange surface for vacuum applications

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RTC&P and Vecom will, by sufficient interest, organize a workshop on this subject.
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