Importance Of Surface Finish In The Design Of Stainless Steel

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Introduction

It has long been recognised that the surface finish on stainless steel has an important effect on its corrosion resistance. Despite this, the message clearly needs to be reinforced from time to time. The mere specification of 1.4401 (316) type stainless steel for exterior architectural applications is not in itself sufficient.

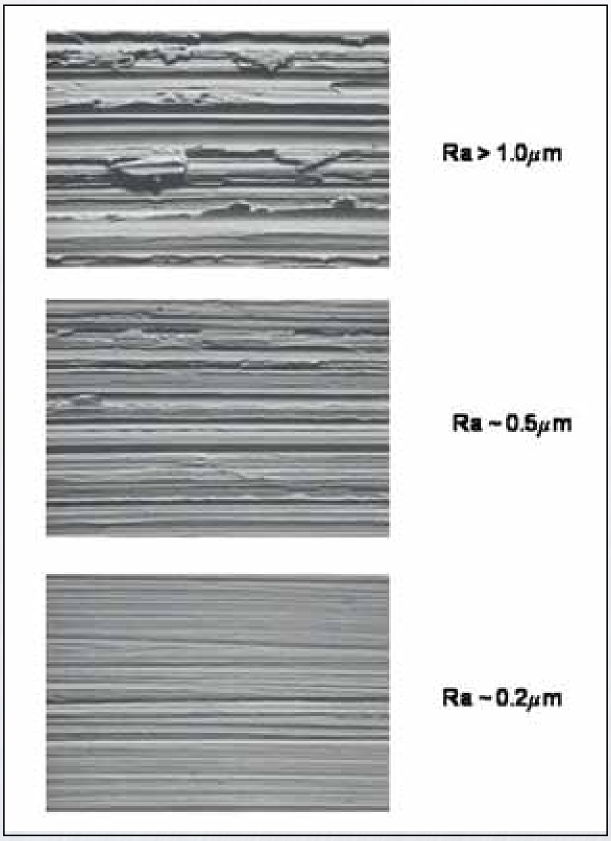
Whilst some readers may ask why this familiar ground is being trodden once again, the evidence from enquiries to the Stainless Steel Advisory Service shows that this factor is still not universally understood.

Why Surface Finish is Important

Directional 'dull' polished finishes are often specified for external architectural applications but this type of surface finish can exhibit a wide range of surface roughness dependent upon the type of belt and polishing grit that has been used. Coarse polished finishes, with transverse Ra values > 1 micron, will exhibit deep grooves where chloride ions can accumulate and destroy the passive film, thereby initiating corrosion attack.

In contrast, fine polished finishes with Ra values < 0.5 micron will generally exhibit clean-cut surfaces, with few sites where chloride ions can accumulate. If a directional polished finish is required, in a coastal/marine situation, it is important that the specification should include a 'maximum' transverse surface roughness requirement of 0.5 microns Ra (e.g. a 2K surface finish in EN10088-2). A simple description, such as satin polish, would be insufficient to guarantee a smooth polished finish with good corrosion resistance.

Fig 1: Variation in dull polishing finishes



Development of a Surface Finish Standard

It is instructive to review the development of the 2K surface finish mentioned above. The specification of the 0.5 micron maximum Ra value originates from work done over 20 years ago but it is still particularly relevant today.

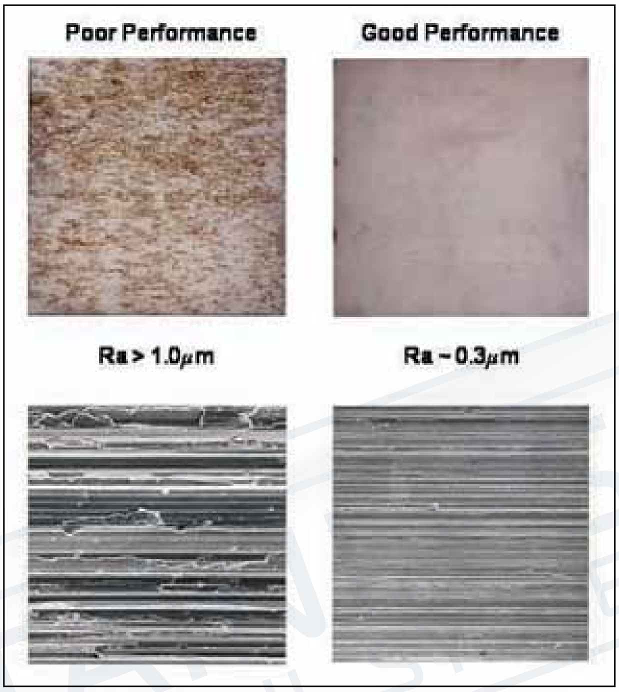
Work carried out in the late 1970's, at British Steel's Swinden Laboratories, showed that dull polished finishes on stainless steel (falling within the generic No 4 finish designation of British Standard BS1449 part 2) could exhibit a wide range of surface roughness, with transverse Ra values ranging from 0.2 to 1.5 microns.

Scanning Electron Microscopy (SEM) revealed that the samples with a high surface roughness (Ra > 1.0 micron) were heavily damaged by the polishing operation, whilst those with low surface roughness were relatively undamaged, showing only light scoring of the surface (see Fig 1).

During the mid-1980's, dull polished finishes were used in a variety of situations, including some prestigious architectural applications. However, it soon became apparent that some of these dull polished finishes had poor corrosion resistance especially when placed at coastal sites. To determine the cause of this variation,

British Steel Stainless carried out an extensive programme of polishing trials, in conjunction with various stockholders/polishers, using different polishing grits and belt types. Samples from each of these trials were submitted to a 21-day accelerated cyclic salt spray test at Swinden Laboratories. The results clearly showed that surface roughness had a controlling influence on the degree of surface staining with 'coarse' polished finishes (Ra > 1.0 micron) showing high levels of staining, whereas 'smooth' polished finishes (Ra < 0.5 micron) showed little staining, after the 21 day test period.

Fig 2: Results from Accelerated Salt Spray Test



SEM examination confirmed the previous work, carried out in the late 1970's, with the heavily stained sample (Ra > 1.0 micron) exhibiting considerable surface damage from the polishing treatment (Fig 2). In contrast, the unstained smooth sample (Ra ~ 0.3 micron) showed only minimal surface damage from the polishing operation.

As a consequence of this work, a new surface finish description was introduced into BS1449 part 2, from the late 1980's. This finish was designated as No 5 and, although ostensibly the same as a No 4 finish, it carried an additional requirement that the transverse Ra value should not exceed 0.5 microns. In practice, this level of roughness could most easily be achieved by using 240 grit silicon carbide polishing belts rather than aluminium oxide abrasives.

When the European Standard EN10088-2 was drawn up in the mid 1990's, the No 5 finish was re-designated as a 2K surface finish, but it still carried the most important requirement that the transverse Ra value should not exceed 0.5 microns.

Other Considerations

a) Orientation

A secondary effect in determining the corrosion resistance is the orientation of the polished surface. With a vertical direction of polish the opportunity for entrapment of harmful species is minimised and the natural washing effect is maximised. However, this may not always be feasible from an aesthetic point of view.

b) Large Scale Effects

The above principles also operate on a much larger scale. The design of external architectural applications should avoid introducing features such as ledges, horizontal grooves and perforations. All of these features will increase the effective surface area that is available for harmful species to accumulate and, consequently, the natural washing-off by rainwater will be minimised.

c) Surface Reflectivity

In terms of reflectivity, a 'smooth' polished finish will produce a more reflective surface and this could give significant and unacceptable dazzle, in bright sunlight, if large flat areas are part of the architectural design. For this type of situation, it may be more appropriate to specify a 'matt' non-directional surface, such as a glass bead blasted finish. However, as with dull polishing, it is important that a 'fine' glass bead option should be selected, to minimise the surface roughness and give the best possible corrosion resistance.

Summary

A wide variation in dull polished finishes, on the same grade of stainless steel, was found to give rise to significant differences in corrosion resistance. This led to a programme of work which resulted in the development of well-defined polished finishes, notably the EN 10088-2 2K finish with a specified maximum surface roughness of 0.5 microns Ra.

The present-day designer needs to be aware of the importance of surface finish in influencing the corrosion resistance of stainless steel and remove any adverse features from the design.