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ALTERNATIVE PRODUCTS: LOW INITIAL COST DOES NOT REFLECT THE TRUE COST OF OWNERSHIP

The opening up of the global economy has led to intense competition from lower cost manufacturers, often arising from lower production costs and sometimes from use of lower quality materials or manufacturing processes. It is important to remember that, particularly under arduous service conditions, the real cost of ownership does not depend only on the first cost of components. What is certain and clearly evident within the instrumentation products market is that there is an enormous amount of lower cost and inevitably lower class goods becoming prevalent.

Lower wage economic structures of and government sponsored trades in certain areas are imposing greater demands to improve our competitiveness. In response to this challenge and in order to reveal the actual implications of low price goods, Parker IPDE in collaboration with the University of Plymouth through a Knowledge Transfer Partnership initiative, has benchmarked its products against its direct competitors from many regions, covering areas like design, manufacture, assembly as well as materials quality and corrosion behaviour.

According to the *People's Daily,* the price of steel in many regions has recently climbed, driven mainly by the market. Consequently, some obsolete or semi-obsolete steel plants producing low quality with high energy consumption and high pollution appear to be in a state of revival [1]. Inability to identify the poor performance until parts corrode results in defects that waste time and money.

Experimental Results

The selected products (i.e. tube fittings) have been analysed by both qualitative and quantitative methods, including optical, SEM and laser microscopy as well as traditional mechanical performance measurements and corrosion behaviour. The results are hereby presented.

The specific material is claimed to be Stainless Steel Grade 316N (UNS S31651), where additions of Nitrogen, in limited amounts, are used to increase the strength of the steel. However, hardness measurements showed that both forgings and bars were softer and therefore of lower strength than their Parker counterparts.

Figures 1, 2 and 3 show the cross section of a forging from a lower cost competitor, now gaining popularity in our market. Although what is shown is indeed an austenitic stainless steel (i.e. austenite grains were observable), what the micrographs have also revealed is a high density of inclusions and impurities, before and after chemical etching. Those alloying additions (dark areas) are believed to be ferrite-δ[1], manganese sulphides[2] and possibly carbides[3] which have detrimental effects on mechanical properties and corrosion resistance, as it will be shown later in this study.

[1] This alloy would seem to be an austenitic type of material which contains tiny patches of residual delta ferrite (formed during cooling), and therefore is not a true austenitic in the strict sense of the word. The delta ferrite can lead to sigma embrittlement.

[2] Pitting corrosion is often associated with manganese sulphide inclusions [2-3].

[3] Precipitation of these carbides is extremely deleterious to the localized corrosion behaviour of austenitic stainless steels [4].

The back ferrule hardening treatment was identified as Edge-Hardening, which is normally associated with poor corrosion resistance properties. Figure 4 shows the details of the edge-hardening treatment. The treatment is believed not only to reduce the corrosion resistance but also to modify the microstructure of the ferrule (probably due to high temperatures associated with the process and high inclusion density of the base material).

Other examples of these tube fittings were subjected to a 175 hours Salt Spray Test as per ASTM B117. Typically, no signs of corrosion are expected to be seen before 100 hours. However, these lower cost products showed corroded areas after only 24 hours of salt spray exposure.

The corrosion is believed to be initiated on the vicinity of the nut-ferrules/tube interface as depicted in Figures 5 and 6. The corrosion resistance of those specimens is a serious threat for the integrity and reliability of the fittings' performance. This severe localised corrosion will eventually lead to damage and ultimately premature and possibly fatal failure, often without previous warning in the short to medium term (depending on media contained and operating environment).

The corrosion mechanisms of such products were studied by confocal laser Microscopy (CLSM)[4] and Scanning Electron Microscopy (SEM)[5] methods. The areas underneath salt and rust deposits were the selected spots for the corrosion study. Figures 7, 8 and 9 were taken by the confocal laser microscope and showed that two types of localised corrosion are taking place: crevice corrosion and intergranular corrosion. This is despite the fact that many of these products will be sold specifically as being resistant to these corrosion mechanisms.

SEM micrographs (Figures 10 and 11) show details of the crevice and intergranular corrosion taking place only after 175 hours of salt-spray exposure.

Conclusion

By using low quality raw materials, the lower cost alternative can offer 'look-alike' and so-called 'fit for purpose' products at an initial reduced price. But what might seem a cost effective alternative, is indeed a blind investment. Are the customers really saving any money?

This paper has shown the real cost of ownership of some so-called 'competitive' and 'fit for purpose' products. Such products should be associated with low quality and poor performance, reduced useful life and increased maintenance costs, as well as likelihood to plant or system closure due to premature fatal failure and even health & safety hazards among others.

References

1. The Epoch Times, 13 September 2004; http://en.epochtimes.com/news/4-9-13/23227.html
2. Khatak, H.S. and Raj, B., Corrosion of Austenitic Stainless Steels, 2002, P. 80.
3. Szklarska- Smialoowska, Z. and Lunarska, E., Werkstoffe and Korrosion, 32, 1981, P. 478.
4. Weiss, P. and Stickler, R., Metallurgical Transactions A, 31A, 1972, P. 851.
5. http://en.wikipedia.org

[4] Confocal laser scanning microscopy is a valuable tool for obtaining high resolution images and 3-D reconstructions. The key feature of confocal microscopy is its ability to produce blur-free images of thick specimens at various depths [5].

[5] The scanning electron microscope is a type of microscope capable of producing high-resolution images of a sample surface. Due to the manner in which the image is created, SEM images have a characteristic three-dimensional appearance and are useful for judging the surface structure of the sample [5].

List of Figures:

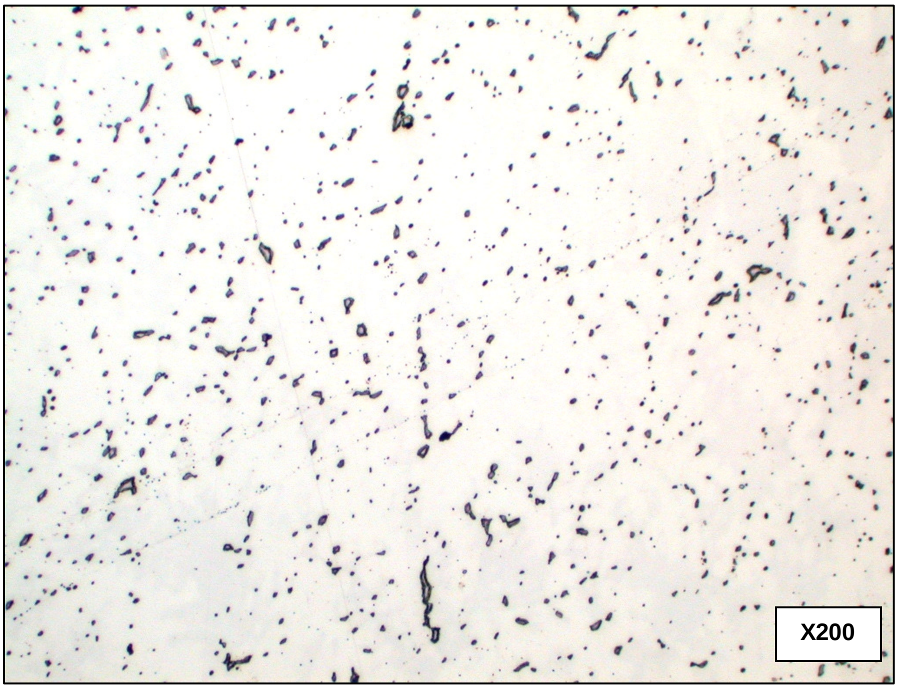


Figure 1 – Polished sample before etching. High density of inclusions and alloying additions are observable.

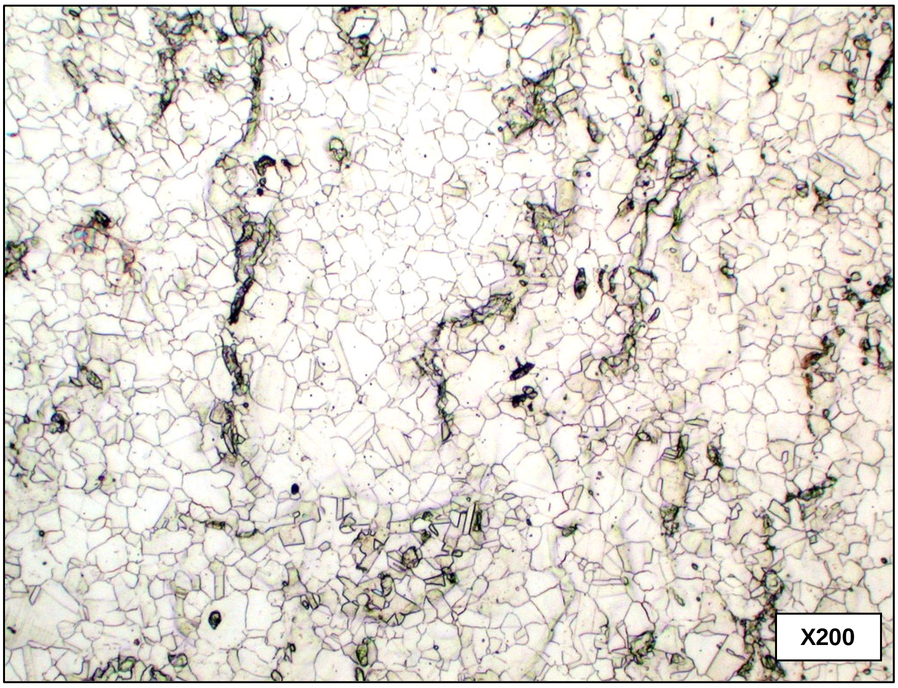


Figure 2 – Polished and electrolitycally etched sample (10% aqueous oxalic acid, 2.5V dc, 45 s). Microstructure of a forged part, showing austenite grains and high density of inclusions.

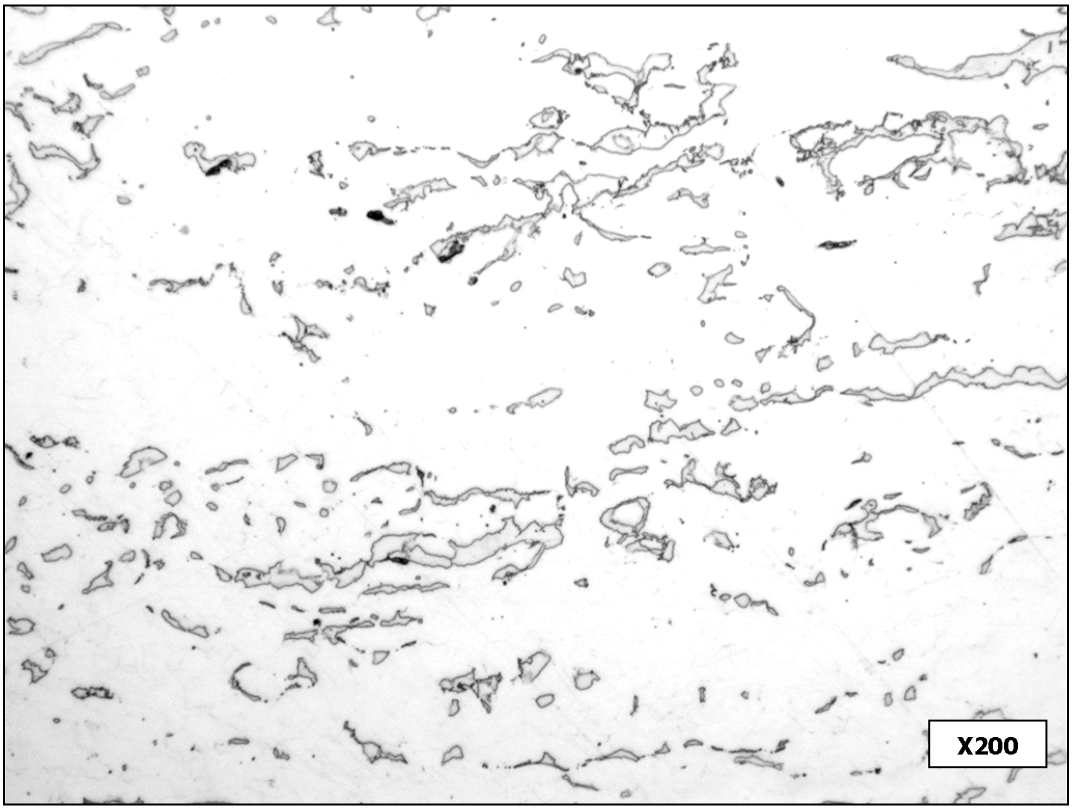


Figure 3 - Ferrite delta stringers were characterized on a forged part. The sample was polished and etched with Kalling's No.2 Reagent.

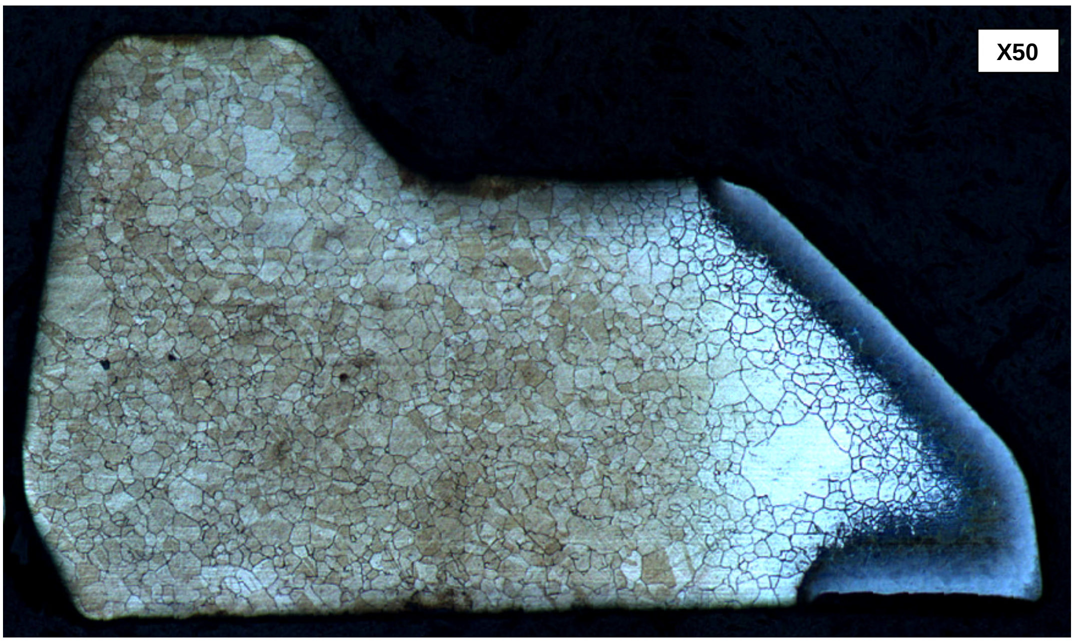
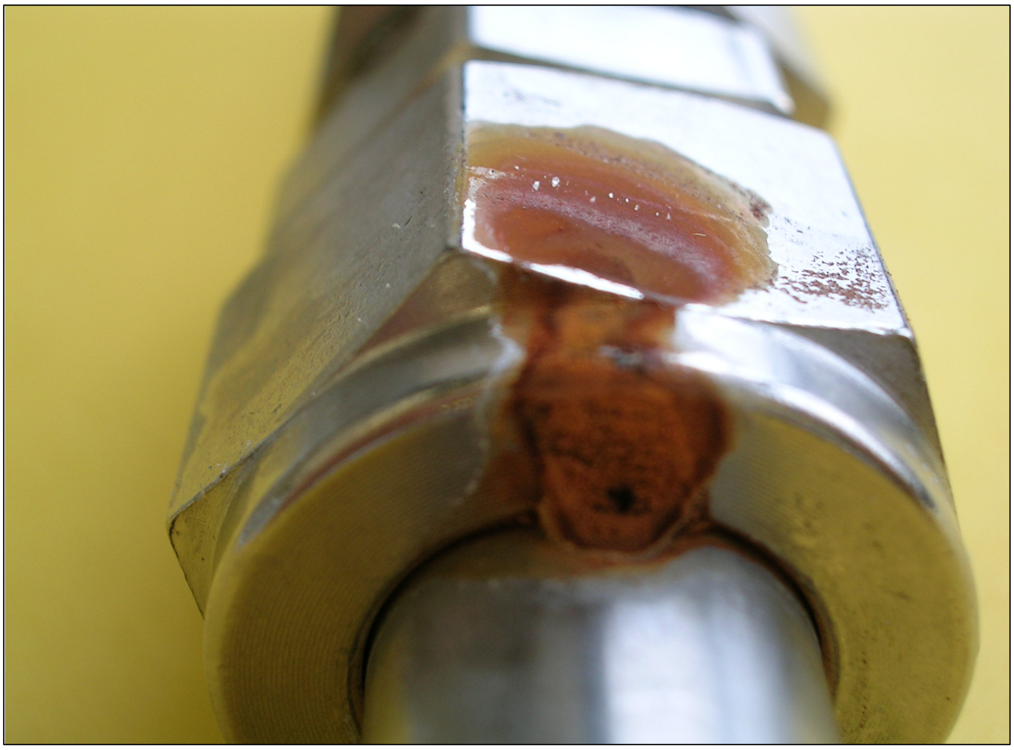


Figure 4 – Back Ferrule: Edge-Hardening Detail. Microstructure revealed by etching the sample with Kalling's No. 2 and Aqua Regia Reagents.



Figures 5 and 6 – Tube Fitting Assemblies with Stainless Steel 316 Tubing after 175h Exposure to Salt-Spray Test as per ASTM B117 Specification.

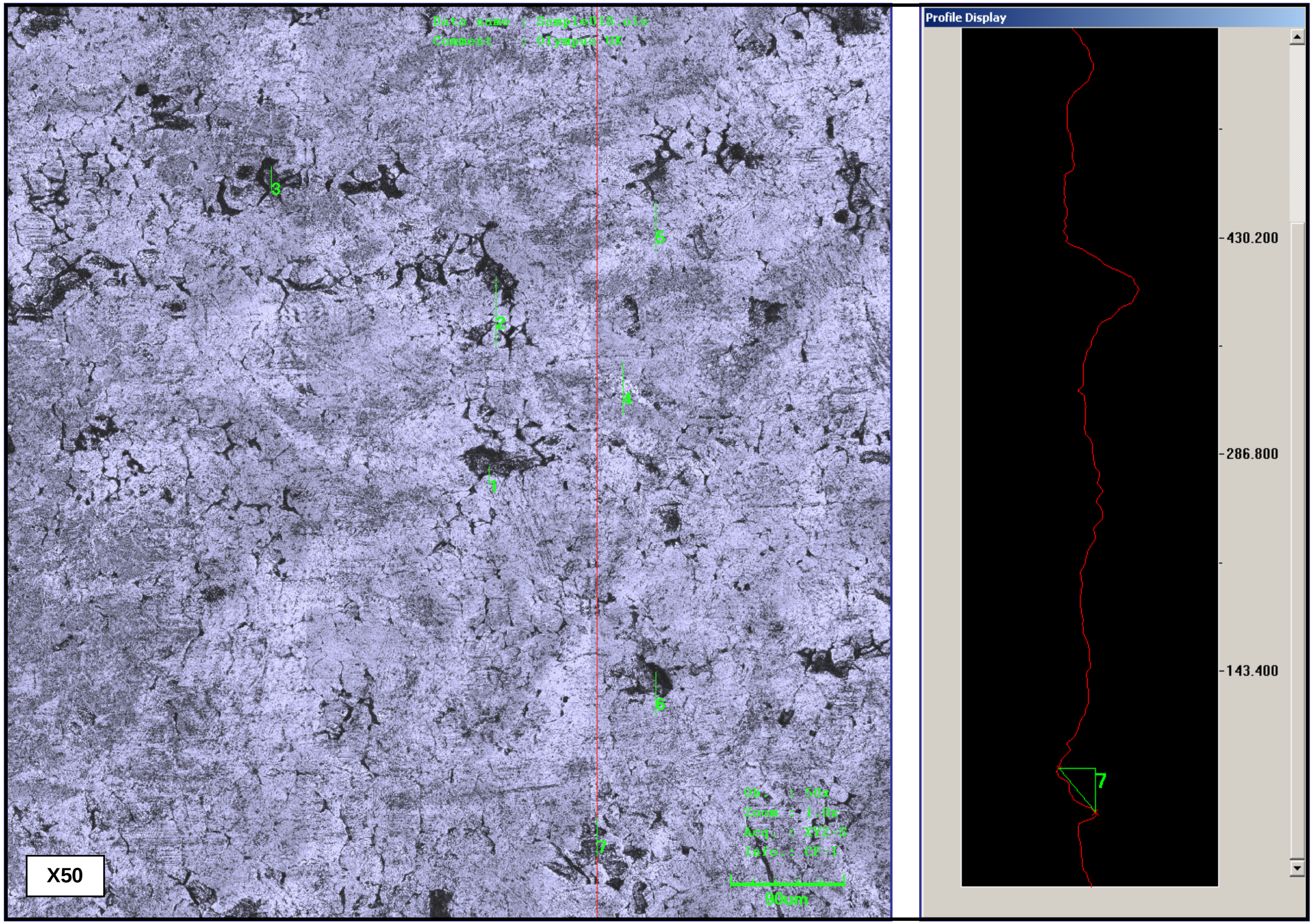


Figure 7 – Confocal Laser Macrograph : Area Under Rust Deposits. Localised Corrosion is taking place (see presence of pits and intergranular attack).

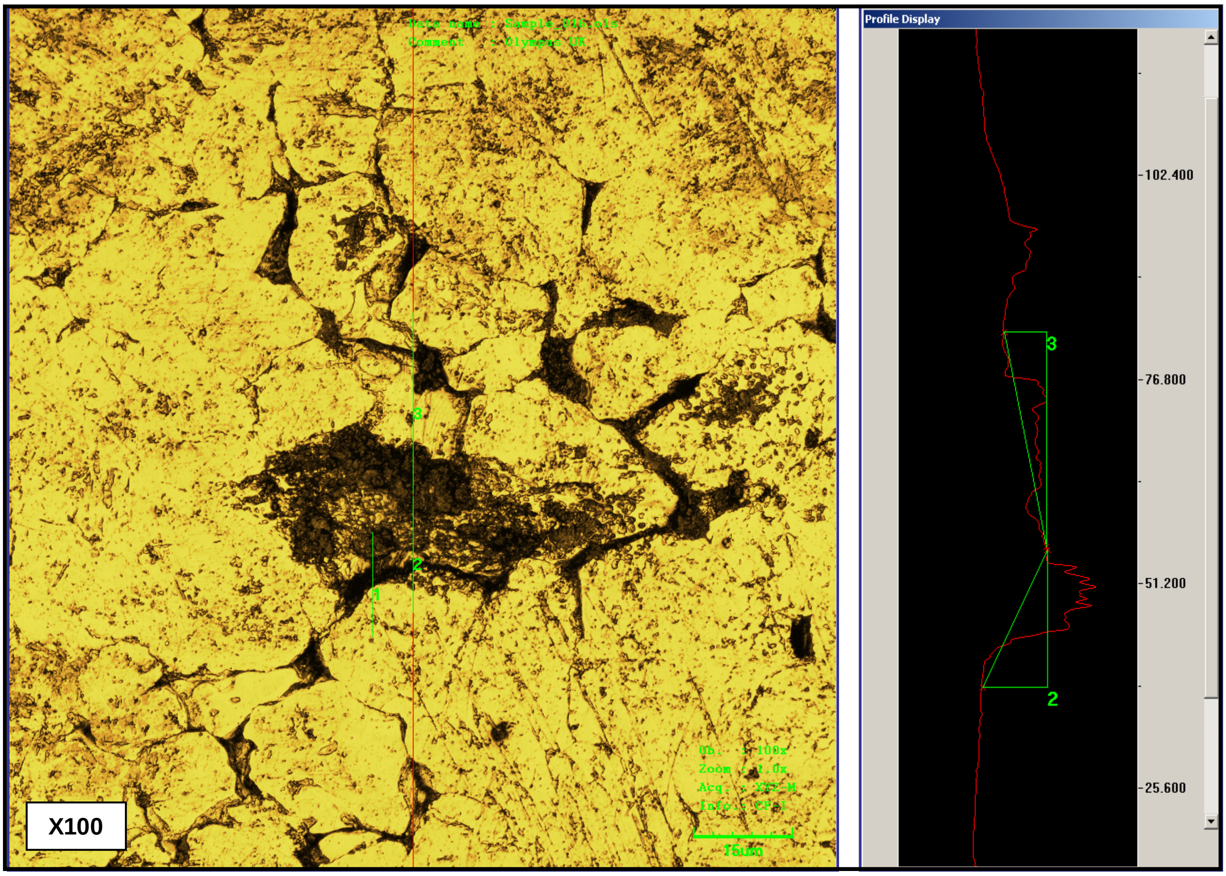


Figure 8 – Confocal Laser Micrograph : Details of Pitting & Intergranular Corrosion.

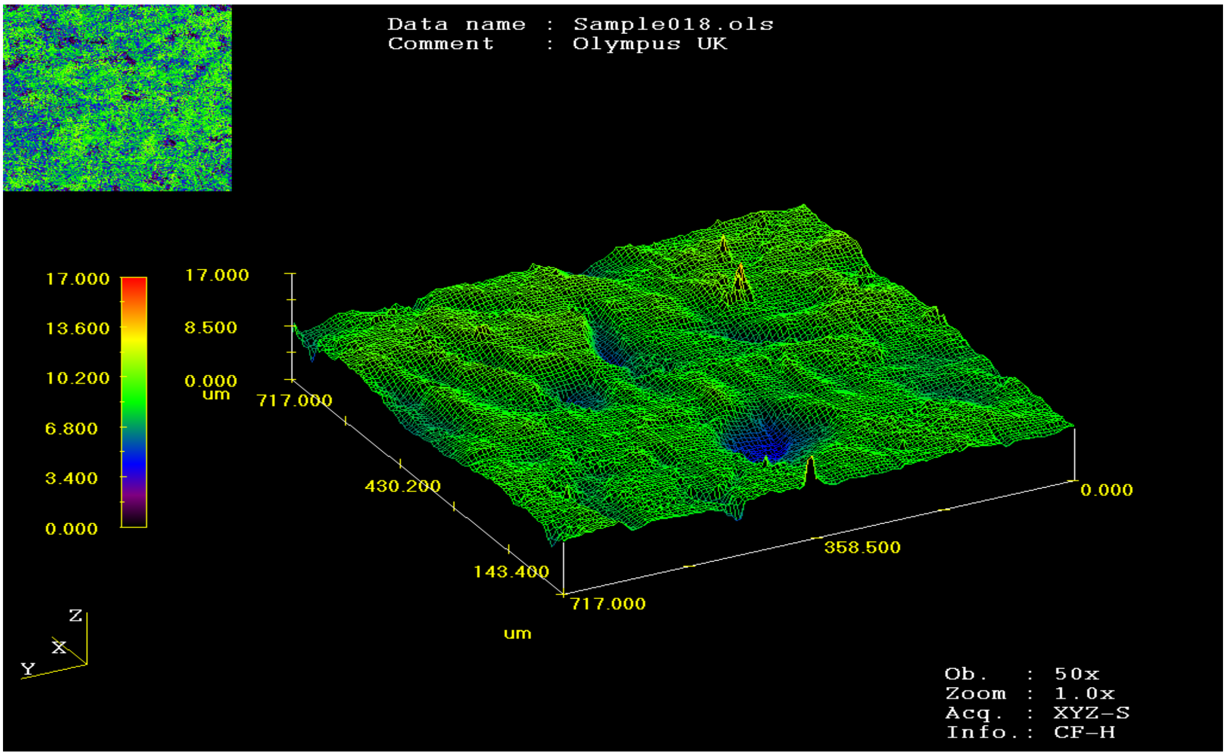
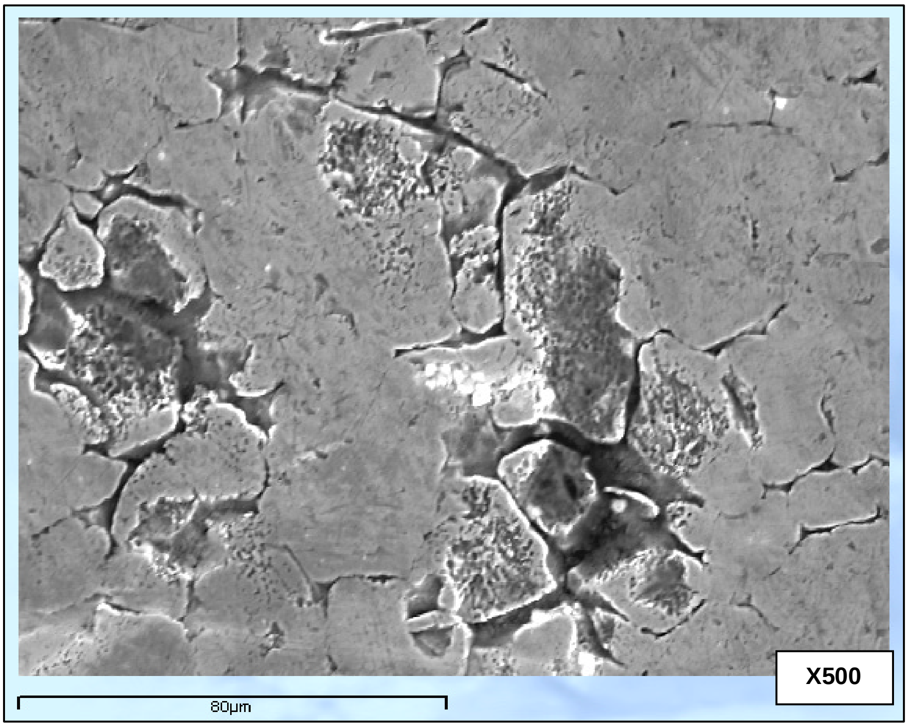
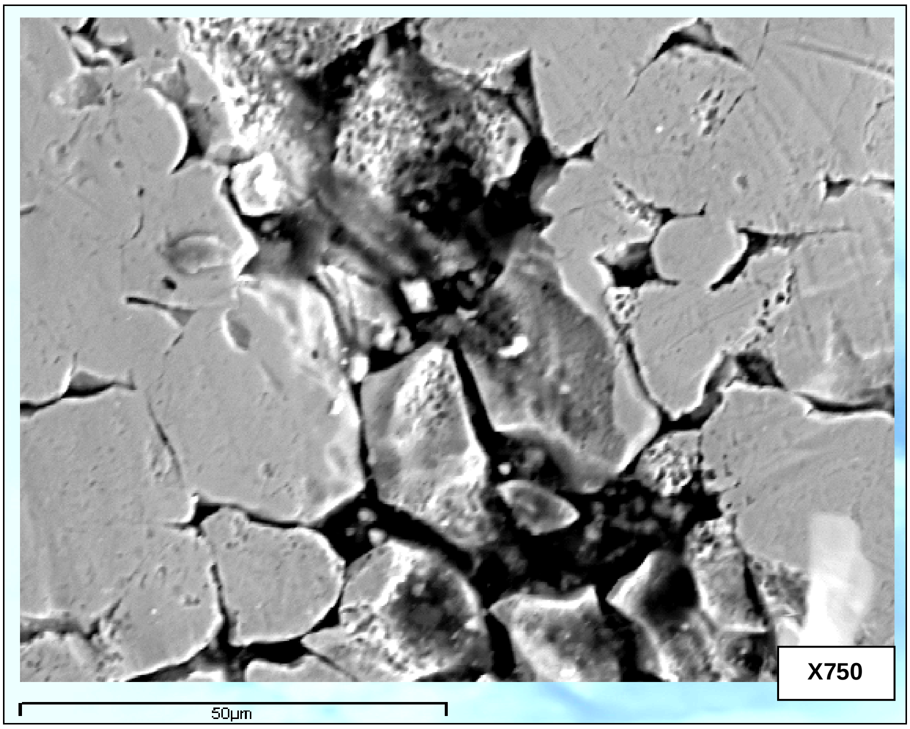


Figure 9 – Confocal Laser Micrograph; 3D Roughness Profile; Pits' Depth;





Figures 10 and 11 – SEM Micrographs. Detail of Localised Corrosion taking place on the material's surface.