Minimox®

Reduction Of Metal Dusting With Minimox® Self-Protective Alloy Treatment

Summary

Minimox-treated and oxidized 601 alloy successfully reduced metal dusting corrosion at 600°C.

Metal dusting (MD) is a severe form of corrosion that manifests itself as a break-up of bulk metal to metal powder in the presence of specific types of carbon-rich atmospheres, including petroleum plants.

At first consideration, the use of a non-continuous dispersion of nanoparticles would not be expected to reduce metal dusting. However, after Minimox-treated surfaces are oxidized, the oxide that forms is uniform with an ultrasmall grain size. As discussed in the literature, [1,2] "If alloys can form a continuous oxide scale on their surface, carbon diffusion through the oxide scale is slowed and carbon accumulation in the alloy diminishes." This observation is graphically depicted in Figures 1 and 2.

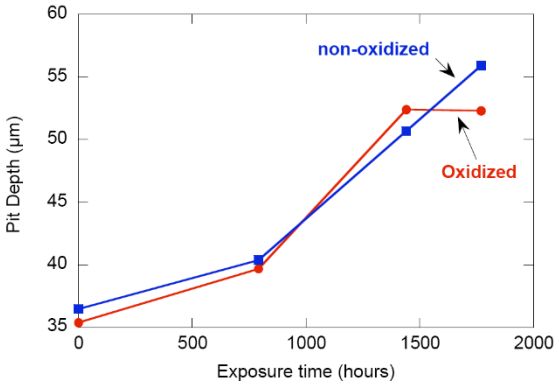

Figure 1. Mitigation of metal dusting by intermediate oxidation treatment for Alloy 230. [1]

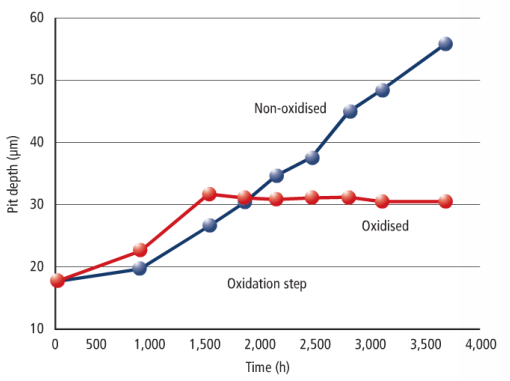

Figure 2. Comparison of pit-depth data for Alloy 617 with and without intermediate oxidation. [2]

Therefore, if a uniform oxide significantly reduces metal dusting attack, alloy treatment with Minimox and subsequent oxidation was anticipated to further reduce metal dusting attack when compared to oxidation without Minimox solution treatment. Experiments showed this was indeed the case.

[1] K. Natesan, Z. Zeng, and D. L. Rink, "*Metal Dusting Research at Argonne National Laboratory,*" MTI Meeting at Orlando, FL, February 20-22, 2006.

[2] Natesan & Zeng, "Metal Dusting Degradation and Mitigation in Structural Alloys," *Hydrocarbon World*, **5(1),** (2010) 35-38.

Technical Bulletin

Dusting Reduction

Summary of testing

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Alloy 601 coupons were coated with Minimox® solution, followed by oxidization at 600°C for 96 hours to form a substantial, uniform oxide layer. The oxide coating was approximately 0.8 µm, or 800 nm.

Metal dusting testing was conducted at Argonne National Laboratory through a Materials Technology Institute (MTI) project. The multicomponent gas environment for the metal dusting program consisted of 23.2%CO, 4%CO_2, 54.6%H_2 and 18.2%H_2O (MD Gas). The specimens were exposed to MD gas at 550°C for 744h and then at 600°C for 4286h.

Figures 3-4 compare the Minimox-treated and untreated 601 alloy after dusting testing for 5030 hours.

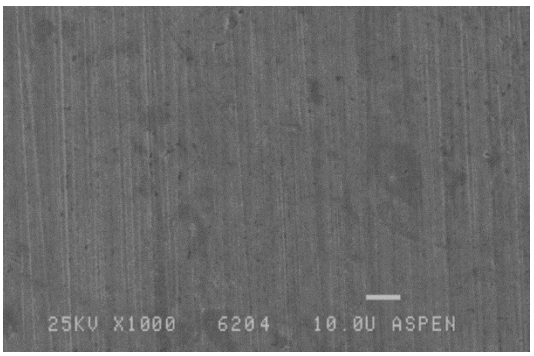

Figure 3. Minimox-treated Ni601 after 600°C MD testing (original magnification 1000X).

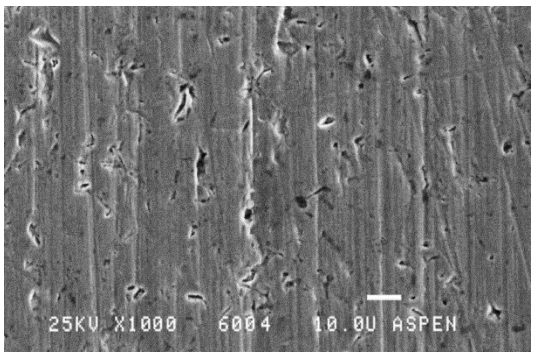

Figure 4. Untreated Ni601 after 600°C MD testing (original magnification 1000X).

As apparent from Figures 3-4, *the integrity of the Minimox-treated surface is vastly superior to that of the untreated 601.* The untreated surface (i.e. in Figure 4) shows substantial pitting.

When the surface (≈ 5 nm) of the oxidized materials were analyzed, **the Minimox-treated and oxidized surface had a 49% higher nickel concentration and a 400% higher silicon composition than untreated and preoxidized nickel alloys.** There is no nickel or silicon in the Minimox solution. The surface diffusion characteristics are radically changed by the presence of Minimox. According to literature [3] [4] references, higher levels of nickel and silicon in the surface layer have been shown to reduce metal dusting attack. Particularly, ***among alloying elements, silicon is the most effective in improving carburization resistance.***

In summary, Minimox-treated and oxidized 601 alloy successfully reduced metal dusting corrosion at 600°C.

For the complete details of the experiments, please contact our office.

[3] C.M. Schillomoller, *Chem. Eng.*, 6 Jan 1986, 83-87.
[4] Stainless Steels, ASM Specialty Handbook, 1994, pg 217.