AA22 - Bayer Process Heat Exchanger Tube with High Corrosion Resistance in Diluted Sulphuric Acid

Darwin Del Aguila[1] and Joseph Del Aguila[2]
1. Aushex Pty Ltd, Corrosion Scientist, Brisbane, Australia
2. Aushex Pty Ltd, Director, Brisbane, Australia
Corresponding author: d.delaguila@aushex.com

Abstract

The objective of this research was to increase the corrosion resistance of the low carbon steel heat exchanger tube used in the Bayer Process. In this application, the tubes are exposed to 6 % sulphuric acid during the regular acid wash of heat exchanger trains to remove DSP formation. By achieving this objective, the lifespan of the tube is increased by up to a factor of 3-4. This improvement reduces maintenance costs and increases alumina production. At the beginning of 2015, a tube sample (referred to as “Special 42”) was accidentally found at the mill facility with a low-quality type microstructure characterized as “partially dispersed cementite” instead of “spheroidised and fully dispersed cementite” which is the specification for this industry. However, when tested, this “Special 42” sample exhibited outstanding corrosion resistance to dilute sulphuric acid. Since then, this sample has constituted the source for further research work. Now, we can confidently say that while spheroidised microstructure does contribute to the increased corrosion resistance of low carbon steel, its impact is much less compared to another metallurgical parameter discovered in 2016 and successfully implemented from the laboratory to the tube production line in the middle of 2017. This new metallurgical parameter is related to a particular grain orientation of the substrate that enhances the formation of a high transfer resistance passive film and consequently inhibits corrosion attack. This new material, now named “Superhex”, has been prepared with different microstructures likely to be found in a typical ASTM 179/192 and evaluated together with current materials under harsh corrosion conditions. The laboratory results indicate a 4-15% mass loss for the Superhex, compared to 26-55 % and 58-95 % mass loss for the Current Alumina Refineries and STD ASTM 179 tube materials, respectively.

Keywords: Sulphuric acid, corrosion resistance, ASTM 179, heat exchanger tube.

1. Introduction

In its dilute form, sulphuric acid reacts with metals (e.g. iron) through Equation (1) producing hydrogen (gas) and metal sulphate (salt) on the metal surface [1,2,3] given by Equation (1):

$$Fe_{(s)} + H_2SO_{4\,(aq)} \rightarrow H_{2\,(g)} + FeSO_{4\,(aq)} \tag{1}$$

Recent advanced technology on crystallography and passivation film has identified key metallurgical parameters that can provide high corrosion resistance in acid solutions. Figure 1 shows an example of the in-laboratory behaviours of two cold-drawn low-carbon steel ASTM-179 tubes, with preferred versus unpreferred crystal grain orientation condition, after 15 h exposure to 6 % v/v uninhibited sulphuric acid at 60 °C and flow rate of 1 m/s. Significant corrosion of the unpreferred orientation (STD ASTM 179) with 94.3 % mass loss in comparison to the relatively unaffected preferred orientation (Superhex) with only 5.5 % mass loss.

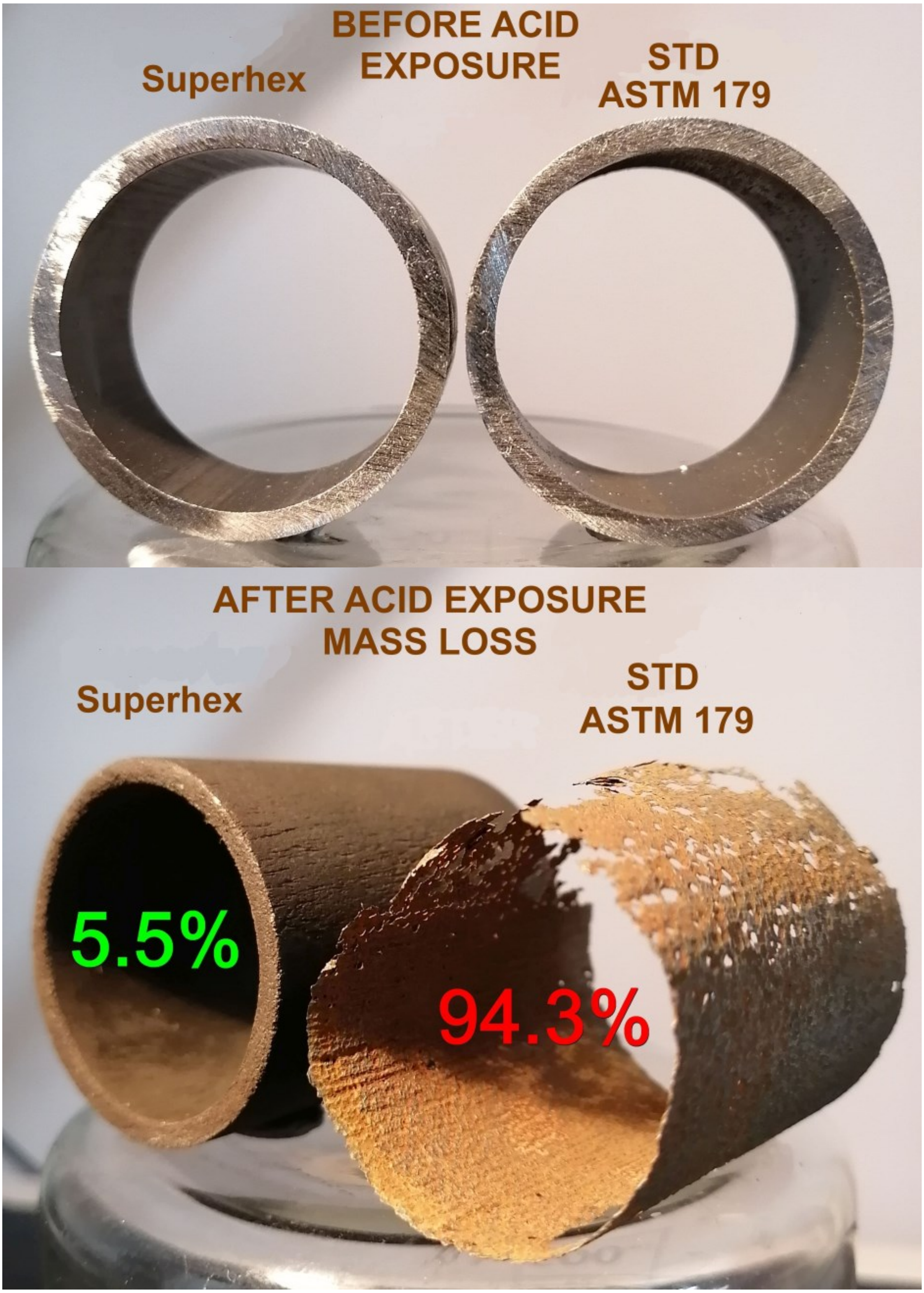

Figure 1. Mass loss images of Superhex vs STD ASTM 179.

6. Acknowledgment

The data reported in the paper were obtained at the Central Analytical Research Facility (CARF) operated by the Institute for Future Environments (IFE) at Queensland University of Technology (QUT). Access to CARF was supported by funding from the Science and Engineering Faculty, QUT. The commercial tube materials were supplied by the Australian alumina refinery. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

7. References

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