Extended Operation Experience of Superhex High Corrosion Resistance Low Carbon Steel at Alumina Refineries

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

Abstract

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Superhex is a low-carbon steel tube metallurgically engineered to provide high acid corrosion resistance by the formation of a strong passive film. This material has been exposed to the alumina refinery process condition for the first time in January 2021. Until now, this material is being trailed in Australia, Brazil, and Canada. In Australia, corrosion performance was monitored during the acid wash and Bayer liquor using a corrosion probe positioned between two live steam heaters (LSH) of an evaporation train, and the corrosion rate (mmpy) was measured from electrochemistry data of linear polarization resistance (LPR) and Impedance. The results consistently showed more corrosion resistance (less corrosion attack) of Superhex against the STD alumina refinery tube and other similar materials in the market. After more than two years (2) into operation, specific Hex units containing both the STD refinery and Superhex tubes, were recently opened for visual comparative inspection. Pictures were taken and will be made available for presentation. The initial electrochemistry assessment has also been confirmed by the low maintenance work records so far observed on these units compared with the ones containing the STD refinery HEX tubes. The life span of Superhex is expected to be higher than the STD alumina refinery tube. Because of its inherent property of forming a passive film in contact with sulphuric and hydrochloric acid in any form, this material is been explored to be used in other forms (sheets, vessels) and industries (fertilizer, power stations, etc.) that use these acids as part of their operations. Its corrosion mechanism has been identified as Diffusion Control of Cathodic Reaction unlikely the STD refinery and other ASTM 179 tubes that are Activation Mechanism.

Keywords: Superhex, 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 sulfate (salt) on the metal surface [1, 2, 3] given by Equation (1):

$$Fe_{(s)} + H_2SO_{4\ (aq)} = H_{2\ (g)} + FeSO_{4\ (aq)} \quad (1)$$

Recent advanced technology in 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 behaviors 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 wt% mass loss in comparison to the relatively unaffected preferred orientation (Superhex) with only 5.5 wt% mass loss.

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

About 1000 tubes (lengths) of the Superhex material have been placed in each brand-new heat exchanger (HEX) unit and exposed to the alumina refinery process conditions as shown in Figure 2.

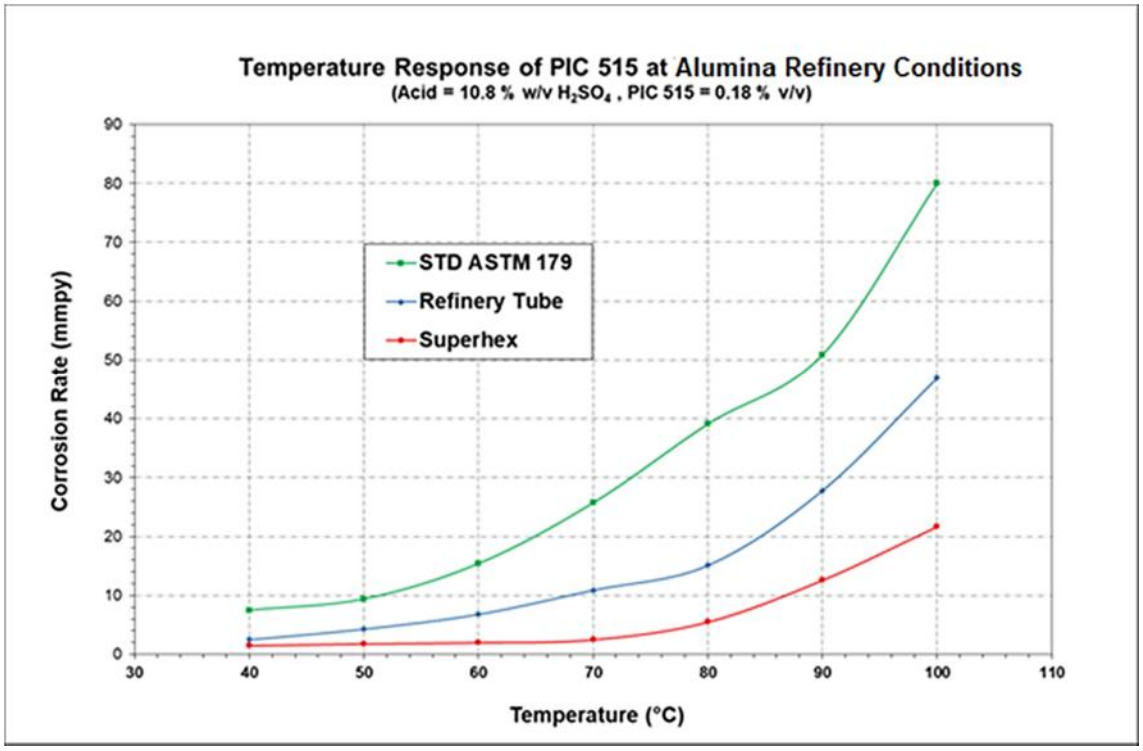

Figure 15. Laboratory temperature response of corrosion inhibitor PIC 515.

4. General Comments and Room for Improvement

Superhex will provide a solid backup to the current operational acid washing procedure due to its high corrosion resistance to uninhibited and inhibited diluted sulphuric acid and good surface adsorption to the current corrosion inhibitor PIC 515.

Corrosion inhibitors are key components to minimize corrosion damage to low-carbon steel exposed to diluted sulphuric or hydrochloric acid. All alumina refineries use corrosion inhibitors to protect their HEX tube exposed during acid wash. The reality is, under this protected environment, the range of life span of their HEX tubes varies from 3 to 5 years (digestion heaters) which is considered low. The tube life span of the tube should be above 5 years. This indicates that the high level of protection given by the inhibitor at a particular time is not kept during the operational life of the tube. Appears to be that the inhibitor protection has not always been there as it should be, as a result, various degrees of corrosion damage has always happened. A high corrosion resistance material based on its inner metallurgy, such as the Superhex, will always be there to mitigate corrosion attack and will enhance the protection with a suitable corrosion inhibitor and reach life spans well beyond 5 years.

The data obtained on this plant trial and the related laboratory tests highlight the fact that there is room for improvement within the current procedure of acid washing.

5. References

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