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Effects of Sulphide Mining on AISI 304 Stainless Steel

Authors : Aguasanta Miguel Sarmiento, José Miguel Dávila, María Luisa de la Torre

Abstract : Acid mine drainage (AMD) is an acidic leachate with high levels of metals and sulphates in solution, which seriously affects the durability and strength of metallic materials used in the construction of structural and mechanical components. This paper presents the results of the evolution over time of the reduction in tensile strength and defects in AISI 304 stainless steel in contact with acid mine drainage. For this purpose, a total of 30 bars with a diameter of 8 mm and a length of 14 cm were placed transversely in the course of a stream contaminated by AMD from the sulphide mines of the Iberian Pyritic Belt (SW Spain). This stream has average pH values of 2.6, a potential of 660 mV and average concentrations of 12 g/L of sulphates, 1.2 g/L of Fe, 191 mg/L of Zn, etc. Every two months of exposure, 6 stainless steel bars were extracted from the acid stream. They were subjected to surface roughness analysis carried out with the help of Mitutoyo Surftest SJ-210 surface roughness tester. The analysis was carried out at three different points on 5 specimens from each series. The average reading of each parameter is calculated in order to ensure the accuracy of the measurements and the surface coverage. Arithmetic mean roughness value (Ra), mean roughness depth (Rz) and root mean square roughness (Rq) were measured. Five specimens from each series were statically tensile tested using universal equipment (Servosis ME 403 of 200kN). The specimens were clamped at their ends with two grips for cylindrical sections and the tensile force was applied at a constant speed of 0.5 kN/s, according to the requirements of standard UNE-EN ISO 6892-1: 2020. To determine the modulus of elasticity, limits close to 15% and 55% of the maximum load were used, depending on the course of each test. Field Emission Scanning Electron Microscopy (FESEM) was used to observe corrosion products and defects generated by exposure to AMD. Energy dispersive X-ray spectrometry (EDS) was used to analyse the chemical composition of the corrosion products formed. For this purpose, small pieces were cut from the resulting specimens, cleaned and embedded in epoxy resin. The results show that after only 5 months of exposure of AISI 304 stainless steel to the mining environment, the surface roughness increases significantly, with average depths almost 6 times greater than the initial one. Cracks are observed on the surface of the material, which increase in size with the time of exposure. A large number of grains with a composition of more than 57% Pb and 16% Sn can be observed inside these cracks. Tensile tests show a reduction in the resistance of this material after only two months of exposure. The results show the serious problems that would result from the use of this material for the use of mechanical components in a sulphide mining environment, not only because of the significant reduction in the lifetime of such components, but also because of the implications for human safety.

Keywords : acid mine drainage, corrosion, mechanical properties, stainless steel
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