Study on Corrosion Resistance of a Novel Alloy $FeNi_2CoMo_{0.2}V_{0.5}$ High Entropy Alloy in Simulated Seawater

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Abstract

The corrosion resistance of $FeNi_2CoMo_{0.2}V_{0.5}$ high entropy alloy and 42CrMo steel was studied by open circuit potential test, electrochemical impedance spectroscopy and potentiodynamic polarization curve test. The results show that the high entropy alloy can reach the stable potential faster than the 42CrMo steel in 3.5% NaCl solution, and the final potential value is higher. The tolerant arc diameter of high entropy alloy is much larger than 42CrMo steel, and the corrosion potential is higher than 42CrMo Steel, corrosion current density than the 42CrMo lower than 4 times, showing better corrosion resistance.

Keywords

High entropy alloy; 42CrMo Steel; Corrosion behavior; Polarization curve.

1. Introduction

With the development of science and technology and industry, the material has put forward higher requirements, such as higher strength, high temperature, high pressure, low temperature, corrosion resistance, wear and other special physical and chemical performance requirements, carbon steel is not complete Meet the requirements, so need to find a new type of alloy material to better serve the industry.

The high entropy alloy[1] (HEA) is a new type alloy whose number of main elements n is 5~13, and the mass fraction of each main element is between 5% and 35% Can be considered solute atoms[2]. Due to the high lattice distortion and mixing entropy, the number of phases obtained after solidification of the high entropy alloy is much lower than that predicted by the equilibrium phase ratio, forming a simple face-centered cubic (fcc) or body-centered cubic (bcc) solid solution , And show high strength, high hardness, wear resistance, excellent thermal stability and corrosion resistance, with a wide range of application potential. $FeNi_2CoMo_{0.2}V_{0.5}$ high entropy alloy, its special element ratio, lower free energy reflects the high entropy of the corrosion resistance of the alloy may be very good. At the same time, $FeNi_2CoMo_{0.2}V_{0.5}$ high entropy alloy is a single-phase homogeneous solid solution, the element composition uniformity is beneficial to the improvement of corrosion resistance, Mo addition can effectively inhibit the solution of Cl-alloy pitting[3] And its fcc structure[4] can reduce the corrosion of the alloy at the interface of the possibility of corrosion, which can effectively reduce the galvanic corrosion in the alloy may occur. Therefore, the electrochemical properties of FeNi2CoMo0.2V0.5 high entropy alloy were investigated by comparing with the 42CrMo steel in the 3.5% NaCl solution (ie, simulated seawater).

2. Experiment

2.1 Sample preparation

The high entropy alloy used in this experiment is to use high purity Fe,Ni,Co,Mo,V as raw materials, under the protection of high purity argon vacuum arc melting method used to prepare high entropy alloy button ingots, each alloy button ingots at high temperature 1200 ℃ smelting 3 to 4 times to ensure uniform composition, and then through the vacuum casting to obtain φ10 mm × 70 mm alloy bar.

2.2 Electrochemical experiment

The electrochemical corrosion behavior of $FeNi_2CoMo_{0.2}V_{0.5}$ high entropy alloy and 42CrMo steel in 3.5% NaCl solution was studied. All experiments were carried out at 25°C, and all the solutions were prepared from analytical reagent and ultrapure water. For better contrast and reproducibility, all corrosive specimens are polished in accordance with metallographic requirements and cleaned with acetone. Hot air is dry and dried. The macro-corrosion test was carried out using an Ametec VersaSTAT3 potentiometer, all of which were sealed with epoxy resin, leaving the surface of the etched electrode and connected with copper wires. High entropy alloy sample corrosion electrode area of 0.785cm2, 42CrMo steel sample area of 1cm2. Electrochemical tests are used saturated potassium chloride/calomel electrode as the reference electrode, platinum electrode as the auxiliary electrode of the standard three-electrode system[5]. Three kinds of electrochemical detection methods were used for open circuit potential (ocp) test, dynamic potential scanning polarization (pdc) test and electrochemical impedance spectroscopy (eis) test. In the 3.5% NaCl solution, the open-circuit potential test time is set to 3600s and the interval is 1s. The electrochemical impedance spectrum frequency range is 100KHz ~ 10mHz and the excitation voltage is 100mV. The scanning interval of the potential polarization test is -0.25V ~ + 0.25V (VSoc), scanning rate of 1mV / s. In order to ensure the accuracy of the experiment, each test is repeated three times. In addition, the experimental measured corrosion potential and corrosion current density[6] are realized by Versa-studio software independent Tafel fitting.

3. Experimental results and analysis

Figure 1 is FeNi2CoMo0.2V0.5 high entropy alloy and 42CrMo steel in 3.5% NaCl solution open circuit potential.

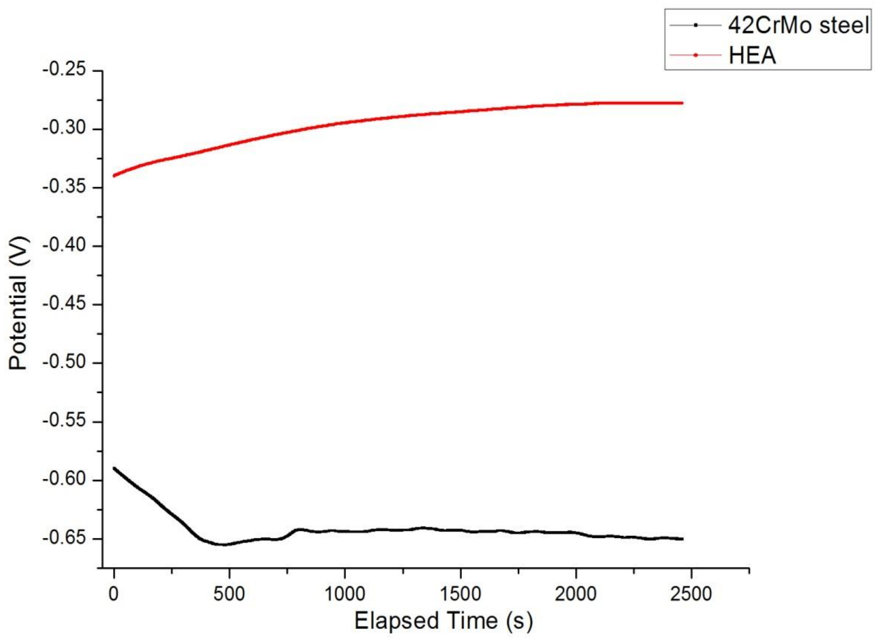

Fig. 1 FeNi2CoMo0.2V0.5 high entropy alloy and 42CrMo steel in 3.5% Na Cl solution open circuit potential

It can be seen from the figure1 that the high entropy alloy can reach the steady state faster and the final stable potential is higher, HEA is -282mV and the 42CrMo steel is -650mV, which indicates that the high entropy alloy is less likely to be corroded, reflecting the high entropy alloy In 3.5% NaCl solution may have better corrosion resistance.

Fig.2 shows the electrochemical impedance spectra of high entropy alloy and 42CrMo steel in 3.5% Na Cl solution. The image is made up of Zsim pwin software according to the equivalent circuit in the figure, where R1 is the solution resistance, R2 is the charge transfer resistance, and C1 is the interface capacitance of the sample.

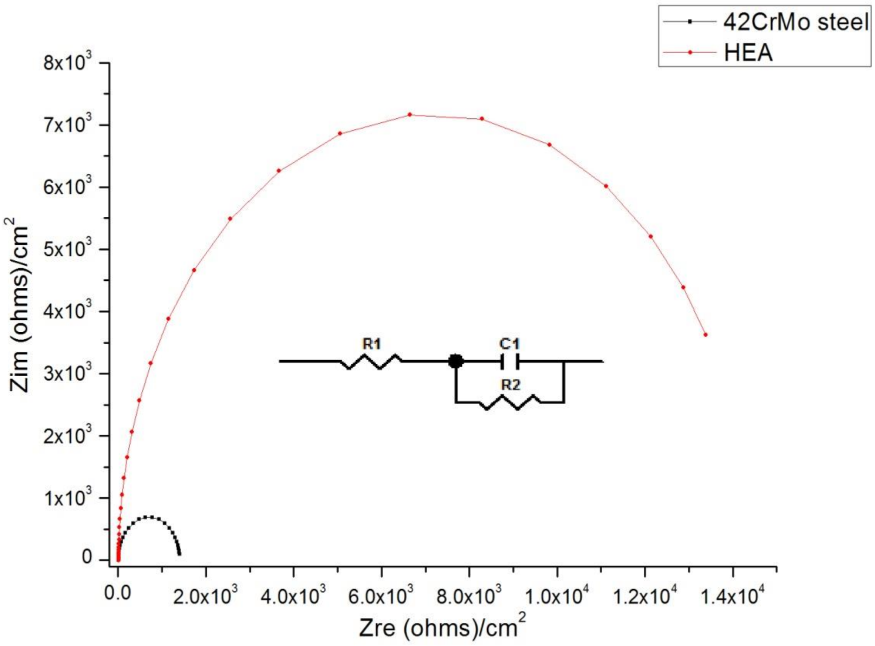

Fig.2 Electrochemical impedance spectroscopy of FeNi2CoMo0.2V0.5 high entropy alloy and 42CrMo steel in 3.5% Na Cl solution

It can be seen from the figure2 that the capacitive arc diameter of the high entropy alloy is 10 times that of 42CrMo steel, which indicates that the high entropy alloy has a lower corrosion rate in 3.5% Na Cl solution, which reflects the better corrosion resistance of high entropy alloy.

Figure3 shows the polarization curves of high entropy alloys and 42CrMo steels in 3.5% Na Cl solution.

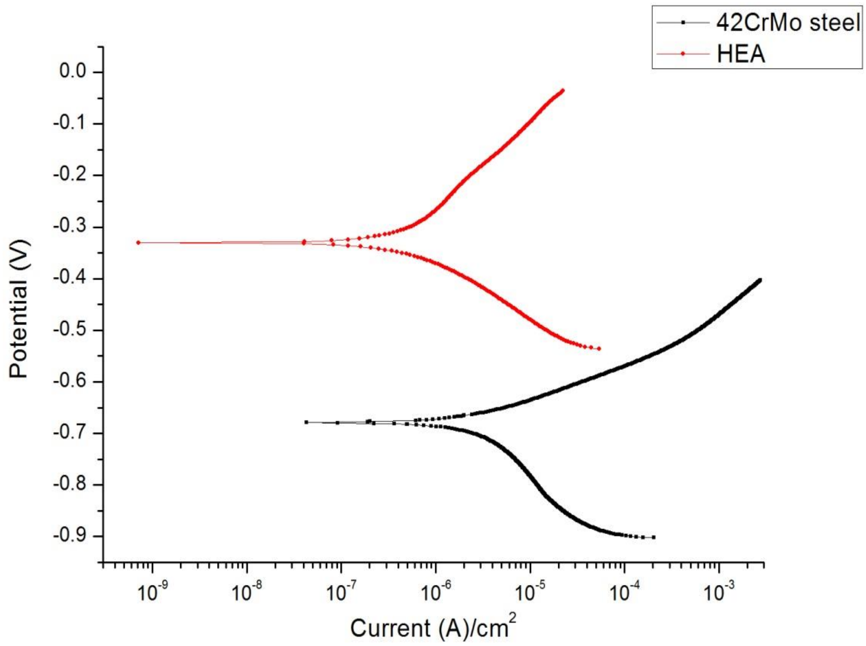

Fig.3 Polarization curve of FeNi2CoMo0.2V0.5 high entropy alloy and 42CrMo steel in 3.5% Na Cl solution

Table 1. FeNi2CoMo0.2V0.5 high-entropy alloy and 42CrMo steel in 3.5% Na Cl solution polarization parameters

Samples	E_{corr}(mv)	I_{corr}(nA/cm^2)
42CrMo steel	-678.695	3206
HEA	-330.121	770

It can be seen from Figure 3, FeNi2CoMo0.2V0.5 high entropy alloy sample curve to move to the upper left, indicating that the corrosion rate than 42CrMo steel significantly reduced; Table 1 polarization parameters, FeNi2CoMo0.2V0.5 high entropy alloy samples The corrosion current density is 4 times lower than that of 42CrMo steel, and the corrosion potential is more than 1 times higher than that of 42CrMo steel. The corrosion resistance of high entropy alloy sample is significantly higher than that of 42CrMo steel.

In conclusion, in 3.5% Na Cl solution, FeNi2CoMo0.2V0.5 high entropy alloy than 42CrMo steel has better corrosion resistance.

4. Conclusion

In the 3.5% Na Cl solution, the open potential of the high entropy alloy is faster and the final stable potential is higher than that of the 42CrMo steel. The electrochemical impedance arc diameter is much higher than that of the 42CrMo steel, and the corrosion potential is higher than that of the 42CrMo steel , Since the corrosion current density is lower than the 42CrMo steel sample, the high entropy alloy corrosion resistance is better.

This is mainly due to the thermodynamic stability of the high entropy alloy itself, the unique element ratio and the special structure. In addition, the addition of Mo can effectively inhibit the pitting effect of Cl on the alloy in the solution, and its fcc structure can reduce the possibility of corrosion damage at the interface of the alloy, which can effectively reduce the possibility of galvanic corrosion in the alloy.

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