Thermoelectric power and mechanical characterization of the effects of 475 °C embrittlement of a 2507 super duplex stainless steel

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Introduction
Due to their excellent mechanical properties and corrosion resistance, duplex stainless steels (DSS) are gaining the attention for different applications in oil, nuclear, gas and chemical industries [1]. These improved mechanical properties and corrosion resistance owed to a duplex microstructure composed of a balanced amount of ferrite and austenite [2]. Like all ferritic stainless steels, duplex stainless steels are susceptible to the embrittlement phenomenon if they are exposed during service at a temperature between 200°C and 500 °C. This phenomenon is known as 475 °C embrittlement since it has been reported that the rate of embrittlement is highest at 475 °C [3-5] and is characterized by the reaction undergone by the ferrite phase: α → α′ + α in this temperature range which is essentially produced by a miscibility gap in iron-chromium binary alloy system [6-7].

Experimental Procedure
The 2507 DSS were aged at 475 °C (the chemical composition given in Table I) to investigate the effects of embrittlement on the microstructure and mechanical properties using scanning electron microscopy (SEM), Vickers microhardness, and Charpy impact energy. The microstructure of the 2507 SDSS is composed of elongated grains of austenite (γ) characterized by the reaction undergone by the ferrite phase: α → α′ + α in this temperature range which is essentially produced by a miscibility gap in iron-chromium binary alloy system.

Table I

| Specimen | T (°C) | C | Mn | Cr | Ni | Mo | W | Ta | C | EMS
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<tr>
<td>A</td>
<td>475</td>
<td>0.07</td>
<td>7.6</td>
<td>3.5</td>
<td>53.5</td>
<td>10.4</td>
<td>0.2</td>
<td>0.02</td>
<td>0.8</td>
<td>0.04</td>
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Results
The microstructure of the 2507 DSS is composed of elongated grains of austenite (γ) in a matrix of ferrite (α) as shown in Fig. 3. SEM analysis shown no perceivable changes in the microstructural characteristics of the 2507 DSS. Vickers microhardness results shown an increasing in microhardness of some regions with the holding time increases. Charpy impact energy results shown that the impact of energy rapidly decreases with the holding time increases and corrosion resistance is affect by the precipitation of phase α′ in SDSS as the holding time increases. And the thermoelectric power results shown an increasing in TEP with the holding time increases.

Conclusions
This work investigated the use thermoelectric power measurements for monitoring 475 °C embrittlement of 2507 SDSS. It is shown that the TEP determined from measurements changes significantly and is well correlated with other measurement data including the DOS, microhardness and Charpy impact energy. Therefore, the measurement technique can be used for the detection and possibly for quantitative evaluation of the 475 °C embrittlement damage that is caused by thermally activated microstructural changes due to the precipitation of nanometric precipitates of α'. Consequently, the present research demonstrates the feasibility of using the TEP probe for in-situ monitoring of 475 °C embrittlement.

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References