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The effect of thermomechanical treatment on pitting corrosion of 17-4PH stainless steel

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Among the precipitation hardening stainless steels, martensitic alloys such as 17-4 PH, 15-5 PH and PH 13-8 Mo have special importance due to their very high strength and hardness [1]. 17-4 PH stainless steel is more common than any other type of precipitation hardened stainless steels [2] and used in many applications such as turbine foams in the aerospace industry, hydrometallurgy, oil and gas extraction and refinement[3]. Thermomechanical treatments are used to improve the structure and toughness of high alloys [4]. The purpose of this work is to consider the effect of thermomechanical treatment on pitting corrosion resistance of 17-4 PH stainless steel. In present study, the effect of thermomechanical treatment on pitting corrosion of 17-4 PH stainless steel was investigated in 3.5% NaCl solution by means of potentiodynamic polarization technique.
Cylindrical samples with a diameter of 11 mm and a height of 16.5 mm were prepared from the bulk material and used for hot compression. The specimens were austenitized at 1200°C for 10 min and cooled to deformation temperature. To obtain a uniform temperature in the samples, they were held for 5 min at furnace prior to applying deformation. Hot compression tests were carried out at temperatures of 950, 1050 and 1150°C with the strain percentage and strain rate of 50% and $0.1 s^{-1}$, respectively. After deformation process, the specimens were instantly quenched in water. A non-deformed specimen was also considered as a comparative sample. This specimen named as solution-treated was austenitized at 1200 °C for 10 min and quenched in water at room temperature. Subsequently, the deformed samples and also solution treated sample were aged for 1hr at 480°C followed by water quenching. To determine pitting potential, potentiodynamic polarization tests were conducted at a sweep rate of 30 mV/min. The distribution of pitting potential measured at different thermomechanical treatment conditions is illustrated in Figure 1 and 2. The cumulative probability (P_{cum}) values were calculated by a mean rank method, that is $P_{cum} = n/(1+N)$, where n is the order in the total number of experiment and N is the total number of experiments [5]. From Fig 1, it is obvious that pitting potential distribution of solution treated specimen shifts to a higher potential region in comparison with the deformed specimens. Also it is found that pitting potential distribution of specimen which has been thermomechanically treated at T=1150°C, shifts to a lower potential region compared with other specimens. The median distribution, E_m, was simply decided at P_{cum} =0.5[5]. The amounts of E_m for different specimens were shown in Table 1. It is seen that before applying aging treatment the highest pitting potential is observed for the solution treated specimen while those which have been deformed show lower pitting potential values. Although, they exhibit lower values of pitting potential but the beneficial effect of thermomechanical treatment on the mechanical properties cannot be rolled out.

Similar behavior on pitting corrosion comparison between solution treated specimen and those which have been applied thermomechanical treatment is also observed after aging treatment at 480°C (see Fig 2). Frankly, the aging treatment has no significant effect on the pitting potential. From Table 1, a slight increase in pitting potential is observed in all samples after applying aging treatment and the highest increase in pitting potential belongs to the specimen deformed at 1150°C (approximately 68 mV). Surprisingly, this specimen (deformed at 1150°C) shows the highest value of pitting potential among the deformed specimens. Bringing in mind that the solution treated sample reveals the best performance between all samples after thermomechanical treatment.

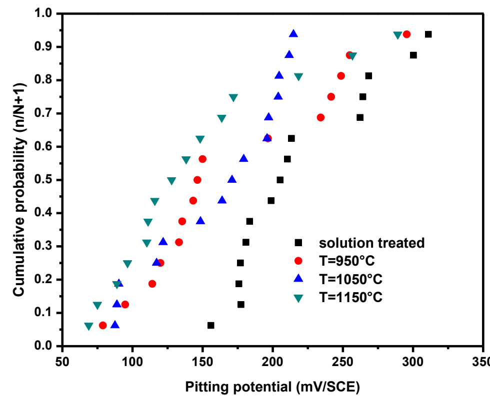

Fig 1. The distribution of pitting potential of 17-4PH stainless steel for specimens thermomechanically treated at different temperatures (before aging).

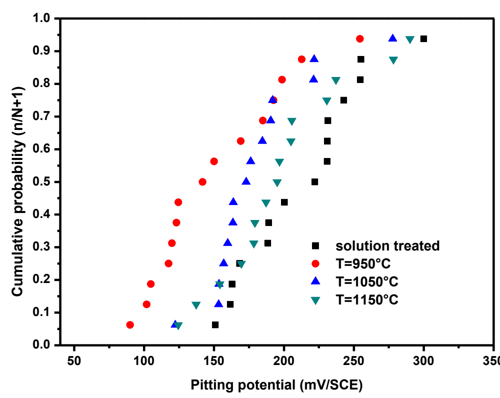

Fig 2. The distribution of pitting potential of 17-4PH stainless steel for specimens thermomechanically treated at different temperatures (after aging).

Table1: the median distribution of 17-4PH stainless steel for different specimens

Sample	Solution treated	Thermomechanically treated specimens at:		
		T=950 °C	T=1050 °C	T=1150 °C
Em mV (vs. SCE) (before aging)	205	141	171	127
Em mV (vs. SCE) (after aging)	222	146	173	195

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