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Effect of cold deformation on pitting initiation of 17-4 PH stainless steel

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In many applications cold rolling is the final manufacturing step of stainless steels. Beside the beneficial strengthening effects of cold deformation, such process may alter the pitting corrosion susceptibility of stainless steels (1, 2). In the present study the effect of cold rolling on pitting corrosion of 17-4 precipitation hardening stainless steel in 3.5% NaCl solution has been investigated. The steel was solution treated at 1050 °C for 1 hr, and then it was rolled at room temperature with final reduction of 10%, 30%, 50% and 70% in thickness. A non-deformed specimen (named as ST in figures) was also considered for comparison. Alloy microstructure was examined using SEM. Potentiodynamic and potentiostatic polarization experiments were carried out to investigate the pitting potential, the frequency of occurrence and the stability product of metastable pits as a function of cold rolling. Statistical approach was also employed to examine the effect of cold rolling on pitting potential.

The SEM micrographs of cold rolled specimens revealed fractures at the interface of martensitic matrix and MnS inclusions. Figure 1 shows SEM micrograph of specimen 30% cold rolled. Fracture at the interface of matrix/inclusion can be observed.

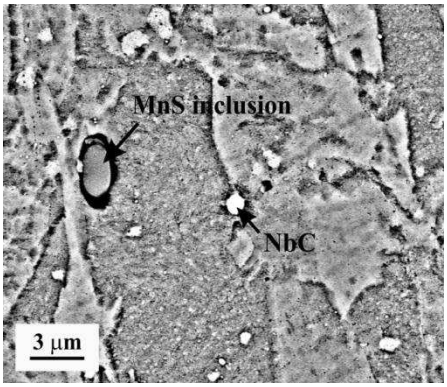

Fig. 1 SEM micrograph of 30% cold rolled 17-4 PH SS.

Figure 2 shows the cumulative probability of pitting potential for different cold rolled specimens. Considering the median value of E_{pit} for different specimens, one can infer that the pitting potential of 17-4 PH stainless steel did not alter by cold working. By assuming metastable pits as hemisphere, the maximum current, life time, radius and then stability product of metastable pits were calculated and the results revealed an increase in stability product with increasing in cold working. In contrary, as figure 3 shows, the metastable pitting frequency was decreased by increasing in cold working. It is believed that the reduction on metastable pitting frequency with increasing cold working can be related to the fractures occurred at matrix/inclusions interface which results in facilitating MnS inclusion dissolution when the steel was left at its corrosion potential prior to polarization (3).

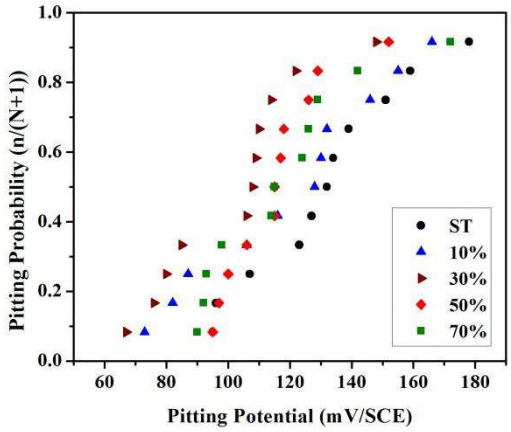

Figure 2- Pitting probability of 17-4 PH SS for different cold rolling reductions.

It has been already proposed that the probability of stable pits formation on stainless steel is as a result of two probabilities: probability of initiation of metastable pits and the possible transition of metastable to stable pit(4). In the present study, while the former probability is decreased by cold rolling, the latter on is increased as a function of plastic deformation. The opposite effect of cold rolling process on metastable pit initiation and also on its transition to stable pit, therefore, it may conclude that cold rolling process has no effect on stable pitting probability. This has been reflected on pitting potential measurement that as it can be seen has not been significantly affected by cold rolling process.

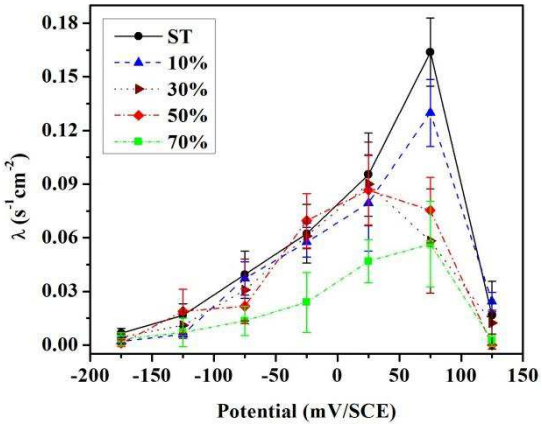

Figure 3- Metastable pitting frequency of 17-4 PH SS in 3.5% NaCl solution as a function of potential for different cold rolled specimens, with error bars showing 95% confidence.

References

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