EFFECT OF HEAT TREATMENT AND LASER SURFACE TREATMENT ON THE CORROSION BEHAVIOR OF STAINLESS STEELS

by

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M.Sc. in Electromechanical Engineering

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Abstract

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In the present study, the effect of heat and laser treatment on intergranular corrosion (IGC) and pitting corrosion behavior of various austenitic stainless steels ASSs (UNS S30400, S31603, S32100, S34700, FeCrMn), duplex stainless steels DSSs (S31803 and S32950) and super duplex stainless steel SDSS (S32760) were investigated. Double loop electrochemical potentiokinetic reactivation (DL-EPR) test was performed by using a potentiostat on aged ASSs in 0.5 M H_2SO_4 + 0.01 M KSCN solution at 25 °C whereas for aged DSSs and SDSS, a more aggressive solution (2 M H_2SO_4, 0.01 M KSCN and 0.5 M NaCl at 25 °C) was used. SEM examination revealed that intergranular attack occurs at the Cr-depleted grain boundaries for the aged ASSs while attack takes place at the phase boundaries of the intermetallic σ phase and metallic phase (γ, δ, γ_2) for the aged DSSs. Cyclic potentiodynamic polarization was also carried out for investigating the pitting corrosion behavior of various aged stainless steels in 3.5 wt% NaCl solution at 25°C. For FeCrMn, increase in the aging time significantly deteriorates the pitting resistance and the specimens

even do not passive when the aging time is longer than 50 h. For aged S31803 and S32950, the pitting resistance is also deteriorated as evidenced by the decrease in pitting potential. Similar results are obtained for aged S32760, but higher repassivation ability was observed mainly due to the present of more passivable alloying elements.

Laser surface melting (LSM) was done on various stainless steels by a 2.5-kW CW Nd:YAG laser and a 2.3-kW diode laser. Different laser processing parameters were applied to melt the surface of FeCrMn and S32950 for optimizing the LSM conditions for corrosion resistance. The pitting resistance of the aged S32950 after LSM with a higher scanning speed and lower power of the laser is higher than that of the ones fabricated with a lower processing speed or higher power. In addition, the aged ASSs were essentially austenitic with some δ (except FeCrMn) but the chromium carbides were completely removed after LSM. For the aged DSS and SDSS after LSM, δ became the major phase and the δ/γ phase balance was disturbed but the σ and γ_2 phases were eliminated. After LSM, the IGC resistance of the aged ASSs was found to be considerably improved as reflected by the reduction in degree of sensitization (DOS). This could be attributed to a more homogenous microstructure and the redissolution of chromium carbides. The IGC resistance of aged DSSs and SDSS was also significantly enhanced as indicated by the decrease in DOS. This could be attributed to a more homogenous microstructure and to the redissolution of σ and γ_2 phases. Furthermore, the effects of re-aging after LSM were also investigated on FeCrMn and S32950. Both of them showed higher pitting resistance as compared with that of the aged specimens.

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LIST of Abbreviations

ASS	Austenitic Stainless Steel
ASTM	America Society of Testing and Materials
DOS	Degree of Sensitization
DSS	Duplex Stainless Steel
$\mathbf{E_{corr}}$	Corrosion Potential
EDX	Energy Dispersive Spectroscopy
$\mathbf{E_{pit}}$	Pitting Potential
$\mathbf{E_{prot}}$	Protection Potential
FSS	Ferrite Stainless Steel
$\mathbf{I_{corr}}$	Corrosion Current
IGC	Intergranular Corrosion
$\mathbf{I_{pass}}$	Passivation Current
ISO	International Organization for Standarization
LC	Laser Cladding
LSA	Laser Surface Alloying
LSM	Laser Surface Melting
OCP	Open Circuit Potential
OM	Optical Microscope
PC	Pitting Corrosion
SDSS	Super Duplex Stainless Steel
SEM	Scanning Electron Microscope
XRD	X-Ray Diffractometry

LIST OF PUBLICATIONS

Book Chapter

1. **W.K. Chan**, C.T. Kwok, K.H. Lo, Chapter 3. Laser surface melting of stainless steels for mitigating intergranular corrosion, in 'Laser Surface Modification of Alloys for Erosion and Corrosion Resistance', C.T. Kwok (Editor), Woodhead Publishing, ISBN 13: 9780857090157 ISBN 10: 0857090151 (to be published in 2012)

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1. C.T. Kwok, K.H. Lo, **W.K. Chan**, F.T. Cheng, H.C. Man, Effect of laser surface melting on intergranular corrosion behaviour of aged austenitic and duplex stainless steels, Corrosion Science, 53 (2011) pp.1581-1591. (SCI, Impact factor: 3.261)

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