

**A Comparative Study On The Tensile And Pitting Behaviours of
AISI 316 Austenitic Stainless Steel And Low-Carbon Steel:
An Assessment Of the Suitability For Use As Concrete Reinforcements**

By

Cheang Keng Hou

M.Sc Electromechanical Engineering

2013/2014



Faculty of Science and Technology

The University of Macau

A Comparative Study On The Tensile And Pitting Behaviours of
AISI 316 Austenitic Stainless Steel And Low-Carbon Steel:
An Assessment Of the Suitability For Use As Concrete Reinforcements

by

Cheang Keng Hou

A thesis submitted in partial fulfillment of the
requirements for the degree of
Master of Science in Electromechanical Engineering
Faculty of Science and Technology
University of Macau
2013

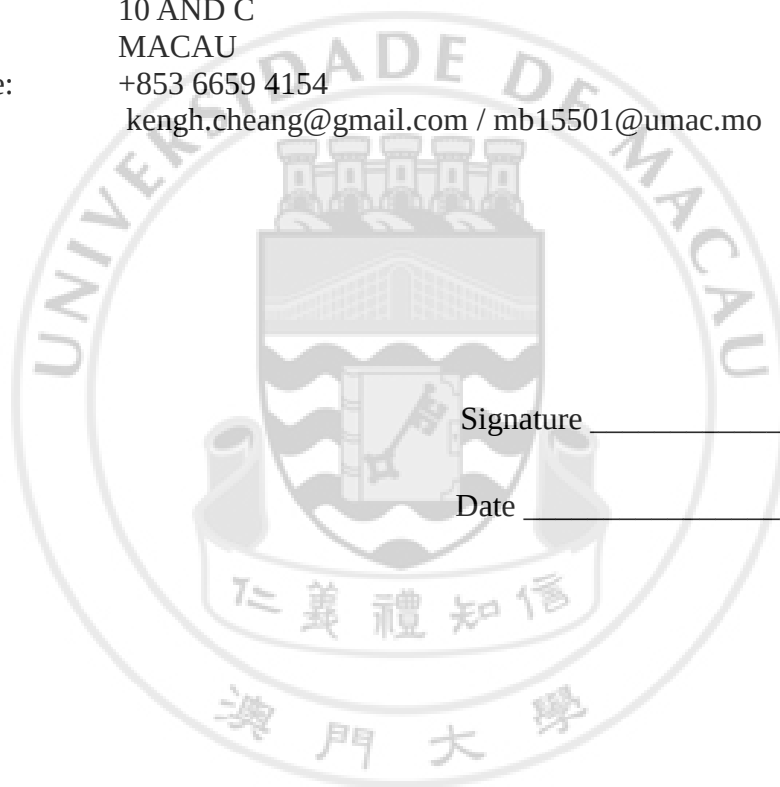
Approved by _____

Supervisor

Date _____

In presenting this thesis in partial fulfillment of the requirements for a Master's degree at the University of Macau, I agree that the Library and the Faculty of Science and Technology shall make its copies freely available for inspection. However, reproduction of this thesis for any purposes or by any means shall not be allowed without my written permission. Authorization is sought by contacting the author at

Address: RUA DA RIBEIRA DO PATANE
EDF LEI CHEONG
10 AND C
MACAU
Telephone: +853 6659 4154
E-mail: kengh,cheang@gmail.com / mb15501@umac.mo



Signature _____

Date _____

University of Macau

Abstract

A Comparative Study On The Tensile And Pitting Behaviours of
AISI 316 Austenitic Stainless Steel And Low-Carbon Steel:
An Assessment Of the Suitability For Use As Concrete Reinforcements

by Cheang Keng Hou

Thesis Supervisor:
Prof. Lo Kin Ho
Master of Science in Electromechanical Engineering

In this thesis, tensile tests and pitting corrosion tests are done on carbon steel and AISI 316 austenitic stainless steel after thermal aging in different temperature range and time intervals.

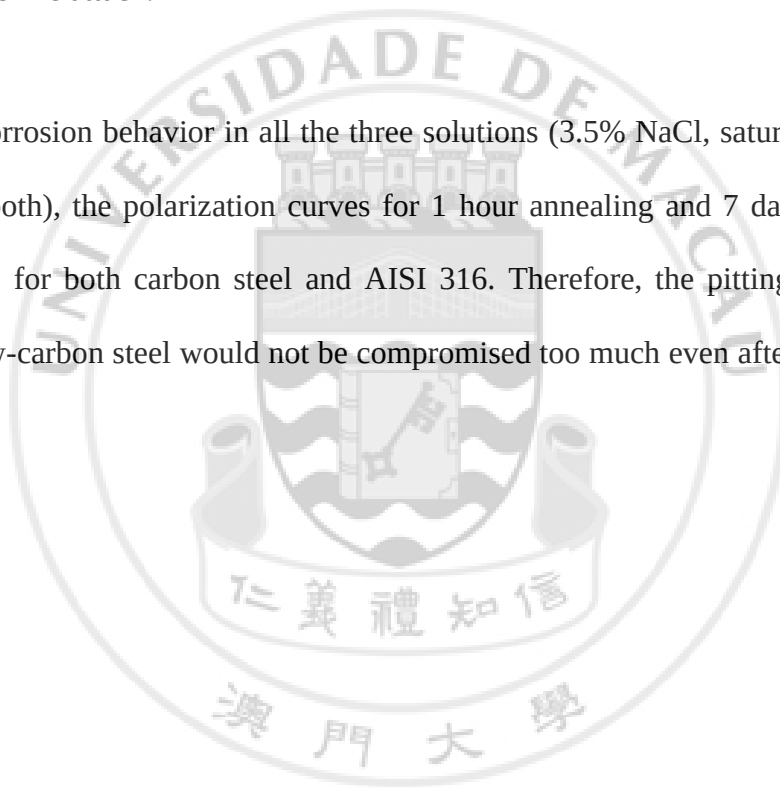
Between 600°C and 900°C, the strengths of AISI 316 show monotonic decrease. This decrease is caused by the more significant grain growth and reduction of dislocations as the temperature goes up. At a fixed temperature in this temperature regime and for up to 7 days, however, AISI 316 does not show any change in its tensile behavior. It may thus be said that the ability to reinforce concrete is not affected at a fixed annealing temperature for up to 7 days.

Between 600°C and 900°C and for annealing time less than 10 hours, a higher temperature would lead to more softening of carbon steel compared with AISI 316. After 1 day, however, the softening of carbon steel annealed at 700°C is more serious than annealed at 800°C. Because a fire accident is unlikely to be longer than 10 hours, it may be said that a higher fire attack temperature

is more damaging to carbon steel rebars. At both 600°C and 800°C, the tensile behavior of carbon steel does not change too much. At 700°C, however, carbon steel shows gradual softening, because the carbides will spheroidize.

Under 500°C, both AISI 316 and low-carbon steel do not show much difference even after annealing for 7 days at a particular temperature. It means both materials are not much affected by a low-temperature fire attack.

For the pitting corrosion behavior in all the three solutions (3.5% NaCl, saturated Ca(OH)_2 and a combination of both), the polarization curves for 1 hour annealing and 7 days annealing are all nearly coincided, for both carbon steel and AISI 316. Therefore, the pitting resistance of both AISI 316 and low-carbon steel would not be compromised too much even after a fire attack under 900°C.



ACKNOWLEDGEMENT

I would like to express my sincerest gratitude to my supervisor Prof. Kin Ho LO for his unmitigated support and guidance on my research work in making this thesis a reality. Without his patience and guidance, this thesis would have been impossible to write. Prof. Lo's constant guidance, yet his willingness in granting me the freedom to work in my own ways, enabled me to fully take charge of this project.

I must acknowledge the financial support given to me by "Fundo para o Desenvolvimento das Ciências e da Tecnologia" (FDCT) through the Grant 031/2010/A2. The stipends I received from this grant enabled me to focus on my studies.

I would like to thank Prof. Lap Mou TAM for the chance of working at the Institute for the Development and Quality (IDQ) as a research assistant. The assistance I got from Prof. Chi Tat KWOK was also acknowledged. Also, I would like to thank Ms. Po Kee WONG and Mr. Weng Kin CHAN for their discussions and technical support.

Finally, I wish to thank my friends and family for supporting me with my study, giving me reason to work hard through my university years. They are the energy that I can finish my study.

PUBLICATIONS

Journal Paper

1. Zeng D, Lo K.H., **Cheang K.H.**, Lai JKL (2013)
A study on tensile, fracture and corrosion behaviour of AISI 316 after short-term high-temperature exposure: implications for use as concrete reinforcing bars
Journal of Materials Engineering and Performance, 22(5), pp.1481-1489
2. Lo K.H., **Cheang K.H.**, Sinan N. (2011)
Some aspects of using stainless steel as concrete reinforcing bars and recent developments in high nitrogen, low nickel stainless steels
Recent Patents on Mechanical Engineering, 4(3), pp.234-242

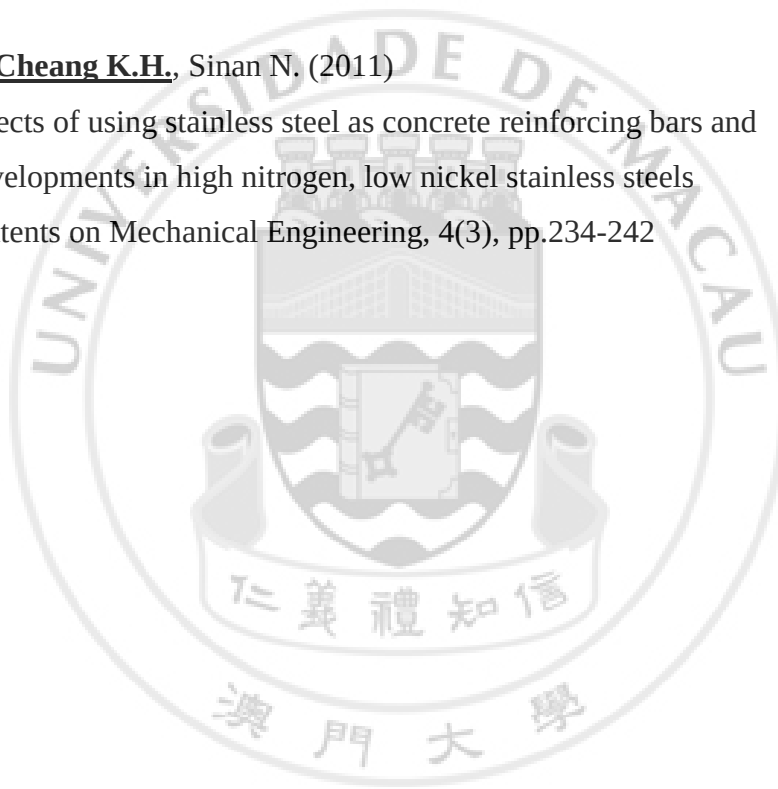


TABLE OF CONTENTS

LIST OF FIGURES	iv
LIST OF TABLES	x
Chapter 1.....	1
1. Introduction and Project Aims and Scope	1
1.1 A brief introduction to ordinary steel rebars.....	1
1.2 Problems associated with ordinary steel rebars: some damaging factors that are commonplace in Macau.....	2
1.3 Methods for mitigating corrosion of steel rebars: all have weaknesses!	5
1.3.1 Concrete Control, Corrosion Inhibitors, Membranes, and Pore liners/Blockers	6
1.3.2 Galvanization.....	8
1.3.3 Epoxy Coating.....	9
1.3.4 Cathodic Protection.....	10
1.4 Stainless steels as rebar materials and the benefits.....	12
1.4.1 Stainless steels as rebar materials and the benefits.....	12
1.4.2 Safety Benefits of Stainless Steel Rebars	14
1.4.3 Summary to the advantages of stainless steel rebars	16
1.5 Scope of the Present Work, Its Aims and Limitations.....	17
Chapter 2.....	18
2. Experimental Details	18
2.1 Raw Materials	18
2.2 Schedule of Annealing Treatment	18
2.3 Tensile Test.....	19
2.4 Anodic Potentiodynamic Polarisation Measurements	20
Chapter 3.....	21
3. Tensile Behavior of AISI 316 and Low-carbon Steel Between 600°C and 900°C	21
3.1 Carbon Steel.....	21
3.1.1 Effects of annealing temperature on carbon steel	21
3.1.2 Effects of annealing time on carbon steel.....	29
3.2 Stainless Steel AISI 316.....	33

3.2.1	Effects of annealing temperature on AISI 316	33
3.2.2	Effects of annealing time on AISI 316	36
3.3	Comparative Analyses Between AISI 316 and Low-carbon Steel	39
3.4	Discussion of Tensile Tests	43
3.4.1	Discussion on carbon Steel.....	43
3.4.2	Discussion on AISI 316.....	45
3.5	Conclusions.....	45
Chapter 4.....	.....	47
4. Tensile Behavior of AISI 316 and Low-carbon Steel Between 300°C and 500°C .....	.....	47
4.1 Carbon Steel.....	.....	47
4.1.1 Effects of low annealing temperature on carbon steel.....	.....	47
4.1.2 Effects of annealing time on carbon steel.....	.....	51
4.2 Stainless Steel AISI 316.....	.....	55
4.2.1 Effects of low annealing temperature on AISI 316 .....	.....	55
4.2.2 Effects of annealing time on AISI 316 .....	.....	57
4.3 Comparative Analyses between different annealing temperature of low-carbon steel.	.....	59
4.4 Result and Discussion of Low Annealing Temperature Tensile Tests .....	.....	63
4.5 Conclusions.....	.....	64
Chapter 5.....	.....	65
5. Pitting Corrosion Behavior of AISI 316 and low-carbon steel between 300°C and 900°C.....	.....	65
5.1 Carbon Steel Annealed Between 600°C and 900°C.....	.....	65
5.1.1 Polarization Tests in 3.5% NaCl Solution.....	.....	65
5.1.2 Polarization Curve in 3.5% NaCl + saturated Ca(OH) ₂ Solution.....	.....	69
5.1.3 Polarization Curve in saturated Ca(OH) ₂ Solution.....	.....	72
5.2 AISI 316 Annealed Between 600°C and 900°C.....	.....	79
5.2.1 Polarization Curve in 3.5% NaCl Solution.....	.....	79
5.2.2 Polarization Curve in 3.5% NaCl + saturated Ca(OH) ₂ Solution.....	.....	83
5.2.3 Polarization Curve in saturated Ca(OH) ₂ Solution.....	.....	87
5.3 AISI 316 and Low-Carbon Steel Between 300°C and 500°C.....	.....	95
5.3.1 Polarization Curve Under 3.5% NaCl +0.2% Ca(OH) ₂ Solution .....	.....	95

5.3.2	Polarization Curve Under 3.5% NaCl +0.2% Ca(OH) ₂ Solution	96
5.4	Discussion on Pitting Behavior of AISI 316 and Low-Carbon Steel	98
5.5	Conclusions.....	100
Chapter 6.....		101
6.	Fractography of AISI 316 and Low-Carbon Steel	101
6.1	Carbon Steel.....	101
6.1.1	Fractography of Carbon Steel	101
6.2	Stainless Steel AISI 316.....	115
6.2.1	Fractography of AISI 316 Samples.....	115
6.3	Conclusions.....	135
Chapter 7.....		136
7.	Thesis Conclusions and Recommendations for Future Work.....	136
7.1	For the tensile tests.....	136
7.2	Conclusion for Pitting Corrosion Tests.....	137
7.3	Conclusions on Fractography	137
7.4	Future Works	139
Appendix.....		140
References.....		146

LIST OF FIGURES

Fig 1.1 Ribs made on a steel rebar [3]	2
Fig 1.2 Schematic representation of the corrosion of a steel rebar in concrete [1].....	3
Fig 1.3 Clipping of Macao Daily showing the insecurity of water supply to Macau (Macao Daily News)	4
Fig 1.4 Rusting of steel rebars and the attendant volume expansion may engender concrete peel-off and spalling.....	5
Fig 1.5 Schematic representation of the cathodic protection of rebar	11
Fig 1.6 The façade of the Chrysler building and the Gateway to the West in St.Lois are epitomes of stainless steels used for construction purposes	13
Fig 1.7 Comparative cost analysis of using steel rebars and stainless steel rebars for concrete highway bridge ([38])	14
Fig 1.8 Retention of strength of stainless steel and carbon steel at elevated temperatures [39]..	15
Fig 1.9 Retention of stiffness of stainless steel and carbon steel at elevated temperatures [39] ..	16
Fig 2.1 Geometry of the tensile samples.....	19
Fig 3.1 Tensile test curves for carbon steel annealed between 600°C and 800°C for 1 hour	22
Fig 3.2 Tensile test curves for carbon steel annealed between 600°C and 800°C for 2 hours.....	22
Fig 3.3 Tensile test curves for carbon steel annealed between 600°C and 800°C for 5 hours.....	23
Fig 3.4 Tensile test curves for carbon steel annealed between 600°C and 800°C for 10 hours.....	23
Fig 3.5 Tensile test curves for carbon steel annealed between 600°C and 800°C for 1 day	25
Fig 3.6 Tensile test curves for carbon steel annealed between 600°C and 800°C for 2 days	25
Fig 3.7 Tensile test curves for carbon steel annealed between 600°C and 800°C for 7 days	26
Fig 3.8 Microstructure of a carbon steel sample annealed at 700°C for 1 hour.....	27
Fig 3.9 Microstructure of a carbon steel sample annealed at 700°C for 7 days.....	27
Fig 3.10 Microstructure of a carbon steel sample annealed at 600°C for 7 days.....	28
Fig 3.11 Microstructure of a carbon steel sample annealed at 800°C for 7 days.....	29
Fig 3.12 Tensile test curves for carbon steel at 600°C annealed for different time periods.....	30
Fig 3.13 Tensile test curves for carbon steel at 700°C annealed for different time periods.....	30
Fig 3.14 Tensile test curves for carbon steel at 800°C annealed for different time periods.....	31
Fig 3.15 Tensile test curves for AISI 316 annealed between 600°C and 900°C for 1 hour.....	33
Fig 3.16 Tensile test curves for AISI 316 annealed between 600°C and 900°C for 5 hours	34
Fig 3.17 Tensile test curves for AISI 316 annealed between 600°C and 900°C for 10 hours	34
Fig 3.18 Tensile test curves for AISI 316 annealed between 600°C and 900°C for 1 day	35
Fig 3.19 Tensile test curves for AISI 316 annealed between 600°C and 900°C for 2 days.....	35
Fig 3.20 Tensile test curves for AISI 316 annealed between 600°C and 900°C for 7 days.....	36
Fig 3.21 Tensile test curves for AISI 316 annealed at 600°C for different time periods	37
Fig 3.22 Tensile test curves for AISI 316 annealed at 700°C for different time periods	38
Fig 3.23 Tensile test curves for AISI 316 annealed at 800°C for different time periods	38
Fig 3.24 Tensile test curves for AISI 316 annealed at 900°C for different time periods	39

Fig 3.25 Ductility changes of carbon steel and AISI 316 at different temperatures and annealing times.....	40
Fig 3.26 Changes in the ductility of carbon steel and AISI 316 with time at different temperatures	40
Fig 3.27 Ultimate tensile strength changes of carbon steel and AISI 316 at different temperatures and annealing times	41
Fig 3.28 Changes in ultimate tensile strength of carbon steel and AISI 316 with time at different temperatures	41
Fig 3.29 Yield stress changes of carbon steel and AISI 316 at different temperatures and annealing times.....	42
Fig 3.30 Changes in yield stress of carbon steel and AISI 316 with time at different temperatures	42
Fig 4.1 Tensile test curves for carbon steel annealed between 300°C and 500°C for 1 hour	48
Fig 4.2 Tensile test curves for carbon steel annealed between 300°C and 500°C for 2 hours.....	48
Fig 4.3 Tensile test curves for carbon steel annealed between 300°C and 500°C for 5 hours.....	49
Fig 4.4 Tensile test curves for carbon steel annealed between 300°C and 500°C for 1 day	49
Fig 4.5 Tensile test curves for carbon steel annealed between 300°C and 500°C for 2 days	50
Fig 4.6 Tensile test curves for carbon steel annealed between 300°C and 500°C for 7 days	50
Fig 4.7 Tensile test curves for carbon steel at 300°C annealed for different time periods.....	52
Fig 4.8 Tensile test curves for carbon steel at 400°C annealed for different time periods.....	52
Fig 4.9 Tensile test curves for carbon steel at 500°C annealed for different time periods.....	53
Fig 4.10 Microstructure of a carbon steel sample annealed at 400°C for 7 days.....	54
Fig 4.11 Tensile test curves for AISI 316 annealed between 300°C and 500°C for 1 hour	56
Fig 4.12 Tensile test curves for AISI 316 annealed between 300°C and 500°C for 7 days.....	56
Fig 4.13 Tensile test curves for AISI 316 annealed at 300°C for different time periods	57
Fig 4.14 Tensile test curves for AISI 316 annealed at 400°C for different time periods	57
Fig 4.15 Tensile test curves for AISI 316 annealed at 500°C for different time periods	58
Fig 4.16 Ductility of carbon steel at different temperatures, but for the same annealing time.....	59
Fig 4.17 Changes in the ductility of carbon steel with time at different temperatures	60
Fig 4.18 Ultimate tensile strength of carbon steel at different temperatures, but for the same annealing time	60
Fig 4.19 Changes in ultimate tensile strength of carbon steel with time at different temperatures	61
Fig 4.20 Yield stress of carbon steel at different temperatures, but for the same annealing time	61
Fig 4.21 Changes in yield stress of carbon steel with time at different temperatures	62
Fig 5.1 Polarization curves for carbon steel samples annealed at 600°C for 1 hour and 7 days (NaCl).....	66
Fig 5.2 Polarization curves for carbon steel samples annealed at 700°C for 1 hour and 7 days (NaCl).....	66
Fig 5.3 Polarization curves for carbon steel samples annealed at 800°C for 1 hour and 7 days (NaCl).....	67
Fig 5.4 Polarization curves for carbon steel samples annealed at different temperature for 1 hour (NaCl).....	67
Fig 5.5 Polarization curves for carbon steel samples annealed at different temperature for 7 days (NaCl).....	68

Fig 5.6 Polarization curves for carbon steel samples annealed at 600°C for 1 hour and 7 days (NaCl + Ca(OH) ₂)	69
Fig 5.7 Polarization curves for carbon steel samples annealed at 700°C for 1 hour and 7 days (NaCl + Ca(OH) ₂)	70
Fig 5.8 Polarization curves for carbon steel samples annealed at 800°C for 1 hour and 7 days (NaCl + Ca(OH) ₂)	70
Fig 5.9 Polarization curves for carbon steel samples annealed at different temperatures for 1 hour (NaCl + Ca(OH) ₂)	71
Fig 5.10 Polarization curves for carbon steel samples annealed at different temperatures for 7 days (NaCl + Ca(OH) ₂)	71
Fig 5.11 Polarization curves for carbon steel samples annealed at 600°C for 1 hour and 7 days (Ca(OH) ₂)	73
Fig 5.12 Polarization curves for carbon steel samples annealed at 700°C for 1 hour and 7 days (Ca(OH) ₂)	73
Fig 5.13 Polarization curves for carbon steel samples annealed at 800°C for 1 hour and 7 days (Ca(OH) ₂)	74
Fig 5.14 Polarization curves for carbon steel samples annealed at different temperatures for 1 hour (Ca(OH) ₂)	74
Fig 5.15 Polarization curves for carbon steel samples annealed at different temperatures for 7 days (Ca(OH) ₂)	75
Fig 5.16 Polarization curves for carbon steel samples annealed at 600°C for 1 hour in different solutions	76
Fig 5.17 Polarization curves for carbon steel samples annealed at 600°C for 7 days in different solutions	76
Fig 5.18 Polarization curves for carbon steel samples annealed at 700°C for 1 hour in different solutions	77
Fig 5.19 Polarization curves for carbon steel samples annealed at 700°C for 7 days in different solutions	77
Fig 5.20 Polarization curves for carbon steel samples annealed at 800°C for 1 hour in different solutions	78
Fig 5.21 Polarization curves for carbon steel samples annealed at 800°C for 7 days in different solutions	78
Fig 5.22 Polarization curves for AISI 316 samples annealed at 600°C for 1 hour and 7 days (NaCl)	79
Fig 5.23 Polarization curves for AISI 316 samples annealed at 700°C for 1 hour and 7 days (NaCl)	80
Fig 5.24 Polarization curves for AISI 316 samples annealed at 800°C for 1 hour and 7 days (NaCl)	80
Fig 5.25 Polarization curves for AISI 316 samples annealed at 900°C for 1 hour and 7 days (NaCl)	81
Fig 5.26 Polarization curves for AISI 316 samples annealed at different temperatures for 1 hour (NaCl)	81
Fig 5.27 Polarization curves for AISI 316 samples annealed at different temperatures for 7 days (NaCl)	82
Fig 5.28 Polarization curves for AISI 316 samples annealed at 600°C for 1 hour and 7 days (NaCl + Ca(OH) ₂)	83

Fig 5.29 Polarization curves for AISI 316 samples annealed at 700°C for 1 hour and 7 days (NaCl + Ca(OH) ₂)	84
Fig 5.30 Polarization curves for AISI 316 samples annealed at 800°C for 1 hour and 7 days (NaCl + Ca(OH) ₂)	84
Fig 5.31 Polarization curves for AISI 316 samples annealed at 900°C for 1 hour and 7 days (NaCl + Ca(OH) ₂)	85
Fig 5.32 Polarization curves for AISI 316 samples annealed at different temperatures for 1 hour (NaCl + Ca(OH) ₂)	85
Fig 5.33 Polarization curves for AISI 316 samples annealed at different temperatures for 7 days (NaCl + Ca(OH) ₂)	86
Fig 5.34 Polarization curves for AISI 316 samples annealed at 600°C for 1 hour and 7 days (Ca(OH) ₂)	87
Fig 5.35 Polarization curves for AISI 316 samples annealed at 700°C for 1 hour and 7 days (Ca(OH) ₂)	88
Fig 5.36 Polarization curves for AISI 316 samples annealed at 800°C for 1 hour and 7 days (Ca(OH) ₂)	88
Fig 5.37 Polarization curves for AISI 316 samples annealed at 900°C for 1 hour and 7 days (Ca(OH) ₂)	89
Fig 5.38 Polarization curves for AISI 316 samples annealed at different temperature for 1 hour (Ca(OH) ₂)	89
Fig 5.39 Polarization curves for AISI 316 samples annealed at different temperatures for 7 days (Ca(OH) ₂)	90
Fig 5.40 Polarization curves for AISI 316 samples in different solutions and annealed at 600°C for 1 hour	91
Fig 5.41 Polarization curves for AISI 316 samples in different solutions and annealed at 600°C for 7 days	91
Fig 5.42 Polarization curves for AISI 316 samples in different solutions and annealed at 700°C for 1 hour	92
Fig 5.43 Polarization curves for AISI 316 samples in different solutions and annealed at 700°C for 7 days	92
Fig 5.44 Polarization curves for AISI 316 samples in different solutions and annealed at 800°C for 1 hour	93
Fig 5.45 Polarization curves for AISI 316 samples in different solutions and annealed at 800°C for 7 days	93
Fig 5.46 Polarization curves for AISI 316 samples in different solutions and annealed at 900°C for 1 hour	94
Fig 5.47 Polarization curves for AISI 316 samples in different solutions and annealed at 900°C for 7 days	94
Fig 5.48 Polarization curves for carbon steel samples annealed at different temperature for 1 hour (NaCl + Ca(OH) ₂)	95
Fig 5.49 Polarization curves for carbon steel samples annealed at different temperature for 7 days (NaCl + Ca(OH) ₂)	96
Fig 5.50 Polarization curves for AISI 316 samples annealed at different temperature for 1 hour (NaCl + Ca(OH) ₂)	97
Fig 5.51 Polarization curves for AISI 316 samples annealed at different temperature for 7 days (NaCl + Ca(OH) ₂)	97

Fig 6.1 Fractography of steel annealed at 300°C for 1 hour at 300X	102
Fig 6.2 Fractography of steel annealed at 300°C for 1 hour at 1000X	102
Fig 6.3 Fractography of steel annealed at 400°C for 1 hour at 300X	103
Fig 6.4 Fractography of steel annealed at 400°C for 1 hour at 1000X	103
Fig 6.5 Fractography of steel annealed at 500°C for 1 hour at 300X	104
Fig 6.6 Fractography of steel annealed at 500°C for 1 hour at 1000X	104
Fig 6.7 Fractography of steel annealed at 600°C for 1 hour at 300X	105
Fig 6.8 Fractography of steel annealed at 600°C for 1 hour at 1000X	106
Fig 6.9 Fractography of steel annealed at 700°C for 1 hour at 300X	106
Fig 6.10 Fractography of steel annealed at 700°C for 1 hour at 1000X	107
Fig 6.11 Fractography of steel annealed at 800°C for 1 hour at 300X.....	108
Fig 6.12 Fractography of steel annealed at 800°C for 1 hour at 1000X	108
Fig 6.13 Fractography of steel annealed at 300°C for 7 days at 300X	109
Fig 6.14 Fractography of steel annealed at 300°C for 7 days at 1000X	109
Fig 6.15 Fractography of steel annealed at 400°C for 1 hour at 300X	110
Fig 6.16 Fractography of steel annealed at 400°C for 7 days at 1000X	110
Fig 6.17 Fractography of steel annealed at 500°C for 7 days at 300X	111
Fig 6.18 Fractography of steel annealed at 500°C for 7 days at 1000X	111
Fig 6.19 Fractography of steel annealed at 600°C for 7 days at 300X	112
Fig 6.20 Fractography of steel annealed at 600°C for 7 days at 1000X	113
Fig 6.21 Fractography of steel annealed at 700°C for 7 days at 300X	113
Fig 6.22 Fractography of steel annealed at 700°C for 7 days at 1000X	114
Fig 6.23 Fractography of steel annealed at 800°C for 7 days at 300X	114
Fig 6.24 Fractography of steel annealed at 800°C for 7 days at 1000X	115
Fig 6.25 Fractography of AISI 316 annealed at 300°C for 1 hour at 300X.....	116
Fig 6.26 Fractography of AISI 316 annealed at 300°C for 1 hour at 1000X.....	116
Fig 6.27 Fractography of AISI 316 annealed at 400°C for 1 hour at 300X.....	117
Fig 6.28 Fractography of AISI 316 annealed at 400°C for 1 hour at 1000X.....	117
Fig 6.29 Fractography of AISI 316 annealed at 500°C for 1 hour at 300X.....	118
Fig 6.30 Fractography of AISI 316 annealed at 500°C for 1 hour at 1000X.....	118
Fig 6.31 Fractography of AISI 316 annealed at 600°C for 1 hour at 300X.....	119
Fig 6.32 Fractography of AISI 316 annealed at 600°C for 1 hour at 1000X.....	119
Fig 6.33 Fractography of AISI 316 annealed at 700°C for 1 hour at 300X.....	120
Fig 6.34 Fractography of AISI 316 annealed at 700°C for 1 hour at 1000X.....	120
Fig 6.35 Fractography of AISI 316 annealed at 800°C for 1 hour at 300X.....	121
Fig 6.36 Fractography of AISI 316 annealed at 800°C for 1 hour at 1000X.....	121
Fig 6.37 Fractography of AISI 316 annealed at 900°C for 1 hour at 300X.....	122
Fig 6.38 Fractography of AISI 316 annealed at 900°C for 1 hour at 1000X.....	122
Fig 6.39 Fractography of AISI 316 annealed at 300°C for 7 days at 90X.....	123
Fig 6.40 Fractography of AISI 316 annealed at 400°C for 7 days at 90X.....	124
Fig 6.41 Fractography of AISI 316 annealed at 500°C for 7 days at 90X.....	124
Fig 6.42 Fractography of AISI 316 annealed at 600°C for 7 days at 90X.....	125
Fig 6.43 Fractography of AISI 316 annealed at 700°C for 7 days at 90X.....	125
Fig 6.44 Fractography of AISI 316 annealed at 800°C for 7 days at 90X.....	126
Fig 6.45 Fractography of AISI 316 annealed at 900°C for 7 days at 90X.....	126

Fig 6.46 Fractography of AISI 316 annealed at 300°C for 7 days at 300X	128
Fig 6.47 Fractography of AISI 316 annealed at 300°C for 7 days at 1000X	128
Fig 6.48 Fractography of AISI 316 annealed at 400°C for 7 days at 300X	129
Fig 6.49 Fractography of AISI 316 annealed at 400°C for 7 days at 1000X	129
Fig 6.50 Fractography of AISI 316 annealed at 500°C for 7 days at 300X	130
Fig 6.51 Fractography of AISI 316 annealed at 500°C for 7 days at 1000X	130
Fig 6.52 Fractography of AISI 316 annealed at 600°C for 7 days at 300X	131
Fig 6.53 Fractography of AISI 316 annealed at 600°C for 7 days at 1000X	131
Fig 6.54 Fractography of AISI 316 annealed at 700°C for 7 days at 300X	132
Fig 6.55 Fractography of AISI 316 annealed at 700°C for 7 days at 1000X	132
Fig 6.56 Fractography of AISI 316 annealed at 800°C for 7 days at 300X	133
Fig 6.57 Fractography of AISI 316 annealed at 800°C for 7 days at 1000X	133
Fig 6.58 Fractography of AISI 316 annealed at 900°C for 7 days at 300X	134
Fig 6.59 Fractography of AISI 316 annealed at 900°C for 7 days at 1000X	134
Fig A.1 Polarization curves for carbon steel samples annealed at 600 °C for 1 hour (NaCl)	140
Fig A.2 Polarization curves for carbon steel samples annealed at 700 °C for 1 hour (NaCl)	140
Fig A.3 Polarization curves for carbon steel samples annealed at 800 °C for 7 days (NaCl)	141
Fig A.4 Polarization curves for carbon steel samples annealed at 600 °C for 1 hour (Ca(OH) ₂)	141
Fig A.5 Polarization curves for carbon steel samples annealed at 800 °C for 7 days (Ca(OH) ₂)	142
Fig A.6 Polarization curves for stainless steel samples annealed at 600 °C for 7 days (NaCl)	142
Fig A.7 Polarization curves for stainless steel samples annealed at 900 °C for 7 days (NaCl)	143
Fig A.8 Polarization curves for stainless steel samples annealed at 600 °C for 7 days (Ca(OH) ₂)	143
Fig A.9 Polarization curves for stainless steel samples annealed at 800 °C for 1 hour (Ca(OH) ₂)	144
Fig A.10 Polarization curves for stainless steel samples annealed at 600 °C for 7 days (NaCl + Ca(OH) ₂)	144
Fig A.11 Polarization curves for stainless steel samples annealed at 800 °C for 1 hours (NaCl + Ca(OH) ₂)	145

LIST OF TABLES

Table 5-1 Corrosion properties of carbon steel and AISI 316 in saturated Ca(OH)_2	99
Table 5-2 Corrosion properties of carbon steel and AISI 316 in 3.5% NaCl + saturated Ca(OH)_2	99
Table 5-3 Corrosion properties of carbon steel and AISI 316 in 3.5% NaCl	99

