## Advances in Stainless Steels

## **Editors**

Baldev Raj, K Bhanu Sankara Rao, T Jayakumar, P V Sivaprasad, Saroja Saibaba, P Shankar

<sup>1</sup> Indira Gandhi Centre for Atomic Research, Kalpakkam, India.
 <sup>2</sup> University of Hyderabad Central University (P.O), Hyderabad, India.
 <sup>3</sup> Sandvik Materials Technology R&D, Sandvik Asia Limited, Pune, India.
 <sup>4</sup> Nehru Institute of Engineering & Technology, T M Palayam, Coimbatore, India.

## **Editor-in-Chief: Baldev Raj**



Series in Metallurgy and Materials Science





CRC is an imprint of the Taylor & Francis Group, an informa business

## **Contents**

Foreword to the series		v
For	Foreword to the book Preface	
Pre		
	COMPONENT DESIGN MODELLING AND STRUCTURAL INTEGRITY	
1.	<b>Design and Material Aspects Concerning Austenitic Stainless Steel Components</b> <i>S C Chetal</i>	1
2.	Improvement of Austenitic Pipings with Welds—Corrosion Resistance, Non-destructive Testing and Loadability Eberhard Roos	9
3.	Design and Fabrication of Stainless Steel Components for Long Life of Spent Fuel Reprocessing Plants R Natarajan, P Ramkumar, V Sundararaman, K Shanmugam, U Kamachi Mudali and Baldev Raj	29
4.	Inverse Method for Detection and Sizing of Vertical Bottom Surface Cracks in Thin Sections Using a Hybrid Genetic Algorithm Based Signal Parametrization  L Satyanarayan, K Bharath Kumaran, C V Krishnamurthy, Krishnan Balasubramaniam	45
5.	Characterization of Irradiated Stainless Steel Wrapper from Fast Breeder Test Reactor  C N Venkiteswaran, P Parameswaran, V Anandaraj, V Karthik,  N G Muralidharan, V Venugopal, S Saroja, M Vijayalakshmi,  K V Kasiviswanathan and Baldev Raj	59
	MANUFACTURING TECHNOLOGY	
6.	Application of Light Energy Beam for Stainless Steel Fabrication G Buvanashekaran	67

7.	Practice and Products for Welding Duplex Stainless Steels  M Larén	85
8.	Repair Welding of Martensitic Stainless Steel Blades and Shrouds of Steam Turbines	
	A K Bhaduri, S K Albert, C R Das and V Ramasubbu	97
9.	Fabrication of Dummy Fuel Sub-assemblies for PFBR P Sivaraman, M Krishnamoorthy, N Easwaran, R Veluswamy and A S L K Rao	113
10.	A New Methodology based on Ultrasonic Attenuation to Characterize Dynamically Recrystallized Microstructure in a 15Cr-15Ni-2.2Mo-Ti Modified Austenitic Stainless Steel S Mandal, S Kumar, A Kumar, P V Sivaprasad, I Samajdar, T Jayakumar and Baldev Raj	125
	PROPERTY EVALUATION	
11.	Relationship Between Small Punch Creep Properties and Uniaxial Creep Properties of Chromium Martensitic Steels S-i Komazaki, T Nakata, T Sugimoto and Y Kohno	135
12.	Improvements in High Temperature Properties Based on Creep Fracture Mechanism of Austenitic Stainless Steels  N Shinya, J Kyono and K Laha	147
13.	High Strength Stainless Steels—Temper Rolled A Kyröläinen	163
14.	Microdeformation Behaviour and Damage Mechanisms in Super Duplex Stainless Steels Chai Guocai, Lillbacka Robert and Lin Peng Ru	179
15.	Importance of Crack Tip Stress Shielding Effect on Fatigue Crack Growth Resistance  Y Mutoh	193
16.	High Temperature Fatigue of 316L(N) Stainless Steel K Bhanu Sankara Rao and R Sandhya	205
17.	Nano/Sub-micron Grained Austenitic Stainless Steels S Rajasekhara, L P Karjalainen, A Kyrolainen and P J Ferriera	221

	Contents	xiii
18.	Property Enhancement in Metastable Austenitic Stainless Steels through the Formation of Ultra-fine Grained Austenite and Shear Reversion Pasi Juntunen, Mahesh Somani, Pentti Karjalainen, Devesh Misra and Antero Kyröläinen	235
19.	Microstructure, Mechanical Properties and Residual Stress Distribution in Similar and Dissimilar Stainless Steel Welds  G Madhusudhan Reddy and T Mohandas	257
20.	Characterization of Thermal Properties of a Titanium Modified Austenitic Stainless Steel (Alloy D9) S Raju and E Mohandas	285
21.	Enhancement of Properties of SS 410 Track Forging by Suitable Heat Treatment Sandeep Korantak, R Rajkumar, S Ramsundar, M K Mathur, Parag Ahmedabadi and Vivekanand Kain	303
22.	Influence of Dynamic Strain Ageing on Tensile Strain Energy of Type 316L(N) Austenitic Stainless Steel  E Isaac Samuel, B K Choudhary and K Bhanu Sankara Rao	313
	ALLOY DEVELOPMENT AND APPLICATIONS	
23.	A Perspective on Research and Development in Austenitic Stainless Steels for Fast Breeder Reactor Technology at Kalpakkam Baldev Raj, P Shankar and T Jayakumar	325
24.	Developments in Chrome–Manganese and Low Nickel Austenitic Stainless Steels: Characteristics, Applications and Trends L K Singhal	367
25.	<b>Modern Developments in Stainless Steel Making</b> <i>V Ramaswamy</i>	383
26.	<b>Developments in High Chromium Steels for Advanced Power Plants</b> <i>P J Ennis</i>	397
27.	High Performance Stainless Steels for Critical Engineering Applications M Narayana Rao	407
28	Evolution of Stainless Steels in Nuclear Industry	

417

Farhad Tavassoli

xiv	Contents	
29.	Technological Advances in Refining and Processing of Stainless Steel—a Brief Overview	
	S K Das, S P Mehrotra, and K M Godiwalla	431
30.	Thermochemistry of Stainless Steel Making G Balachandran	453
31.	Stainless Steel Waterlines—A Promising Application	
	P M Balasubramanian and M Ramdas	475
	NDE METHODS	
32.	Non-destructive Evaluation of Steels Using Magnetic Methods $D\ C\ Jiles$	485
33.	Stainless Steels—Fabrication, Quality Control and Non-destructive Testing  N V Wagle	493
	iv v wagie	473
34.	Non-destructive Characterization of Austenitic Stainless Steels T Jayakumar and Anish Kumar	509
35.	Pulsed Electromagnetic Methods for Defect Detection, Stress Measurement and Material Characterization	
	Gui Yun Tian and John W Wilson	521
36.	Enhancing the Capabilities of Eddy Current Techniques for Non-destructive Evaluation of Austenitic Stainless Steels B P C Rao, S Thirunavukkarasu, B Sasi, T Jayakumar and Baldev Raj	539
	B F C Rao, S Intrunavukkarasu, B Sasi, 1 Jayakumar ana Bataev Raj	339
	CORROSION AND SURFACE MODIFICATION	
37.	Sensitization-induced Localized Corrosion in Austenitic Stainless Steels B K Shah	549
38.	Nitrogen Addition and Localized Corrosion Behaviour of Austenitic Stainless Steels	
	U Kamachi Mudali and S Ningshen	561

Corrosion of Stainless Steel in Shallow and Deep Sea Environment

579

R Venkatesan and E S Dwarakadasa

39.

	Contents	χv
40.	Current Issues and Control Strategies to Combat Corrosion Degradation for Austenitic Stainless Steels in Applications using Nitric Acid	<b>5</b> 00
	Vivekanand Kain, K N Adhe, K Chandra and B P Sharma	589
41.	Stress Corrosion Cracking Behaviour of 904L SS and type 317L SS Weld-fusion Zones in Boiling Water Reactor Startup Conditions $VSRaja$	611
42.	Chloride Stress Corrosion Cracking of a Super Duplex Stainless Steel: Role of Nitrite Addition	
	R K Singh Raman and W H Siew	617
43.	Monitoring Early Biofilm Formation in Cooling Water Systems using Electrochemical Probes Made of AISI Type 316 Stainless Steel	
	R P George, P Muraleedharan, R K Dayal and H S Khatak	627
44.	Electrochemical Corrosion Behaviour of Ni- and Mn-free High Nitrogen Stainless Steels	
	S B Arya, V S Raja, A N Tiwari and Y Katada	637
45.	Atmospheric Corrosion Resistance of Stainless Steel in Saline Environment	
	T Nishimura and V Raman	647
46.	Advances in Wear Behaviour of Stainless Steel Modified by Ion Implantation	
	Chenglong Liu and Paul K Chu	659
	About the editors	670
	Author Index	671

673

Subject Index