

Table of Contents

1	Introduction	1
1.1	Need for High Temperature Materials	1
1.2	High Temperature Materials	3
1.3	Historical Development of High Temperature Materials ...	4
2	Design and Manufacture.	9
2.1	Plant Design and Material Selection	9
2.2	Component Manufacture.....	11
2.3	Process Models	14
2.4	Component Life Extension	17
3	Requirements of High Temperature Materials	19
3.1	Environmental Resistance	19
3.1.1	Oxidation	20
3.1.2	Sulphidation.....	22
3.1.3	Salt- and Ash-Deposit Corrosion	22
3.1.4	Carburisation	24
3.2	Erosion	24
3.3	Wear	25
3.4	Mechanical Behaviour	25
3.4.1	Zero Time Deformation	25
3.4.2	Creep	26
3.4.3	Mechanical Fatigue	28
3.4.4	Thermo-Mechanical Fatigue	31
3.4.5	Corrosion-Fatigue.....	32
3.5	Physical Properties	33
4	Increasing Temperature Capability.	35
4.1	Metallic Materials	35

4.1.1	Solid Solution Strengthening	36
4.1.2	Precipitation Strengthening	37
4.1.3	Dispersion Strengthening	39
4.1.4	Grain Size and Grain Boundary Effects.....	39
4.1.5	Environmental Resistance	41
4.2	Ceramic Materials.....	46
4.2.1	Phase Control.....	46
4.2.2	Defect Tolerance	46
4.2.3	Thermal Shock Resistance.....	48
4.3	Composite Materials	49
5	Steels	52
5.1	Ferritic Heat Resistant Materials	52
5.2	Creep Resisting Martensitic Steels.....	54
5.3	Austenitic Steels	58
5.3.1	Corrosion Resistant Austenitic Steels.....	58
5.3.2	High Strength Austenitic Steels.....	62
5.4	Controlled Transformation Stainless Steels	62
6	Cast Iron	64
6.1	Grey Cast Irons	64
6.2	Spheroidal Graphite Irons.....	65
6.3	Austenitic Irons.....	65
7	Nickel Alloys.....	68
7.1	Oxidation and Corrosion Resistant Nickel Alloys	68
7.2	Nickel Superalloys	69
7.2.1	Alloy Composition-Dominated Developments	71
7.2.2	Developments Dependent on Process and Alloy Composition	75
7.2.3	Process Dominated Developments.....	77
8	Cobalt Alloys	83
9	Refractory Metals	86
10	Titanium	90
10.1	Production.....	90
10.2	Alloys	91

10.3 Component Manufacture.....	94
11 Intermetallic Materials	97
11.1 Titanium Aluminides	98
11.2 Nickel Aluminides.....	100
11.3 Iron Aluminides.....	102
11.4 Speculative Intermetallics	102
12 Cermets	104
12.1 Cemented Carbide Cutting Tools	104
12.2 Wear Resistant Coatings.....	106
13 Refractories and Insulating Materials	111
14 Engineering Ceramics.....	115
14.1 Manufacture.....	115
14.2 Properties.....	116
14.3 Alumina	118
14.4 Zirconia.....	119
14.5 Silicon Carbide	121
14.6 Silicon Nitride	123
14.7 Glass Ceramics.....	126
15 High Temperature Composite Materials	127
15.1 Metal Matrix Composites.....	129
15.2 Titanium Matrix Composites	130
15.3 Carbon and Carbon-Carbon Composites	132
15.4 Ceramic Matrix Composites	135
15.5 Intermetallic Matrix Composites	138
16 Coatings for High Temperature Materials	140
16.1 Corrosion/Oxidation Resistant Coatings.....	141
16.2 Thermal Barrier coats	144
References	148
Subject Index	159