Table of contents

Table of content…….…….……..….i
List of Figures…….…..…v
List of Tables…….……..….ix
Preface…….…...…..xi
Chapter-1: Solid Waste Generation and Use in Integrated Steel Plants (ISP)….……....(1-21)
1.1 Global metal production scenario……1
1.2 Metal production techniques and routes……...2
1.3 Pyro-metallurgical method for metal production…….....…3
1.4 Major solid waste generation in Integrated Steel Plants and its utilization……....……..3
1.5 Literature Survey……..…5
1.5.1 Iron ore slime……5
1.5.2 Bottom ash……7
1.5.2.1 Type of boilers and ash characteristics……..…….....8
(a) Fluidized Bed Combustion (FBC) Boiler…….....8
(b) Pulverized Coal Combustion Boiler…….....8
1.5.2.2 Production of bottom ash quantity and use……....9
1.5.2.3 Disposal and environmental problems…….....10
1.5.3 Properties of Iron ore slime and Bottom ash……... 11
1.5.3.1 Microstructure……...……11
1.5.3.2 Composition and physical properties……11
1.5.3.3 Particle size analysis…….……...….13
1.5.3.4 Geotechnical properties of bottom ash compared to sand……...….13
1.5.4 Studies on the applications of iron ore slime……...…15
1.5.5 Studies on the applications of bottom ash…….....…..15
1.5.6 Utilization scenario of bottom ash…….....…18
1.6 Conclusions from literature survey……..…….....18
1.6.1 Detection of unexplored areas for studies……...…….....19
1.6.2 Objective of this study……...……..20
1.7 Plan of work for the present study……..……21
Chapter-2: Characterization of Iron Ore Slime and Bottom Ash……..….(23-43)
2.1 Introduction……...……..23
2.2 Experimental…….……..25
2.2.1 Test Material Procurement…….…..25
2.2.2 Testing Techniques……..…25
2.2.2.1 Physicochemical properties……..25
2.2.2.2 Geotechnical properties……26
2.3 Results and Discussion…….……..28
2.3.1 Physicochemical and mineralogical properties…….…...28
2.3.2 Geotechnical properties……...….31
2.3.2.1. Grain size analysis……....31
2.3.2.2 Compaction behavior……32
2.3.2.3 Shear strength…….……...33
2.3.2.4 California Bearing Ratio (CBR) test…….35
2.3.2.5 Permeability……..36

2.3.2.6 Compressibility and consolidation……....37
2.3.2.7 Bed Filter Suitability……38
2.4 Conclusions……...……...42
Chapter-3: Preparation of Building Bricks from Bottom Ash……..(45-64)
3.1 Introduction……45
3.2 Experimental……..…….48
3.2.1 Materials for test sample preparation……..……48
3.2.2 Procedure for test sample preparation…….……....49
3.2.2.1 Sample preparation and curing…….……....49
3.2.3 Testing of samples…….…...51
3.3 Results and Discussions……..……51
3.3.1 Cold crushing strength……52
3.3.2 Water absorption……..54
3.3.3 Apparent Density……....56
3.3.4 Phase analysis……..56
3.3.5 FT-IR analysis……...……..58
3.3.6 SEM analysis……...60
3.3.7 Tentative bonding mechanism……61
3.4 Conclusions……63
Chapter-4: Preparation of Insulation Bricks from Bottom Ash and Iron Ore Slime..(65-100)
4.1 Introduction……..…65
4.2 Experiments for feasibility study……...…66
4.2.1 Preparation of test samples……..66
4.2.2 Testing methodology of test samples……..67
4.2.3 Results……..…70
4.2.3.1 Cold crushing strength……...…70
4.2.3.2 Apparent porosity……..71
4.2.3.3 Bulk density……..73
4.2.3.4 Thermal conductivity……75
4.2.3.5 SEM analysis……76
4.2.3.6 Phase analysis……...77
4.2.4 Discussions……..79
4.2.5 Optimized method for preparing brick test samples……....81
4.3 Experiments for Insulation brick sample making……..…82
4.3.1 Materials used and their characterization……....82
4.3.2 Preparation of brick samples……....83
4.3.3 Testing methodology……...84
4.4 Results & Discussions……84
4.4.1 Properties of green brick samples……...…84
4.4.2 Properties of fired brick samples……85
4.4.2.1 Effect of firing time……..86
4.4.2.2 Effect of firing temperature……..87
4.4.3 Tentative bonding mechanism……97
4.5 Conclusions……...…….99

Chapter-5:Design and Fabrication of Transferred Arc Plasma (TAP) Furnace for Smelting studies…….…….…….....(101-130)
5.1 Introduction……...101
5.2 Design of transferred arc plasma (TAP) furnace in laboratory…….....103
5.2.1 Selection of transformers……...103
5.2.2 Electrode……..…....104
5.2.3 Electrode holder…….....105
5.2.4 Furnace body and roof……...105
5.2.5 High-temperature electrical connector……..106
5.2.6 Lining……....106
5.2.6.1 Graphite crucible……106
5.2.6.2 Magnesite crucible…….……107
5.2.7 Plasma gas flow control system……109
5.2.8 Sample collector……110
5.3 Fabrication……...….111
5.4 Characterization of TAP furnace……..111
5.4.1 Operation of plasma arc furnace……. …..111
5.4.2 Results and Discussions..……..113
5.4.2.1 Melt Temperature and meltdown time……..…….113
5.4.2.2 Arc length……...……117
5.4.2.3 Energy consumption…….……..120
5.4.2.4 Sound level……122
5.4.2.5 Electrode consumption……..……124
5.4.2.6 Lining life……..……126
5.5 Conclusions……..128
Chapter-6: Smelting of Bottom Ash and Iron Ore Slime in Plasma Arc Furnace….(131-152)
6.1 Introduction…….……..131
6.2. Experimental……134
6.2.1. Raw Materials……...……134
6.2.2 Smelting Furnace…….…..136
6.2.3 Smelting procedure……136
6.3 Results and Discussions..……139
6.3.1 Recovery of major elements in metals…….……139
6.3.1.1 Melting time……...139
6.3.1.2 Reactivity of reductant……...……141
6.3.1.3 Types of arc……...….142
6.3.1.4 Stoichiometric ratio of carbon content……...143
6.3.1.5 Charge form……144
6.3.1.6 Charge layer thickness……145
6.3.1.7 Crucible lining materials……145
6.3.1.8 Effect of reducing agents……146
6.3.2 Tentative mechanism of smelting……..147
6.4 Conclusions……...151

Chapter-7:Economic and Environmental Parameters Under Smelting of Solid Waste in TAP Furnace…….…..(153-175)
7.1 Introduction……..153
7.2 Experimental……156
7.3 Results and Discussions……...157
7.3.1 Economic parameters……157
7.3.1.1 Arc type……..157
7.3.1.2 Crucible material……158
7.3.1.3 Forms of charge material……160
7.3.1.4 Reductant reactivity……160
7.3.1.5 Stoichiometry carbon content……161
7.3.1.6 Charge layer thickness……161
7.3.1.7 Reducing agents……..162
7.3.2 Environmental parameters……163
7.3.2.1 Sound generation……164
7.3.2.2 Dust generation…….. 166
7.3.3 Partitioning of elements recovered in metal, slag and gas……170
7.3.3.1 Arc type…… 170
7.3.3.2 Crucible material……170
7.3.3.3 Charge forms…… 171
7.3.3.4 Reductant reactivity…….. 172
7.3.3.5 Stoichiometry of carbon…… 172
7.4 Conclusions…… 174
Chapter-8: Achievements from the Present Study……...…(177-178)
8.1 Overall Conclusions……177
8.2 Scope for future work……...177
References……..…..(179-190)
Appendices……...….(191-197)
List of publications……...199