

CONTENTS

Synopsis		i
List of Figures		
List of Tables		
List of Symbols		
Chapter		
-	• · · • ·	_
1	Introduction	1 6
	Objectives	7
	Plan of Work	/
2	Review of Literature	8
2.1	Review on Composite Pellets	8
2.1.1	Preparation of composite pellets	9
2.1.1.1	Criteria for binders and cold bonding of pelletization	9
2.1.1.2	Using inorganic binders	11
2.1.1.3	Using organic binders	13
2.1.1.4	Using combined binders	14
2.1.2	Reduction of composite pellets	15
2.1.2.1	Theory of reduction	15
2.1.2.2	Pyrolysis of coal	16
2.1.2.3	Kinetics of carbothermic reduction and gasification reaction	19
2.1.2.4	Brief review on reduction of composite pellets by previous	19
	investigators	
2.1.3	Advantages of composite pellets	27
2.1.4	Prospects of iron ore-coal composite pellets in smelting reduction	27
	processes	
2.2	Review of Smelting Reduction Processes	29
2.2.1	Introduction and historical development	29
2.2.2	Fundamentals of smelting reduction technology	32
2.2.2.1	Concept of smelting reduction process	33
2.2.2.2	Basic principle of smelting reduction	33
2.2.2.3	Pre-reduction and Post-combustion in smelting reduction	34
2.2.2.4	Why is post combustion so important?	37
2.2.3	Foaming slag in smelting reduction processes	37
2.2.4	Classification of smelting reduction processes	38
2.2.4.1	Processes utilizing coal and electricity	38
1.3.4.2	Processes utilizing oxygen and coal	40
2.2.5	Some popular smelting reduction processes	43
2.2.5.1	Corex Process	43
2.2.5.2	Finex Process	45
2.2.5.3	Romelt Process	46
2.2.5.4	DIOS Process	47

2.2.5.5 Hismelt Process 48 2.2.5.7 Ausfron Process 52 2.2.5.8 Redsmelt Process 53 2.2.5.9 Iron Dynamics Process 54 2.2.5.10 Kawasaki Star Process 55 2.2.5.11 Fastmet Process 56 2.2.5.12 ITmk3 (fronmaking Technology Mark-3) Process 58 2.2.6 Smelting reduction processes A comparative study 59 2.2.7 Advantages and limitations of smelting reduction processes 62 2.8 Kinetics of smelting reduction of composite pellets in liquid bath 64 2.9 Kinetics of smelting reduction of composite pellets in liquid bath 64 2.2.9 Kinetics of smelting reduction of composite pellets in liquid bath 64 2.2.9 Kinetics of smelting reduction of composite pellets in liquid bath 64 2.2.9 Kinetics of smelting reduction of composite pellets in liquid bath 64 2.2.10 Concluding Remark 87 3 Mass Balance and Theoretical Calculations 88 3.1 Importance of Mass Balance 90 3.4 Stoichiometric Coal Requirement for Reduction of Iron Oxides				
22.5.7 AISI-DOE Process 52 2.2.5.8 Redsmell Process 53 2.2.5.9 Iron Dynamics Process 54 2.2.5.10 Kawasaki Star Process 55 2.2.5.11 Fastmet Process 56 2.2.5.12 ITmk3 (Ironmaking Technology Mark-3) Process 58 2.2.6 Smelting reduction processes - A comparative study 59 2.2.7 Advantages and limitations of smelting reduction processes 62 2.8 Kinetics of smelting reduction of composite pellets in liquid bath 64 2.9 Kinetics of smelting reduction - A comparative study 76 2.10 Concluding Remark 87 3 Mass Balance and Theoretical Calculations 88 3.1 Importance of Mass Balance 88 3.2 Material Balance Procedure 88 3.3 Development of Mathematical Model for Mass Balance 90 3.4 Stoichiometric Coal Requirement for Reduction of Iron Oxides 98 3.5 Measurement of Degree of Reduction 99 3.5.1 Review of methods for measurement of degree of reduction in composite pellets 108 <		2.2.5.5	HIsmelt Process	48
22.5.8 Redsmelt Process 53 2.2.5.9 Iron Dynamics Process 54 2.2.5.10 Kawasaki Star Process 55 2.2.5.11 Fastmet Process 56 2.2.5.12 ITmk3 (Ironmaking Technology Mark-3) Process 58 2.2.6 Smelting reduction processes A comparative study 59 2.2.7 Advantages and limitations of smelting reduction processes 62 2.2.8 Kinetics of smelting reduction A comparative study 76 2.2.10 Concluding Remark 87 3 Mass Balance and Theoretical Calculations 88 3.1 Importance of Mass Balance 89 3.3 Development of Mathematical Model for Mass Balance 90 3.4 Stoichiometric Coal Requirement for Reduction of Iron Oxides 98 3.5 Measurement of Degree of Reduction 99 3.5.1 Review of methods for measurement of degree of reduction in composite pellets 108 4.1 Characterization and preparation of Raw Materials 109 4.1.1 Size analysis 109 4.1.2 Briquette / Pellet preparation 113 4.2.		2.2.5.6	AusIron Process	50
2.2.5.9Iron Dynamics Process542.2.5.10Kawasaki Star Process552.2.5.11Fastmet Process562.2.5.12ITmk3 (Ironmaking Technology Mark-3) Process582.2.6Smelting reduction processes - A comparative study592.2.7Advantages and limitations of smelting reduction processes622.8Kinetics of smelting reduction of composite pellets in liquid bath642.2.9Kinetics of smelting reduction of composite pellets in liquid bath642.2.9Kinetics of smelting reduction of composite pellets in liquid bath642.2.9Kinetics of smelting reduction of composite pellets in liquid bath643Mass Balance and Theoretical Calculations883.1Importance of Mass Balance893.2Material Balance Procedure893.3Development of Mathematical Model for Mass Balance903.4Stoichiometric Coal Requirement for Reduction of Iron Oxides983.5Measurement of Degree of Reduction in composite pellets994.1Characterization and preparation of Raw Materials1084.1.1Size analysis of raw materials1094.1.2Briquette / Pellet preparation1134.2.1Pellet preparation1134.2.2Pellet preparation1134.2.3Microstructural observation of dry composite pellets1154.3Testing results of pellets1164.3.1Density of pellets1164.3.2Porsity o		2.2.5.7	AISI-DOE Process	52
2.2.5.10 Kawasaki Star Process 55 2.2.5.11 Fastmet Process 56 2.2.5.12 ITmk3 (Ironmaking Technology Mark-3) Process 58 2.2.6 Smelting reduction processes - A comparative study 59 2.2.7 Advantages and limitations of smelting reduction processes 62 2.2.8 Kinetics of smelting reduction of composite pellets in liquid bath 64 2.2.9 Kinetics of smelting reduction A comparative study 76 2.10 Concluding Remark 87 3 Mass Balance and Theoretical Calculations 88 3.1 Importance of Mass Balance 89 3.2 Material Balance Procedure 89 3.3 Development of Mathematical Model for Mass Balance 90 3.4 Stoichiometric Coal Requirement for Reduction of Iron Oxides 98 3.5 Measurement of Degree of Reduction 99 3.6.1 Review of methods for measurement of degree of reduction in composite pellets 108 4.1 Characterization and preparation of Raw Materials 108 4.1.1 Size analysis of raw materials 109 4.1.3 Microstructural observat		2.2.5.8	Redsmelt Process	53
2.2.5.10 Kawasaki Star Process 55 2.2.5.11 Fastmet Process 56 2.2.5.12 ITmk3 (Ironmaking Technology Mark-3) Process 58 2.2.6 Smelting reduction processes - A comparative study 59 2.2.7 Advantages and limitations of smelting reduction processes 62 2.2.8 Kinetics of smelting reduction of composite pellets in liquid bath 64 2.2.9 Kinetics of smelting reduction A comparative study 76 2.2.10 Concluding Remark 87 3 Mass Balance and Theoretical Calculations 88 3.1 Importance of Mass Balance 89 3.2 Material Balance Procedure 89 3.3 Development of Mathematical Model for Mass Balance 90 3.4 Stoichiometric Coal Requirement for Reduction of Iron Oxides 98 3.5 Measurement of Degree of Reduction 99 3.5.1 Review of methods for measurement of degree of reduction in composite pellets 108 4.1 Characterization and preparation of Raw Materials 109 4.1.3 Microstructural observation of Ray composite pellets 113 4.1 Ch		2.2.5.9	Iron Dynamics Process	54
2.2.5.12 ITmk3 (Ironmaking Technology Mark-3) Process 58 2.2.6 Smelting reduction processes A comparative study 59 2.2.7 Advantages and limitations of smelting reduction processes 62 2.8 Kinetics of smelting reduction of composite pellets in liquid bath 64 2.2.9 Kinetics of smelting reduction A comparative study 76 2.2.10 Concluding Remark 87 3 Mass Balance and Theoretical Calculations 88 3.1 Importance of Mass Balance 88 3.2 Material Balance Procedure 89 3.4 Stoichiometric Coal Requirement for Reduction of Iron Oxides 98 3.5 Measurement of Degree of Reduction 99 3.5.1 Review of methods for measurement of degree of reduction in composite pellets 99 4 Experimental Work 108 4.1.1 Characterization and preparation of Raw Materials 109 4.1.2 Chemical analysis of raw materials 109 4.1.3 Microstructural observation (SEM) of raw materials 112 4.2 Briquette preparation 113 4.2.1 Briquette preparation </td <td></td> <td>2.2.5.10</td> <td>Kawasaki Star Process</td> <td>55</td>		2.2.5.10	Kawasaki Star Process	55
2.2.6 Smelting reduction processes - A comparative study 59 2.2.7 Advantages and limitations of smelting reduction processes 62 2.2.8 Kinetics of smelting reduction - A comparative study 76 2.9 Kinetics of smelting reduction - A comparative study 76 2.2.9 Kinetics of smelting reduction - A comparative study 76 2.2.10 Concluding Remark 87 3 Mass Balance and Theoretical Calculations 88 3.1 Importance of Mass Balance 89 3.2 Material Balance Procedure 89 3.3 Development of Mathematical Model for Mass Balance 90 3.4 Stoichiometric Coal Requirement for Reduction of Iron Oxides 98 3.5.1 Review of methods for measurement of degree of reduction in composite pellets 99 4 Experimental Work 108 101 4.1.1 Characterization and preparation of Raw Materials 103 4.1.2 Chemical analysis of raw materials 109 4.1.3 Microstructural observation (SEM) of raw materials 112 4.2 Briquette preparation 113 4.2.1 <td< td=""><td></td><td>2.2.5.11</td><td>Fastmet Process</td><td>•</td></td<>		2.2.5.11	Fastmet Process	•
2.2.6 Smelting reduction processes - A comparative study 59 2.2.7 Advantages and limitations of smelting reduction processes 62 2.2.8 Kinetics of smelting reduction - A comparative study 76 2.9 Kinetics of smelting reduction - A comparative study 76 2.2.9 Kinetics of smelting reduction - A comparative study 76 2.2.10 Concluding Remark 87 3 Mass Balance and Theoretical Calculations 88 3.1 Importance of Mass Balance 89 3.2 Material Balance Procedure 89 3.3 Development of Mathematical Model for Mass Balance 90 3.4 Stoichiometric Coal Requirement for Reduction of Iron Oxides 98 3.5.1 Review of methods for measurement of degree of reduction in composite pellets 99 4 Experimental Work 108 101 4.1.1 Characterization and preparation of Raw Materials 103 4.1.2 Chemical analysis of raw materials 109 4.1.3 Microstructural observation (SEM) of raw materials 112 4.2 Briquette preparation 113 4.2.1 <td< td=""><td></td><td>2.2.5.12</td><td>ITmk3 (Ironmaking Technology Mark-3) Process</td><td>58</td></td<>		2.2.5.12	ITmk3 (Ironmaking Technology Mark-3) Process	58
2.2.7 Advantages and limitations of smelting reduction processes 62 2.2.8 Kinetics of smelting reduction of composite pellets in liquid bath 64 2.2.9 Kinetics of smelting reduction - A comparative study 76 2.2.10 Concluding Remark 87 3 Mass Balance and Theoretical Calculations 88 3.1 Importance of Mass Balance 88 3.2 Material Balance Procedure 89 3.3 Development of Mathematical Model for Mass Balance 90 3.4 Stoichiometric Coal Requirement for Reduction of Iron Oxides 98 3.5 Measurement of Degree of Reduction 99 3.5.1 Review of methods for measurement of degree of reduction in composite pellets 108 4.1 Characterization and preparation of Raw Materials 108 4.1.1 Size analysis of raw materials 109 4.1.2 Chemical analysis of raw materials 109 4.1.3 Microstructural observation (SEM) of raw materials 113 4.2.2 Pellet preparation 113 4.2.2 Pellet preparation 113 4.3.1 Density of pellets 116<		2.2.6		59
2.2.8 Kinetics of smelting reduction of composite pellets in liquid bath 64 2.2.9 Kinetics of smelting reduction A comparative study 76 2.2.10 Concluding Remark 87 3 Mass Balance and Theoretical Calculations 88 3.1 Importance of Mass Balance 88 3.2 Material Balance Procedure 89 3.3 Development of Mathematical Model for Mass Balance 90 3.4 Stoichiometric Coal Requirement for Reduction of Iron Oxides 98 3.5 Measurement of Degree of Reduction 99 3.5.1 Review of methods for measurement of degree of reduction in composite pellets 108 4.1 Characterization and preparation of Raw Materials 108 4.1.1 Size analysis of raw materials 109 4.1.2 Briquette / Pellet preparation 113 4.2.1 Briquette / Pellet preparation 113 4.2.2 Briquette / Pellet preparation 113 4.2.3 Microstructural observation of dry composite pellets 115 4.3 Testing of Briquettes / Pellets 116 4.3.1 Density of pellets 116				
2.2.9Kinetics of smelting reduction - A comparative study762.2.10Concluding Remark873Mass Balance and Theoretical Calculations883.1Importance of Mass Balance883.2Material Balance Procedure893.3Development of Mathematical Model for Mass Balance903.4Stoichiometric Coal Requirement for Reduction of Iron Oxides983.5Measurement of Degree of Reduction993.5.1Review of methods for measurement of degree of reduction in composite pellets1084.1Characterization and preparation of Raw Materials1084.1.1Size analysis1094.1.2Chemical analysis of raw materials1094.1.3Microstructural observation (SEM) of raw materials1134.2.1Briquette Preparation1134.2.2Pellet preparation1134.2.3Microstructural observation of dry composite pellets1154.3Testing of Briquettes / Pellets1164.3.1Density of pellets1174.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of priquettes1234.4Flow rate of argon gas1234.5Induction furnace1234.5.1Principle of induction furnace1234.5.5Mould preparation124				
2.2.10Concluding Remark873Mass Balance and Theoretical Calculations883.1Importance of Mass Balance883.2Material Balance Procedure893.3Development of Mathematical Model for Mass Balance903.4Stoichiometric Coal Requirement for Reduction of Iron Oxides983.5Measurement of Degree of Reduction993.6Measurement of Degree of Reduction993.7Review of methods for measurement of degree of reduction in composite pellets1084Experimental Work1084.1Characterization and preparation of Raw Materials1094.1.2Chemical analysis of raw materials1094.1.3Microstructural observation (SEM) of raw materials1124.2Briquette / Pellet preparation1134.2.1Briquette preparation1134.2.2Pellet preparation1134.2.3Microstructural observation of dry composite pellets1154.3Testing of Briquettes / Pellets1164.3.1Density of pellets1164.3.2Porosity of pellets1174.3.3Strength properties of briquettes / pellets1224.4Flow rate of argon gas1234.5Induction furnace1234.5.1Principle of induction furnace1234.5.2Theory of induction furnace1264.5.5Mould preparation128				
3.1Importance of Mass Balance883.2Material Balance Procedure893.3Development of Mathematical Model for Mass Balance903.4Stoichiometric Coal Requirement for Reduction of Iron Oxides983.5Measurement of Degree of Reduction993.5.1Review of methods for measurement of degree of reduction in composite pellets994Experimental Work1084.1Characterization and preparation of Raw Materials1094.1.2Chemical analysis of raw materials1094.1.3Microstructural observation (SEM) of raw materials1124.2Briquette / Pellet preparation1134.2.1Briquette preparation1134.2.2Pellet preparation1134.3.1Density of pellets1164.3.2Porosity of pellets1164.3.3Testing of Briquettes / Pellets1164.3.4Flow rate of argon gas1234.5Induction furnace1234.5Induction furnace1234.5.5Mould preparation123				
3.1Importance of Mass Balance883.2Material Balance Procedure893.3Development of Mathematical Model for Mass Balance903.4Stoichiometric Coal Requirement for Reduction of Iron Oxides983.5Measurement of Degree of Reduction993.5.1Review of methods for measurement of degree of reduction in composite pellets994Experimental Work1084.1Characterization and preparation of Raw Materials1094.1.2Chemical analysis of raw materials1094.1.3Microstructural observation (SEM) of raw materials1124.2Briquette / Pellet preparation1134.2.1Briquette preparation1134.2.2Pellet preparation1134.3.1Density of pellets1164.3.2Porosity of pellets1164.3.3Testing of Briquettes / Pellets1164.3.4Flow rate of argon gas1234.5Induction furnace1234.5Induction furnace1234.5.5Mould preparation123		3	Mass Balance and Theoretical Calculations	88
3.2Material Balance Procedure893.3Development of Mathematical Model for Mass Balance903.4Stoichiometric Coal Requirement for Reduction of Iron Oxides983.5Measurement of Degree of Reduction993.5.1Review of methods for measurement of degree of reduction in composite pellets994Experimental Work1084.1Characterization and preparation of Raw Materials1084.1.1Size analysis1094.1.2Chemical analysis of raw materials1094.1.3Microstructural observation (SEM) of raw materials1124.2Briquette / Pellet preparation1134.2.1Briquette preparation1134.2.2Pellet preparation1134.2.3Microstructural observation of dry composite pellets1164.3.1Density of pellets1164.3.2Porosity of pellets1164.3.3Testing results of briquettes / pellets1194.3.3.1Testing results of briquettes1204.3.3.2Testing results of pellets1224.4Flow rate of argon gas1234.5Induction furnace1234.5.2Theory of induction furnace1234.5.4Lining of induction furnace1274.5.5Mould preparation128				
3.3Development of Mathematical Model for Mass Balance903.4Stoichiometric Coal Requirement for Reduction of Iron Oxides983.5Measurement of Degree of Reduction993.5.1Review of methods for measurement of degree of reduction in composite pellets994Experimental Work1084.1Characterization and preparation of Raw Materials1084.1.1Size analysis1094.1.2Chemical analysis of raw materials1094.1.3Microstructural observation (SEM) of raw materials1124.2Briquette / Pellet preparation1134.2.1Briquette preparation1134.2.2Pellet preparation1134.2.3Microstructural observation of dry composite pellets1154.3Testing of Briquettes / Pellets1164.3.1Density of pellets1164.3.2Porosity of pellets1174.3.3Strength properties of briquettes / pellets1124.4Flow rate of argon gas1234.5Induction furnace1234.5.1Principle of induction furnace1234.5.2Theory of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace128				
3.4Stoichiometric Coal Requirement for Reduction of Iron Oxides983.5Measurement of Degree of Reduction993.5.1Review of methods for measurement of degree of reduction in composite pellets994Experimental Work1084.1Characterization and preparation of Raw Materials1084.1.1Size analysis1094.1.2Chemical analysis of raw materials1094.1.3Microstructural observation (SEM) of raw materials1124.2Briquette / Pellet preparation1134.2.1Briquette preparation1134.2.2Pellet preparation1134.2.3Microstructural observation of dry composite pellets1164.3.1Density of pellets1164.3.2Porosity of pellets1174.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of priquettes1224.4Flow rate of argon gas1234.5.1Principle of induction furnace1234.5.2Theory of induction furnace1264.5.3Advantages of induction furnace1264.5.4Lining of induction furnace128				
3.5Measurement of Degree of Reduction993.5.1Review of methods for measurement of degree of reduction in composite pellets994Experimental Work1084.1Characterization and preparation of Raw Materials1084.1.1Size analysis1094.1.2Chemical analysis of raw materials1094.1.3Microstructural observation (SEM) of raw materials1124.2Briquette / Pellet preparation1134.2.1Briquette preparation1134.2.2Pellet preparation1134.2.3Microstructural observation of dry composite pellets1164.3.1Density of pellets1164.3.2Porosity of pellets1174.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of pellets1224.4Flow rate of argon gas1234.5Induction furnace1234.5.2Theory of induction furnace1234.5.3Advantages of induction furnace1264.5.4Lining of induction furnace1274.5.4Lining of induction furnace128				
3.5.1Review of methods for measurement of degree of reduction in composite pellets994Experimental Work1084.1Characterization and preparation of Raw Materials1084.1.1Size analysis1094.1.2Chemical analysis of raw materials1094.1.3Microstructural observation (SEM) of raw materials1124.2Briquette / Pellet preparation1134.2.1Briquette / Pellet preparation1134.2.2Pellet preparation1134.2.3Microstructural observation of dry composite pellets1154.3Testing of Briquettes / Pellets1164.3.1Density of pellets1174.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of briquettes1224.4Flow rate of argon gas1234.5.1Principle of induction furnace1234.5.2Theory of induction furnace1264.5.3Advantages of induction furnace1264.5.4Lining of induction furnace1284.5.5Mould preparation128			•	
4Experimental Work1084.1Characterization and preparation of Raw Materials1084.1.1Size analysis1094.1.2Chemical analysis of raw materials1094.1.3Microstructural observation (SEM) of raw materials1124.2Briquette / Pellet preparation1134.2.1Briquette / Pellet preparation1134.2.2Pellet preparation1134.2.3Microstructural observation of dry composite pellets1154.3Testing of Briquettes / Pellets1164.3.1Density of pellets1164.3.2Porosity of pellets1174.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of briquettes1204.3.2.2Testing results of pellets1234.5.1Principle of induction furnace1234.5.2Theory of induction furnace1234.5.3Advantages of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128				
4Experimental Work1084.1Characterization and preparation of Raw Materials1084.1.1Size analysis1094.1.2Chemical analysis of raw materials1094.1.3Microstructural observation (SEM) of raw materials1124.2Briquette / Pellet preparation1134.2.1Briquette preparation1134.2.2Pellet preparation1134.2.3Microstructural observation of dry composite pellets1154.3Testing of Briquettes / Pellets1164.3.1Density of pellets1174.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of pellets1204.3.3.2Testing results of pellets1224.4Flow rate of argon gas1234.5Induction furnace1234.5.1Principle of induction furnace1234.5.2Theory of induction furnace1234.5.3Advantages of induction furnace1264.5.5Mould preparation128		5.5.1		77
4.1Characterization and preparation of Raw Materials1084.1.1Size analysis1094.1.2Chemical analysis of raw materials1094.1.3Microstructural observation (SEM) of raw materials1124.2Briquette / Pellet preparation1134.2.1Briquette preparation1134.2.2Pellet preparation1134.2.3Microstructural observation of dry composite pellets1154.3Testing of Briquettes / Pellets1164.3.1Density of pellets1164.3.2Porosity of pellets1174.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of pellets1204.3.2.2Testing results of pellets1234.5Induction Furnace1234.5Induction furnace1234.5.1Principle of induction furnace1234.5.2Theory of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128				
4.1.1Size analysis1094.1.2Chemical analysis of raw materials1094.1.3Microstructural observation (SEM) of raw materials1124.2Briquette / Pellet preparation1134.2.1Briquette preparation1134.2.2Pellet preparation1134.2.3Microstructural observation of dry composite pellets1154.3Testing of Briquettes / Pellets1164.3.1Density of pellets1164.3.2Porosity of pellets1174.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of briquettes1204.3.3.2Testing results of pellets1224.4Flow rate of argon gas1234.5Induction furnace1234.5.2Theory of induction furnace1234.5.3Advantages of induction furnace1264.5.4Lining of induction furnace1284.5.5Mould preparation128		4	Experimental Work	108
4.1.2Chemical analysis of raw materials1094.1.3Microstructural observation (SEM) of raw materials1124.2Briquette / Pellet preparation1134.2.1Briquette preparation1134.2.2Pellet preparation1134.2.3Microstructural observation of dry composite pellets1154.3Testing of Briquettes / Pellets1164.3.1Density of pellets1164.3.2Porosity of pellets1174.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of briquettes1204.3.3.2Testing results of pellets1224.4Flow rate of argon gas1234.5Induction Furnace1234.5.2Theory of induction furnace1234.5.3Advantages of induction furnace1264.5.4Lining of induction furnace1284.5.5Mould preparation128		4.1	Characterization and preparation of Raw Materials	108
4.1.3Microstructural observation (SEM) of raw materials1124.2Briquette / Pellet preparation1134.2.1Briquette preparation1134.2.2Pellet preparation1134.2.3Microstructural observation of dry composite pellets1154.3Testing of Briquettes / Pellets1164.3.1Density of pellets1164.3.2Porosity of pellets1174.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of briquettes1204.3.3.2Testing results of pellets1234.5Induction Furnace1234.5.1Principle of induction furnace1234.5.2Theory of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128		4.1.1	Size analysis	109
4.2Briquette / Pellet preparation1134.2.1Briquette preparation1134.2.2Pellet preparation1134.2.3Microstructural observation of dry composite pellets1154.3Testing of Briquettes / Pellets1164.3.1Density of pellets1164.3.2Porosity of pellets1174.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of briquettes1204.3.3.2Testing results of pellets1224.4Flow rate of argon gas1234.5Induction Furnace1234.5.1Principle of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128		4.1.2	Chemical analysis of raw materials	109
4.2.1Briquette preparation1134.2.2Pellet preparation1134.2.3Microstructural observation of dry composite pellets1154.3Testing of Briquettes / Pellets1164.3.1Density of pellets1164.3.2Porosity of pellets1174.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of briquettes1204.3.3.2Testing results of pellets1224.4Flow rate of argon gas1234.5Induction Furnace1234.5.1Principle of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128		4.1.3	Microstructural observation (SEM) of raw materials	112
4.2.2Pellet preparation1134.2.3Microstructural observation of dry composite pellets1154.3Testing of Briquettes / Pellets1164.3.1Density of pellets1164.3.2Porosity of pellets1174.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of briquettes1204.3.3.2Testing results of pellets1224.4Flow rate of argon gas1234.5Induction Furnace1234.5.1Principle of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128		4.2	Briquette / Pellet preparation	113
4.2.3Microstructural observation of dry composite pellets1154.3Testing of Briquettes / Pellets1164.3.1Density of pellets1164.3.2Porosity of pellets1174.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of briquettes1204.3.3.2Testing results of pellets1224.4Flow rate of argon gas1234.5Induction Furnace1234.5.1Principle of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128		4.2.1	Briquette preparation	113
4.3Testing of Briquettes / Pellets1164.3.1Density of pellets1164.3.2Porosity of pellets1174.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of briquettes1204.3.3.2Testing results of pellets1224.4Flow rate of argon gas1234.5Induction Furnace1234.5.1Principle of induction furnace1234.5.2Theory of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128		4.2.2	Pellet preparation	113
4.3Testing of Briquettes / Pellets1164.3.1Density of pellets1164.3.2Porosity of pellets1174.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of briquettes1204.3.3.2Testing results of pellets1224.4Flow rate of argon gas1234.5Induction Furnace1234.5.1Principle of induction furnace1234.5.2Theory of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128		4.2.3		115
4.3.1Density of pellets1164.3.2Porosity of pellets1174.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of briquettes1204.3.3.2Testing results of pellets1224.4Flow rate of argon gas1234.5Induction Furnace1234.5.1Principle of induction furnace1234.5.2Theory of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128		4.3		116
4.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of briquettes1204.3.3.2Testing results of pellets1224.4Flow rate of argon gas1234.5Induction Furnace1234.5.1Principle of induction furnace1234.5.2Theory of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128		4.3.1	Density of pellets	116
4.3.3Strength properties of briquettes / pellets1194.3.3.1Testing results of briquettes1204.3.3.2Testing results of pellets1224.4Flow rate of argon gas1234.5Induction Furnace1234.5.1Principle of induction furnace1234.5.2Theory of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128		4.3.2		117
4.3.3.1Testing results of briquettes1204.3.3.2Testing results of pellets1224.4Flow rate of argon gas1234.5Induction Furnace1234.5.1Principle of induction furnace1234.5.2Theory of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128				
4.3.3.2Testing results of pellets1224.4Flow rate of argon gas1234.5Induction Furnace1234.5.1Principle of induction furnace1234.5.2Theory of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128		4.3.3.1		
4.4Flow rate of argon gas1234.5Induction Furnace1234.5.1Principle of induction furnace1234.5.2Theory of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128				
4.5Induction Furnace1234.5.1Principle of induction furnace1234.5.2Theory of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128				
4.5.1Principle of induction furnace1234.5.2Theory of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128		4.5		
4.5.2Theory of induction furnace1264.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128		4.5.1		
4.5.3Advantages of induction furnace1274.5.4Lining of induction furnace1284.5.5Mould preparation128	~			
4.5.4Lining of induction furnace1284.5.5Mould preparation128				
4.5.5 Mould preparation 128				
			• •	
	·	-	- -	

.

. . xi

4.6.1	Pyrolysis of coal Non-isothermal studies of iron ore-coal	129
4.6.2 4.6.3	composite pellets Kinetics of smelting of composite pellets in an induction furnace	129 130
4.6.4	Bulk dissolution of composite pellets and iron recovery	130
4.7	Scanning Electron Microscopy (SEM) and EDAX Analysis	132
4.8	X-ray Diffraction (XRD) Studies	132
4.9	Energy Dispersive X-ray Fluorescence (XRF) Spectrometer	134
4.10	Chemical Analysis Using Optical Emission Spectrometer (OES)	134
5	Results and Discussion on TG-DTA	136
5.1	Introduction to Thermal Analysis	136
5.2	Results and Discussion for Pyrolysis of Coal	137
5.3	Results and Discussion on Iron Ore-Coal Composite Pellets	141
5.3.1	Degree of reduction for composite pellet	144
5.4	Kinetic analysis of non-isothermal reduction of composite pellets	153
6	Results and Discussion on Smelting Reduction	156
6.1	Visual Observation of Dissolution Behaviour of a Single Pellet	157
6.2	Kinetics of composite pellets during smelting	157
6.2.1	Results for dissolution of composite pellets in liquid metal bath	163
6.3	Bulk dissolution of composite pellets in smelting reduction and iron recovery	163
6.3.1	Chemical Analysis	164
6.3.2	Mass balance	166
6.4	X-ray Diffraction (XRD) studies of reduced pellets	166
6.5	Scanning Electron Microscopic (SEM) examination of reduced pellets	168
7	Summary and Conclusions	171
7.1	Summary of Studies	171
7.2	Conclusions	179
7.3	Suggestions for Further Work	183
	References Appendix	185 201