

## List of Figures

Figure 1.1: Effective separation range of mineral processing techniques[18].....	7
Figure 2.1: Typical size ranges for beneficiation methods .....	28
Figure 2.2: Flow diagram of iron ore-coal composite briquette .....	36
Figure 2.3 : Thermogravimetric curves, TGA (-----) and DTG (—), of carbonization of coal and coal/iron oxide mixtures, A - coal; B - Coal + Fe <sub>3</sub> O <sub>4</sub> (30 wt pct ); C - Coal + Fe <sub>2</sub> O <sub>3</sub> (30 wt pct).....	45
Figure 2.4: Classification of ironmaking processes .....	48
Figure 3.1: As received ROM iron ore sample (O) Banded iron ore in pebble shape and sample (R-1 and 2) as rock ore .....	53
Figure 3.2: Prepared sample slide for polarized microscopy observation .....	56
Figure 3.3: Photo micrographs of iron ores by polarized microscopes (100X); phases (colour) - hematite (black), goethite (brown) and quartz (white) .....	57
Figure 3.4: Photo micrographs of iron ores by reflected (stereo and conventional) microscopes (Left-10X and Right-50X); iron bearing minerals interlocked with fine sized gangue minerals .....	58
Figure 3.5: XRD graph of Odisha ore (sample-O).....	60
Figure 3.6: XRD graph of Rajasthan ore (R-1).....	61
Figure 3.7: XRD graph of Rajasthan ore (R-2).....	62
Figure 3.8: SEM photographs of raw iron ore Odisha sample-O at 50X and100X; highly interlocked minerals observed with significant amount of pores.....	63
Figure 3.9: SEM photographs of raw iron ore R-1 sample at 50X and100X; micro-cracks and fine particles of gangue mineral revealed at 100X.....	64
Figure 3.10: SEM photographs of raw iron ore R-2 sample at 50X and100X; quartz (black colour) distributed evenly in ore .....	64
Figure 3.11: EDS analysis of Odisha sample; grey portion indicate iron bearing minerals	65
Figure 3.12: EDS analysis of R-1 sample; black coloured fine sized particle of quartz mineral.....	65
Figure 3.13: EDS analysis of R-2 sample; segregation of minerals in cavity.....	66
Figure 3.14: Flow sheet of two stage beneficiation for Odisha ore .....	72
Figure 3.15: Iron recovery by beneficiation operations .....	73
Figure 3.16: XRD graph for roasted ore at 873 K .....	77

Figure 3.17: XRD graph for roasted ore at 1173 K .....	78
Figure 3.18: Flow sheet for beneficiation of Rajasthan ore .....	82
Figure 3.19: Comparison of carbonaceous material on recovery .....	82
Figure 4.1: Flow diagram for composite briquette making.....	86
Figure 4.2: Tube Furnace .....	88
Figure 4.3: Temperature profile of tube furnace.....	90
Figure 4.4: Isothermally reduced composite briquette.....	90
Figure 4.5: Induction furnace.....	94
Figure 4.6: Dried mould - ready for pouring.....	95
Figure 5.1: fraction of reduction vs time plot at 1223 K, AA .....	100
Figure 5.2: fraction of reduction vs time plot at 1273 K, AA.....	101
Figure 5.3: fraction of reduction vs time plot at 1323 K, AA.....	101
Figure 5.4: Arrhenius plot for Composite briquette AA .....	102
Figure 5.5: fraction of reduction vs time plot at 1223 K, AB .....	103
Figure 5.6: fraction of reduction vs time plot at 1273 K, AB .....	104
Figure 5.7: fraction of reduction vs time plot at 1323 K, AB .....	104
Figure 5.8: Arrhenius plot for Composite briquette AB .....	105
Figure 5.9: fraction of reduction vs time plot at 1223 K, BA .....	107
Figure 5.10: fraction of reduction vs time plot at 1273 K, BA .....	107
Figure 5.11: fraction of reduction vs time plot at 1323 K, BA .....	108
Figure 5.12: Arrhenius plot for Composite briquette BA .....	109
Figure 5.13: fraction of reduction vs time plot at 1223 K, BB .....	111
Figure 5.14: fraction of reduction vs time plot at 1273 K, BB .....	111
Figure 5.15: fraction of reduction vs time plot at 1323 K, BB .....	112
Figure 5.16: Arrhenius plot for Composite briquette BB .....	112
Figure 5.17: XRD graph of composite briquette AA.....	115
Figure 5.18: XRD plot of composite briquette AB .....	116
Figure 5.19: XRD plot of Composite briquette BA .....	117
Figure 5.20: XRD plot of composite briquette BB .....	118
Figure 5.21: SEM images of reduced composite briquette .....	119
Figure 5.22: Simultaneous thermal analysis of AA composite briquette.....	120
Figure 5.23: Simultaneous thermal analysis of AB composite briquette.....	121
Figure 5.24: Simultaneous thermal analysis of BA composite briquette.....	121
Figure 5.25: Simultaneous thermal analysis of BB composite briquette .....	122

Figure 5.26: Arrhenius plot for non isothermal reduction - AA composite briquette.....	124
Figure 5.27: Arrhenius plot for non isothermal reduction - AB composite briquette.....	124
Figure 5.28: Arrhenius plot for non isothermal reduction - BA composite briquette.....	125
Figure 5.29: Arrhenius plot for non isothermal reduction - BB composite briquette.....	125
Figure 5.30: Microstructure of steel structure.....	131