Table 1. Chemical compositions of HAMS /wt %

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| TFe | TMn | MFe | MgO | Al2O3 | CaO | SiO2 | S | P | Mn/Fe | P/Mn |
| 6.15 | 53.48 | 1.91 | 0.64 | 13.21 | 0.90 | 6.79 | 0.058 | 0.10 | 8.7 | 0.0019 |

Table 2. Experimental scheme for the smelting separations of HAMO

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameters | Variation Levels | | | | | | | |
| Smelting temperature /℃ | 1450 | | 1500 | | 1525 | | 1550 | |
| Smelting FC/O /- | 0.7 | | 0.9 | | 1.1 | | 1.3 | |
| Smelting time /min | 15 | 30 | | 45 | | 60 | | 90 |
| Smelting CaO/(SiO2+Al2O3) /- | 0.4 | 0.5 | | 0.6 | | 0.70 | | 0.80 |

Table 3. The reduction reaction of the Mn-Fe ore based on the following equation

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Reaction equation | NO. | Reaction equation | NO. | Reaction equation | NO. |
| 2MnO2+C=Mn2O3+CO | 2 | 3Mn2O3+C=2Mn3O4+CO | 3 | Mn3O4+C=3MnO+CO | 4 |
| MnO+C=Mn+CO | 5 | 3MnO+C=Mn3C+3CO | 6 | 3Fe2O3+C=2Fe3O4+CO | 7 |
| Fe3O4+C=3FeO+CO | 8 | FeO+C=Fe+CO | 9 | 2MnO2+CO=Mn2O3+CO2 | 10 |
| 3Mn2O3+CO=2Mn3O4+CO2 | 11 | Mn3O4+CO=3MnO+CO2 | 12 | MnO+CO=Mn+CO2 | 13 |
| C+CO2=2CO | 14 | FeO+CO=Fe+CO2 | 15 | Fe3O4+4CO=3Fe+4CO2 | 16 |
| Fe3O4+CO=3FeO+CO2 | 17 | 3Fe2O3+CO=2Fe3O4+CO2 | 18 | 7Mn+3C=Mn7C3 | 19 |
| 3Mn+C=Mn3C | 20 | Mn+2Mn7C3=3Mn5C2 | 21 | 5Mn+2Mn5C2=Mn15C4 | 22 |
| 8Mn+3Mn5C2=Mn23C6 | 23 | 7MnO+10C=Mn7C3+7CO | 24 | 3MnO+4C=Mn3C+3CO | 25 |
| 3Mn7C3+37CO2=7Mn3O4+46CO | 26 | Mn3C+4CO2=3MnO+5CO | 27 | Mn7C3+3CO2=7Mn+6CO | 28 |
| Mn3C+CO2=3Mn+2CO | 29 | Mn+CO2=MnO+CO | 30 | Mn7C3+3MnO=10Mn+3CO | 31 |
| 4Mn7C3+3Mn3O4=37Mn+12CO | 32 | Mn3C+MnO=4Mn+CO | 33 | 4Mn3C+Mn3O4=15Mn+4CO | 34 |

Table 4. Chemical composition of the ferromanganese alloy (wt %)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Elements | Mn | C | Si | | P | | S |
| I | II | I | II |
| FeMn78C8.0 | 75.0~82.0 | 8.0 | 1.5 | 2.5 | 0.20 | 0.33 | 0.03 |
| FeMn74C7.5 | 70.0~77.0 | 7.5 | 2.0 | 3.0 | 0.25 | 0.38 | 0.03 |
| FeMn68C7.0 | 65.0~72.0 | 7.0 | 2.5 | 4.5 | 0.25 | 0.40 | 0.03 |
| HCFeMn alloy | 76.76 | 6.73 | 0.17 | | 0.14 | | 0.008 |