§7. The Influence of Microwaves on Residual Impurities during Pig Iron Production

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The application of high power microwaves is a promising, energy efficient alternative to the traditional ohmic heating. Furthermore, microwaves in material sciences are facing growing interest, in particular for processing of microscopic systems at strong thermal non-equilibrium. The application of microwaves in the iron industry may be characterized by a high potential for an essential reduction of carbon dioxide emission. A series of microwave experiments have been conducted to prove the effectiveness of rapid and high purity refinement of iron ores under oxygen-containing environment. Very promising results have been achieved. Experiments performed at 2.45 GHz in nitrogen atmosphere with natural irons ores demonstrate that high purity pig-iron can be produced with less than 1/10 of impurities as compared to pig-iron that modern blast furnaces can produce. Moreover, such a microwave process can reduce the carbon consumption by 1/3. Of course, essential prerequisites for reaching the target of reduced CO_2 emission and for satisfying the needs of steel industry with respect to production capacity are the availability of powerful microwave sources and sufficient supply of electric power which is not based on fossil energy. This motivates further microwave assisted experiments at a frequency of 30 GHz by use of an industrial 15 kW gyrotron system.

For the mm-wave experiments, the applicator of a compact 30 GHz gyrotron system was used. The mm-wave power generated by the gyrotron oscillator can be controlled from 0 - 15 kW in continuous wave (CW) operation. The heating process was controlled along a preset temperature-time program using the temperature signal of a thermocouple.

About 90 g of the mixed powder sample was filled into an alumina crucible surrounded by thermal insulation made of mullite ceramic fiber boards from Rath GmbH, Germany. The temperature was measured by two thermocouples, one sticking in the center of the powder sample, protected by an alumina sheath, another one in contact with the crucible bottom wall used for process control.

The samples used were mixed powders of two types of natural iron ores and carbon. One is KOBE STEEL LTD, Fe_3O_4 with a purity of 88.5 wt.%. The second one is Indian natural iron ores, mainly Fe_2O_3 with a purity of 75.8 wt.%. The weight ratio of KOBE and Indian natural iron ores and carbon was 90.53 to 9.47 and 87.81 to 12.19 wt.%, respectively.

The Figure 1 shows the process temperatures of the KOBE and the Indian sample, respectively. The KOBE powder sample and Indian sample heated by 30GHz was measured by use of a glow discharge mass spectrometer. The results show few wt.ppm about SiO_2 and Al_2O_3, which have high Gibbs energy and temperature of melting point than iron oxide

The production of high quality pig-iron has been demonstrated. Therefore mixed powder samples of natural iron ores and carbon were treated by high power millimetre-waves at a frequency of 30 GHz. The experimental results are suggested on microwave assisted production of iron including the influence on residual impurities in the final pig-iron.

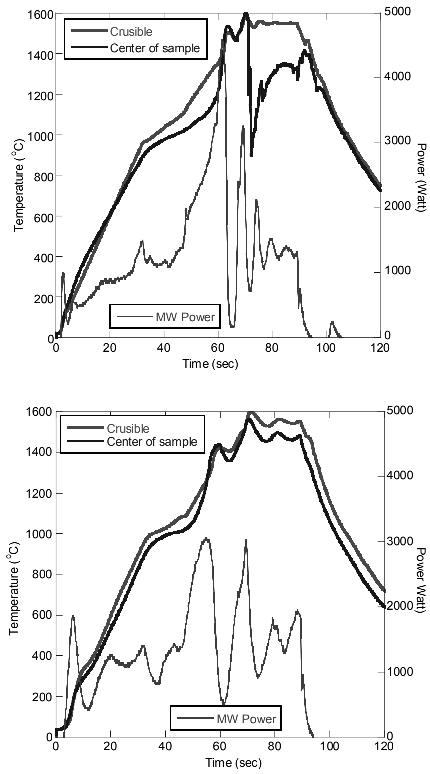

Figure 1: Process temperatures for Fe_3O_4 of KOBE sample(upper) and process temperatures for Fe_2O_3 of Indian sample in nitrogen gas during microwave heating (under).