§11. Concept of Microwave Furnace for Steel Making

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As the Kyoto protocol come into effect, aggressive preservation of resources and energy savings are becoming progressively pressing needs for humanity. The report of microwave heating of powder metals gave an idea that rapid reduction of iron should be possible by application of microwaves without relying on burning of carbon for de-oxidation. Joint experiments with NIFS et al proved that high purity iron (2% carbon density) with less than 1/10th of impurities, such as manganese, sulfur, phosphor, silicon, titanium, etc., as compared to irons from modern blast furnace can be produced in a short time, while reducing consumption of carbon to 1/2.

The experiment showed the process contained three steps. The first was the oxide reduction at very low temperatures under 600 ^{o}C. It is the most characteristic process of microwave in which the direct reaction between the solid□solid phase, i.e. the solid carbon powder and solid oxide irons. The magnetite could be heated by the H-field of microwave and carbon by the E-field selectively.

The second step was the solid - gas / plasma reaction in 600~1100 ^{o}C, at which the reduction and heating continued. The visible light spectroscopy observed the line emissions oriented from the Fe atoms and carbon nitride molecules , etc. The intensity of the line emissions were 10~100 times higher than the background by the black body emission. The third is the carbon solution to produce pure pig iron in 1100~ 1380 ^{o}C.

The result shall be developed into a new research theme of Suppressed CO_2 Emission, Rapid Iron Reduction Method by Microwave Processing, which is aimed for reduction of several millions of tons of CO_2 emission (per single blast furnace). If the renewable energy, such as solar, hydro and nuclear power, is applied to generate microwave, it can reduce the emission of CO_2 at least 50% of what is necessary in the conventional blast furnaces.

That is a horizontal flow system consisting of a rotary kiln having with a metal cylinder rotating on the horizontal axis with a little tilting angle as shown in Figure-1. The rotating motion enhances the mixing and refreshing the solid -solid contacts between the iron oxide and carbon powders. The powders supply to an end of the cylinder and flow down slowly to the other end proceeding to solid-solid reactions. The attenuation depth of microwave estimated to 0.2m at 2.45GHz experimentally limits the depth of powder layer in the cylinder.

The design parameters of microwave furnace, both for full industry scale, a prototype and the conventional ballast furnaces, are listed in the table-1 for the comparison.

	Microwave Furnace		Conventional Blast Furnace
	Prototype	Full Scale	
Height	3m	15m	30 m
Volume	2m3	60m3	> 1000m3
Production Rate	50~100 kg/hour	3 ton / h /segments	400 ton/ h
Maximum Temperature	1380 ^{o}C	1380 ^{o}C	1550 ^{o}C
Process time (in to out)	1 hour	1 hour	8 hours
Start up time	1 hour	6 hours	---

Table-1 Comparisons of Basic Parameters of Microwave Furnace and Blast Furnace

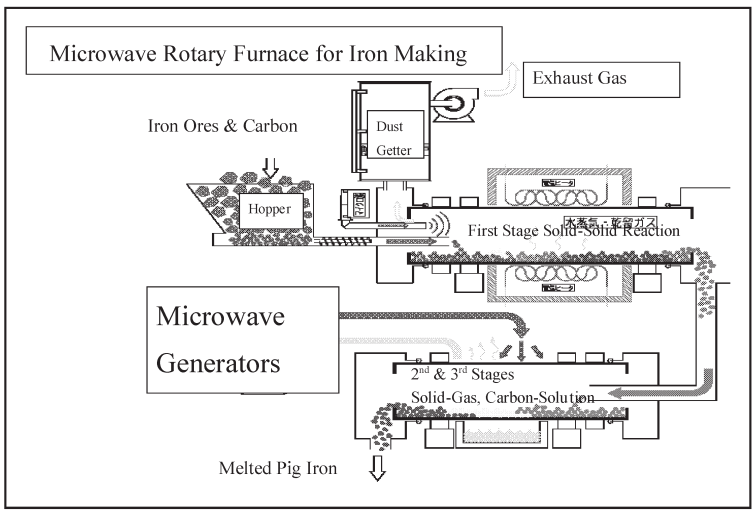

Figure-1 Schematic diagram of a microwave rotary furnace

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