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Letter to Editor Open Access

Microwave-Based Extractive Metallurgy for the Purification of Pure Metals: A Review

Shoki Kosai*

Global Innovation Research Organization, Ritsumeikan University, Noji-Higashi 1-1-1, Kusatsu-shi, Shiga, 525-8577, Japan

Letter to Editor

Introduction

Despite the economic and social value of metals, natural ore depletion is inescapable if mining continues. New technological developments in processing natural ores and recycling waste materials to obtain pure metals with high efficiency have become increasingly important throughout time. Microwave-based furnaces, which heat samples quickly, uniformly, and selectively, are gaining popularity as a potential alternative to traditional heating methods. On the other hand, the current condition of microwave technology for getting pure metals has not been thoroughly monitored. Using the microwave heating process, this study investigates extractive metallurgical methods for extracting pure metals from virgin and waste sources.

Metals are necessary for economic growth and human well-being. Kruusmann found that global metal consumption in 2005 was 19 times that in the early twentieth century, and historical trends suggest that it will continue to rise. Because all metals on Earth have a mineable limit, the risk of metal depletion rises as demand rises [1]. As a result, technological innovations are urgently required to improve the efficiency of pure metal production from natural ores and to increase the productivity of waste products, or urban ores.

At both the industrial and laboratory scales, a variety of techniques are utilised to acquire pure metals. Furnaces are the most popular of the traditional methods. Blast furnaces and converter furnaces, for example, are widely employed in the iron-making business. Due to its efficiency, blast-smelting iron and steel production has become increasingly essential in the manufacturing iron making business. Earlier articles have mostly focused on the microwave-based pyrometallurgical process[2-5]. The hydrometallurgical process has received very little study. As a result, this section only covers the pyrometallurgical techniques used to generate virgin metals using microwave technologies. The methods for manufacturing iron have been thoroughly evaluated, and other metals have also been considered.

Hayashi compared the application of microwave-based reduction of pure hematite powder to iron to that of magnetite reduction at maximum power. Hematite reduction required a longer heating time in the microwave approach than magnetite reduction, as it did in the conventional furnace-based reduction strategy. Despite being heated at a greater temperature than magnetite, it was shown that hematite needed a longer heating time to achieve a similar reduction rate to magnetite.

The present research works based on the clarification of the microwave-based reduction mechanism are summarised in this section, with a special emphasis on the distinct reduction behaviours of the electric and magnetic fields, as well as the measurement of the apparent activation energy. The resonant cavities apparatus was used to separate the electromagnetic field and evaluate the natural behaviour of the electric and magnetic fields separately. The cavity was used at a maximum power of 0.50 kW and 2.45 GHz to study the pure magnetite reduction of iron. In the microwave cavity, the magnetite and carbon black mixed powder was irradiated at the highest electric field position.

Another study evaluated the apparent activation energy of iron oxide reduction to iron reduction under various heating sources to determine the benefit of microwave irradiation. Huang et al. measured the apparent activation energy of natural hematite ore in the non-thermal action of a microwave at 2.45 GHz with a maximum power. The apparent activation energy in the reduction of hematite ore to iron under microwave irradiation and kJ/mol, respectively, in the temperature ranges of 554 and 800 and 820 and 1050.

Although metals are fundamental to the economy and human well-being, natural ore depletion is inevitable with the continuation of mining. Awareness of the importance of new developments in technologies to process natural ores and to recycle waste materials to obtain pure metals with high efficiency has been growing over time. The microwave-based furnace, which heats samples rapidly, uniformly and selectively, has recently been given more attention as an alternative to the conventional heating systems. However, the current progress of microwave technology for obtaining pure metals has not been fully monitored. This study reviews the extractive metallurgical approaches for obtaining pure metals by subjecting virgin materials and waste materials to the microwave heating method. In this paper, the principles of the microwave-based furnace to heat the samples are first summarized. Then, the studies of microwave-based pyrometallurgical and hydrometallurgical approaches to produce the virgin metals and to recycle metals are abridged. Finally, the limitations of current progress and the future prospects of microwave-based metallurgical technology are identified. A number of clear advantages of microwave irradiation emerged through the review process.

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Conflict of Interest

The authors declare that they are no conflict of interest.

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***Corresponding author:** Shoki Kosai, Global Innovation Research Organization, Ritsumeikan University, Noji-Higashi 1-1-1, Kusatsu-shi, Shiga, 525-8577, Japan,Email: kosi@fc.ritmei.ac.jp

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