Processing of red mud by low temperature microwave hydrogen plasma for production of iron: An eco-friendly technology

Bhagyadhar Bhoi[1], Priyanka Rajput[2], and Chitta Ranjan Mishra[3]
1. Chief Scientist , 2. Scientist,CSIR - Institute of Minerals & Materials Technology, Bhubaneswar, Odisha, India
3. Former Deputy General Manager (R&D) National Aluminium Company Limited, NALCO Bhawan, Bhubaneswar,Odisha, India
Corresponding author: bbhoi@immt.res.in or bbhoi@yahoo.com

Abstract

Red mud is produced in huge quantities during the processing of bauxite for the production of alumina. So far, few economically attractive processes have been developed for bulk utilization of red mud. Researchers are trying to develop interesting processes and products from this waste material; success achieved so far is restricted to laboratory, pilot scale, isolated or minor volume utilization applications and processes. Red mud of Indian origin contains around 45 – 55 % Fe_2O_3, 11 % TiO_2, 20 % Al_2O_3, 9 % SiO_2 and other associated oxides in minor quantities. Iron being the major component, bulk utilization of red mud will be difficult without an economically and technically viable process being developed for the production of iron from red mud. Indian iron ore containing 45 % Fe_2O_3 is considered as the cut-off grade for the economic production of iron. Accordingly, red mud of Indian origin can be considered as a low grade iron ore. The present study examines the processing of Indian red mud by Low Temperature Hydrogen Plasma for the production of iron in eco-friendly manner at laboratory scale. The iron produced contains 95 % Fe with low carbon and sulphur. Water, which can be recycled, is produced as a by-product of the process.

Key words: Red mud; hydrogen reduction; microwave hydrogen plasma reactor; iron from red mud.

1 Introduction

Red Mud is a byproduct generated during the processing of bauxite with caustic soda utilizing the Bayer process. It is considered as a hazardous material and till today few economically interesting applications or processes have been developed for its bulk utilization. Researchers have tried to produce pig iron from Red Mud by the application of plasma smelting technology [1], production of pig iron and portland slag cement from red mud by application of novel thermal plasma technique [2], production of ordinary Portland cement (OPC) from Red Mud [3], and processing of Red Mud for the production of wood substitute materials [4]. All efforts in this direction have so far been restricted either to laboratory or pilot scale processes. Iron oxide is a major constituent of Red Mud and for this reason it can very well be considered as a low grade iron ore. Red mud of Indian origin contains around 45 – 55 % Fe_2O_3, 11 % TiO_2, 20 % Al_2O_3, 9 % SiO_2 and other associated oxides in minor quantities. The quantum of generation of Red Mud by the alumina industries all over the globe warrants its gainful utilization in bulk quantities. An important option available presenting to researchers is extraction of iron from Red Mud in a most eco-friendly manner.

The reduction of Fe_2O_3 present in Red mud to metallic iron can be achieved either by Carbothermic or Hydrogen reduction processes. The Carbothermic reduction process involves a Blast Furnace

route for production. However, this process is not free from pollution and emits large quantities of carbonaceous gases which add to global warming. It has been estimated that for production of one tone of iron, around three tones of green house gases are generated. Under the circumstances, industry have few other alternatives but to follow an eco-friendly (and lower energy cost) path way for production of iron through a Hydrogen reduction process. Researchers elsewhere have tried to produce metallic iron from iron ore employing the Hydrogen reduction process by using hydrogen gas as reductant in a high temperature furnace [5]. This process has limitations, such as it being a time consuming process associated with low yield and moreover, consumption of hydrogen gas was also increased.

The answer to this challenge lies with the state-of-the-art technology for production of metallic iron from iron ores by application of the low temperature Microwave Hydrogen Plasma Reduction route. Through this route, iron was extracted successfully from iron ores as Direct Reduced Iron [6].

Once researchers successfully accomplished such an eco-friendly reduction process, the process know- how was then suitably replicated for production of iron from Red Mud through application of a Low Temperature Microwave Hydrogen Plasma Reduction Process using hydrogen gas as a reductant. The product so obtained contains 95% Fe with low carbon and sulphur. The process is eco-friendly and free from carbon. Moreover, 'water' is generated in the process as a by-product which can be recycled when commercially used.

2 Raw Materials

The Red Mud of Indian origin was used as principal raw material for the study. The mineralogical composition and chemical analysis of Red Mud are furnished in Figure 1 and Table 1 respectively. The other raw materials used for the study were Hydrogen gas of 99.9% purity and Argon gas.

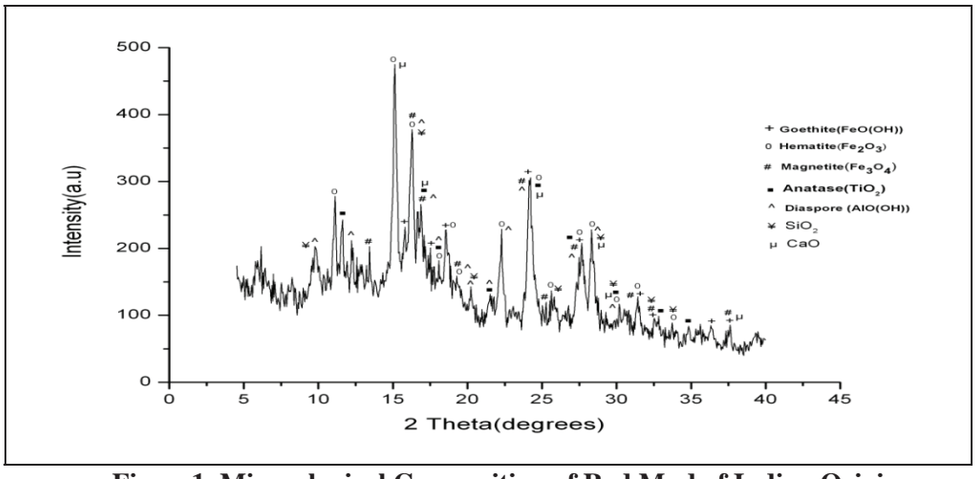

Figure1. Mineralogical Composition of Red Mud of Indian Origin.

6. Conclusions

From the above experimental evidences and observations, it can be concluded that red mud containing around 53.6 % Fe_2O_3 and some appreciable quantities of Al_2O_3 and other associated metal oxides in minor quantities, can very well be reduced to iron by the application of Microwave Hydrogen Plasma technology.

The process has been successfully demonstrated at laboratory scale, but needs to be demonstrated at pilot scale before its commercial feasibility is established. CSIR-IMMT, Bhubaneswar, Odisha, India is in possession of laboratory scale technology for production of iron from Red Mud of Indian origin and the know-how is readily available for commercial exploitation.

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