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Recycling of Sintered NdFeB Magnet Waste Via Oxidative Roasting and Selective Leaching

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Abstract : Neodymium-iron-boron (NdFeB) magnets classified as high-power magnets are widely used in various applications such as electrical and medical devices and account for 13.5 % of the permanent magnet’s market. Since its typical composition of 29 - 32 % Nd, 64.2 – 68.5 % Fe and 1 – 1.2 % B contains a significant amount of rare earth metals and will be subjected to shortages in the future. Domestic NdFeB magnet waste recycling should therefore be developed in order to reduce social, environmental impacts toward a circular economy. Most research works focus on recycling the magnet wastes, both from the manufacturing process and end of life. Each type of wastes has different characteristics and compositions. As a result, these directly affect recycling efficiency as well as the types and purity of the recyclable products. This research, therefore, focused on the recycling of manufacturing NdFeB magnet waste obtained from the sintering stage of magnet production and the waste contained 23.6% Nd, 60.3% Fe and 0.261% B in order to recover high purity neodymium oxide (Nd_2O_3) using hybrid metallurgical process via oxidative roasting and selective leaching techniques. The sintered NdFeB waste was first ground to under 70 mesh prior to oxidative roasting at 550 - 800 °C to enable selective leaching of neodymium in the subsequent leaching step using H_2SO_4 at 2.5 M over 24 h. The leachate was then subjected to drying and roasting at 700 – 800 °C prior to precipitation by oxalic acid and calcination to obtain neodymium oxide as the recycling product. According to XRD analyses, it was found that increasing oxidative roasting temperature led to an increasing amount of hematite (Fe_2O_3) as the main composition with a smaller amount of magnetite (Fe_3O_4) found. Peaks of neodymium oxide (Nd_2O_3) were also observed in a lesser amount. Furthermore, neodymium iron oxide ($NdFeO_3$) was present and its XRD peaks were pronounced at higher oxidative roasting temperatures. When proceeded to acid leaching and drying, iron sulfate and neodymium sulfate were mainly obtained. After the roasting step prior to water leaching, iron sulfate was converted to form hematite as the main compound, while neodymium sulfate remained in the ingredient. However, a small amount of magnetite was still detected by XRD. The higher roasting temperature at 800 °C resulted in a greater Fe_2O_3 to $Nd_2(SO_4)_3$ ratio, indicating a more effective roasting temperature. Iron oxides were subsequently water leached and filtered out while the solution contained mainly neodymium sulfate. Therefore, low oxidative roasting temperature not exceeding 600 °C followed by acid leaching and roasting at 800 °C gave the optimum condition for further steps of precipitation and calcination to finally achieve neodymium oxide.

Keywords : NdFeB magnet waste, oxidative roasting, recycling, selective leaching
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