UNIVERSITI TEKNOLOGI MARA

RECOVERY OF IRON FROM ELECTRIC ARC FURNACE SLAG (EAFS) BY THE OXIDATIVE AND NON-OXIDATIVE LEACHING

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ABSTRACT

A significant amount of electric arc furnace slag (EAFS) is generated as a by-product from steelmaking industry. To intensify the iron recovery from EAFS in the final product, acid leaching was carried out with both the presence and absence of oxidants. Oxidative leaching refers to the process whereby the oxidant participates in redox reactions with the metal compounds, facilitating the breakdown of the EAFS compound and promoting the dissolution of the desired metals, while non-oxidative leaching does not involve the use of an oxidant. In this study, hydrogen peroxide and potassium permanganate were used as the oxidants in leaching process. The influences of the leaching factors, such as the concentration of leaching reagent (0.5–8 M), leaching temperature (323–363 K), EAFS particle size (50–300 µm) and concentration of the oxidants (1–3 M), were also studied. The findings revealed that the particle size, acid dosage and type of oxidants significantly influenced iron recovery. Smaller particle sizes greatly improved the recovery of iron. İn the non-oxidative leaching environment, sulphuric acid exhibited a higher iron recovery compared to hydrochloric acid. The recovery efficiency was found to be 60 %. The recovery efficiency of iron for oxidative leaching in sulphuric acid was the highest at 2 M hydrogen peroxide as compared to potassium permanganate. This was because an overdose hydrogen peroxide can cause radical quenching which will reduce oxidant utilization. Oxidative leaching results in better iron recovery at optimum leaching conditions with a temperature of 50 °C, 5 M H_2SO_4, 1 M hydrogen peroxide, a leaching time of 120 minutes, a solid to liquid ratio of 1:20 and a stirring rate of 300 rpm. The reaction was found to follow the chemical-reaction model with chemical reaction constant of 2.04×10^3 min^{-1} and the activation energy of +16.95 kJ/mol. The cyclic voltammetry tests were conducted at potential ranges of -1.0 to 1.0 V at a scan rate of 100 mV/s using screen printed carbon electrode (SPCE). The cyclic voltammogram indicated that there were two distinct oxidation peaks to confirm that 80 °C has higher iron recovered compared to 60 °C. This study concludes that oxidative leaching environment (5 M H_2SO_4, 2 M H_2O_2, 1:20 solid to liquid ratio, 50 °C) is a promising method to recover iron as compared to non-oxidative environment. In summary, the findings in this work support the Sustainable Development Goal (SDG 12) in prioritizing on the minimization of solid waste by recycling the waste in order to reduce adverse impacts on the environment.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

Steel is an alloy of pure iron with small amounts of carbon and trace amount of other elements that is generally high in tensile strength. Meanwhile, iron is a silvery-white substance with subpar mechanical properties since it is very soft and brittle. However, iron is known for its excellent thermal and electrical conductivity and exceptional magnetic properties. Steel is used as the raw material in the manufacturing, technology and machinery sectors because steel exhibits the properties of high strength (Guo et al., 2019), low weight, durability, ductility and corrosion resistance (Bajaj et al., 2020; Roy et al., 2019). Steel is also used in transportation as well as being used as the primary commodity for construction operations, not only limited to these main sectors. According to World Steel Association, the world production of steel is approaching 149.3 million tonnes in 2022 (World Steel Association, 2022). Electric furnace arc are furnaces in which the melting of metallic materials takes place with the aid of an electric arc. The malting and the discharging temperature in these furnaces varies and can range from 1600 and 3000°C (Daneshmand et al., 2023). Electric arc furnace slag (EAFS) is the discharge material from electric arc furnace processes and is widely reused for secondary steel manufacturing processes where the raw material is fed into the electric arc. After a while the current in the terminal furnace is passed through the metal loaded. Each tonne of steel production will generates up to 10-15% of EAFS (Mioc et al., 2009; Yu et al., 2023). Steel production was the primary goal of steel manufacturers up to the current decade. Steel slag was treated as a by-product for disposal until the quantity of slag in the landfills reached enormous amounts. Improper disposal of steel slag poses as serious environmental concern due to the high content of heavy metals ions including chromium, nickel and cadmium (Luo et al., 2024). If steel slags are not properly managed, it can lead to contamination of land and groundwater systems. Rising costs and decreasing capacity at the landfills have forced the steel industry to change this view. Hence, recycling of steel slag into secondary applications are necessary to reduce raw material use and emissions thereby reducing waste management costs.