P-ISSN 0126-3188
E-ISSN 2443-3926

BRIN
BADAN RISET
DAN INOVASI NASIONAL

METALURGI

VOLUME 39 No 1 2024

SCIENTIFIC JOURNAL ACCREDITATION NO.3/E/KPT/2019

National Research and Innovation Agency

BRIN
BADAN RISET
DAN INOVASI NASIONAL

Publisher :
National Research and Innovation Agency (BRIN)
KST B.J Habibie Serpong, Tangerang Selatan, Banten, Indonesia, 15314

E-mail: metalurgi@brin.go.id

Science and technology magazine, regularly published every year; one volume consists of 3 editions

METALURGI

VOLUME 39 NUMBER 1 2024

P-ISSN 0126-3188
E-ISSN 2443-3926

ACCREDITATION: SK No. 72/E/KPT/2024

PREFACE

The author gives thanks to Allah for bestowing His blessing and direction, allowing the **Metalurgi Journal Volume 39, Edition 1**, **2024** to be successfully published.

The first article results from Soesaptri Oediyani and colleagues research activities on *The Added Value of Copper and Silver Metal from Printed Circuit Boards Waste Using Davis Tube with Variations of Size and Magnetic Intensity*. Vita Astini and colleagues presented the second article, *Influence of Electrolyte Molarity and Applied Voltage on the Purification of Ferronickel by Electrolysis Method*. Haviz Aulia and colleagues reviewed *Surface Modification of Composite Coating for Marine Application: A Short Review* in the following article. For the fourth article, Rahadian Nopriantoko reviewed *Green Approaches to Extractive Metallurgy: A Novel Synthesis of Sustainable Practices*. The fifth article by Fadhli Muhammad and his colleagues discussed *Microstructural Stability and High-Temperature Oxidation Behavior of* $Al_{0.25}$*CoCrCuFeNi High Entropy Alloy*.

The publication of this volume in Metalurgi Journal will benefit the advancement of research in Indonesia.

EDITORIAL

METALURGI

ISSN 0126 – 3188 Vol. 39 No. 1, 2024

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Soesaptri Oediyani, Rahman Faiz Suwandana, Tiara Triana, Dewi Kusumaningtyas, Adjie Pradana, Zuhrainis Syaifara (Department of Metallurgy, Sultan Ageng Tirtayasa University)

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The Added Value of Copper and Silver Metal from Printed Circuit Boards Waste using Davis Tube with Variations of Size and Magnetic Intensity

The widespread use of electronic devices has led to a significant increase in electronic waste, including PCB (printed circuit board) waste. PCBs contain valuable metals like copper and silver, which can be reclaimed and reused. Recently, there has been a growing demand for urban mining processes to extract electronic waste PCB FR-2 (Flame Retardant-2) from laptops and computers. During the urban mining process, PCB FR-2 waste undergoes various physical treatments such as dismantling, crushing, and concentration processes. One of the concentration processes involves magnetic separation using a Davis tube. This study aims to investigate the effects of size and magnetic intensity variations on the recovery of copper and silver levels in FR-2 PCB waste. The magnetic concentration process was carried out using different size ranges (-63+100#, -100+150#, -150#) and magnetic intensities (1000 G, 2000 G, 3000 G). The results indicated that the most effective size for separating copper and silver is -63+100# and the optimal magnetic intensity is 1000 G. This resulted in copper and silver content of 45.66% and 0.162%, with recoveries of 80.135% and 62.505% respectively.

Keywords: Davis tube, electronic waste, magnetic separation, PCB FR-2, recovery

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ISSN 0126 – 3188 Vol. 39 No. 1, 2024

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Vita Astini[a] , Selvia Meirawati[b], Sulistia Nengsih[b], Arif[b], Hasriyanti[b], Johny Wahyuadi Mudaryoto Soedarsono[a], Anne Zulfia[a] ([a]Department of Metallurgy and Materials Engineering, University of Indonesia; [b]Department of Mining Engineering, Sembilanbelas November University)

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Influence of Electrolyte Molarity and Applied Voltage on the Purification of Ferronickel by Electrolysis Method

The current advancements in the automotive industry highlight the critical need for electric vehicles, which require a reliable supply of nickel for battery production. A potential nickel source is Ferronickel's local content, which can be used as a secondary resource. However, research on converting smelted Ferronickel into electrolytic nickel is still limited. This study aims to examine the effects of electrolyte molarity and applied voltage during the electrolysis process for refining Ferronickel. The molarities of HCl employed in this research are 0.1, 0.25, 0.5, 0.75, and 1 M for 2 hours. Additionally, the molarities of HCl are set at 2, 3, and 4 M for 6 hours. Further experiments were performed using varying voltages of 1, 2, 4, 6, and 8 V while keeping the solution concentration constant at 1 M and maintaining an electrolysis duration of 2 hours. The electrolysis solution was subsequently analyzed using the AAS (atomic absorption spectrophotometry) test. The results indicated that higher molarity levels were associated with increased current, resulting in faster reaction rates and greater solubilization of nickel metal. The Ni concentration rose with higher molarity, increasing from 76.50 mg/L in .25 M HCl to 91.88 mg/L in 1 M HCl. In contrast, the Fe concentration remained nearly constant across various molarity levels, ranging from 11.81 mg/L in .25 M HCl to 11.95 mg/L in 1 M HCl, suggesting a minimal influence of molarity below 1 M. Fe exhibited a strong positive correlation with increasing electrolyte molarity, showing a significant rise in concentration from 49.06 g/L at 2 M to 90.17 g/L at 4 M. Ni showed a more modest response to elevated molarity, with concentrations increasing from 11.95 g/L at 2 M to 22.70 g/L at 4 M. The Ni concentration increased with the applied voltage up to 6 V, reaching 95.57 mg/L, but then decreased to 77.67 mg/L at 8 V, indicating that the optimum voltage is 6 V. The Fe concentration displayed slight fluctuations but remained relatively stable across different voltage levels, measuring 11.81 mg/L at 1 V and 12.28 mg/L at 8 V, indicating that the applied voltage does not significantly influence Fe concentration in the solution.

Keywords: Ferronickel, electrolysis, molarity, applied voltage, concentration

METALURGI

ISSN 0126 – 3188 Vol. 39 No. 1, 2024

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Metalurgi, Vol. 39 No. 1, 2024

Surface Modification of Composite Coating for Marine Application: A Short Review

Corrosion is a prevalent phenomenon that significantly contributes to the deterioration of materials in offshore applications. The aggressive nature of marine corrosion is primarily attributed to the high salt content and the low electrical resistivity of seawater. While corrosion cannot be entirely eliminated, its reaction can be slowed down. Applying protective coatings is an effective and widely utilized method to protect metal surfaces from corrosion. These coatings act as a protective barrier that separates the metal from its surrounding environment, effectively retarding the corrosion rate. According to ISO 12944, the most commonly used generic coating systems for marine service include alkyd, acrylic, ethyl silicate, epoxy, vinyl ester, polyurethane, polyaspartic, and polysiloxane. The latest innovations in marine coatings still employ a layer-by-layer coating method, involving primer coats, intermediate coats, and top coats, depending on the desired thickness. Marine structures exposed to atmospheric conditions are commonly coated with one or two layers of epoxy. For enhanced performance, a more expensive system involving a layer of zinc-rich primer, followed by epoxy and aliphatic polyurethane coatings, may be utilized. Coating systems for atmospheric conditions are frequently employed in intertidal and splash zones. On the other hand, immersion zones of marine structures are typically coated with one or two layers of 100% solid epoxy or three layers of solvent-borne epoxy. The use of a single polymer as a generic coating has limitations. Incorporating fillers is a widely employed technique to enhance the characteristics of polymers, thereby transforming them into composites. In marine coatings, fillers are still limited to glass flakes and powder. Poor dispersion and agglomeration might reduce the effectiveness of fillers in the matrix, which decreases the adhesion properties. The fillers must be surface-modified before application. This review provides a comprehensive and critical analysis of the current research status of composite coatings that serve as candidates to be used in marine coating applications.

Keywords: Corrosion, marine coating, composite, surface modification

METALURGI

ISSN 0126 – 3188 Vol. 39 No. 1, 2024

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Metalurgi, Vol. 39 No. 1, 2024

Green Approaches to Extractive Metallurgy: A Novel Synthesis of Sustainable Practices

The realm of extractive metallurgy, a cornerstone for diverse industrial applications, has traditionally grappled with environmental challenges stemming from conventional extraction methods. This thorough literature review delves into the realm of innovative green approaches within extractive metallurgy, with the overarching goal of synthesizing sustainable practices. The introduction casts a spotlight on the environmental quandaries associated with traditional metallurgical practices, underscoring the imperative for ecologically friendly alternatives. The research methodology meticulously entails a comprehensive review of peer-reviewed literature, applying stringent criteria to handpick studies that delve into sustainable metallurgical practices. The results and discussion section intricately categorizes and dissects an array of green approaches in metal extraction, including bioleaching, ionic liquids, supercritical fluid extraction, green hydrometallurgy, electrochemical methods, and hybrid processes, providing nuanced insights into their efficacy and sustainability. Through the lens of case studies, the study sheds light on recent strides made by industries that have wholeheartedly embraced these sustainable practices, with a keen focus on unraveling their consequential environmental and economic impacts. Moreover, the study conscientiously addresses the challenges encountered in the adoption of green metallurgy and adeptly identifies latent opportunities for further development in this transformative field. The findings resonate with a resounding call for the widespread adoption of sustainable practices within extractive metallurgy, emphasizing their profound implications for both industrial application and the trajectory of future research endeavors. This expanded exploration underscores the pivotal role of environmentally conscious approaches in reshaping the landscape of extractive metallurgy, paving the way for a more sustainable and responsible future.

Keywords:Green, extraction, metallurgy, eco-friendly, sustainability

METALURGI

ISSN 0126 – 3188 Vol. 39 No. 1, 2024

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Fadhli Muhammad[a], Ernyta Mei Lestari[a], Tria Laksana Achmad[a], Akhmad Ardian Korda[a], Budi Prawara[b], Djoko Hadi Prajitno[c], Bagus Hayatul Jihad[d], Muhamad Hananuputra Setianto[d], and Eddy Agus Basuki[a] ([a]Department of Metallurgical Engineering, Faculty of Mining and Petroleum Engineering, Institut Teknologi Bandung, [b]Research Centre for Advanced Materials, National Research and Innovation Agency, [c]Research Organization for Nuclear Technology, National Research and Innovation Agency, [d]Research Centre for Rocket Technology, Research Organization for Aeronautics and Space, National Research and Innovation Agency

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Microstructural Stability and High Temperature Oxidation Behavior of Al0.25CoCrCuFeNi High Entropy Alloy

$Al_{0.25}$CoCrCuFeNi is a high-entropy alloy composed of transition metals, specifically designed for high-temperature applications owing to its favorable mechanical properties, high melting point, and excellent high-temperature resistance. This alloy has been identified as a promising material for space exploration, particularly in the fabrication of combustion chambers and rocket nozzles by the National Aeronautics and Space Agency. Ongoing alloy development involves modifying the elemental composition. This study reduced aluminum content in the equiatomic AlCoCrCuFeNi alloy to $Al_{0.25}$CoCrCuFeNi, followed by isothermal oxidation treatments at 800, 900, and 1000°C. A series of experiments were conducted to investigate the microstructure stability and oxidation behavior of the $Al_{0.25}$CoCrCuFeNi alloy. The alloying elements were melted using a single DC electric arc furnace, followed by homogenization at 1100°C for 10 hours in an inert atmosphere. Subsequently, samples were cut into coupons for isothermal oxidation testing at the desired temperatures for 2, 16, 40, and 168 hours. The oxidized samples were characterized using XRD (x-ray diffraction), SEM (scanning electron microscopy) equipped with EDS (energy-dispersive X-ray spectroscopy), optical microscopy, and Vickers hardness testing. The as-homogenized alloy consisted of two constituent phases: an FCC (face-centered cubic) phase in the dendritic region and a copper-rich FCC phase in the inter-dendritic region. The oxides formed during the oxidation process included Al_2O_3, Cr_2O_3, Fe_3O_4, CoO, CuO, NiO, and spinel oxides $(Co, Ni, Cu)(Al, Cr, Fe)_2O_4$), with distinct formation mechanisms at each temperature.

Keywords: High-entropy alloy, isothermal oxidation, FCC structure, high temperature, phase stability