

ABSTRACT

THE EFFECT OF OXIDATION PRE-TREATMENT TIME, FUSION TIME, AND NaOH CONCENTRATION ON TIN (Sn) RECOVERY FROM IRON-TIN BY-PRODUCT OF PT TIMAH TBK THROUGH ALKALI FUSION PROCESS

By

Made Anditha Dwipayana Ugracena

NIM: 116210069

(Metallurgical Engineering Undergraduated Program)

The tin smelting and refining industry in Indonesia, particularly PT Timah Tbk, produces a by-product from processing refinement in flame oven using liquation method known as iron-tin, which still contains a significant amount of valuable tin. The accumulation of underutilized iron-tin not only poses potential economic losses due to the loss of tin value but also increases waste management costs and environmental risks. The reutilization of iron-tin through oxidation pre-treatment and alkali fusion is expected to enhance Sn recovery while supporting sustainable secondary resource utilization strategies. This study was conducted using variations in oxidation pre-treatment time (60, 90, and 120 minutes), alkali fusion time (60, 90, and 120 minutes), and NaOH concentration (3.5, 5.5, and 7.5 M). The oxidation process was carried out at 800 °C in a muffle furnace, followed by alkali fusion under similar conditions, and the product was then leached with distilled water to dissolve sodium stannate (Na_2SnO_3). The Sn content was analyzed using the iodometric titration method, while the data were further examined statistically using Taguchi and ANOVA methods to determine the most influential process parameters and identify the optimum conditions. The results showed that oxidation pre-treatment time was the most significant parameter, contributing 64.31% to Sn recovery ($P < 0.05$), followed by NaOH concentration at 30.76%, while alkali fusion time contributed only a minor effect of 2.50%. The optimum condition was obtained at 120 minutes of oxidation, 90-120 minutes of alkali fusion, and 5.5 M NaOH concentration, yielding the highest Sn recovery of 69,51%. These findings highlight the potential implementation of oxidation pre-treatment alkali fusion methods to improve the efficiency of iron-tin by-product utilization at PT Timah Tbk and contribute to the development of secondary resource processing technologies.

Keywords: alkali fusion, iron-tin, NaOH concentration, oxidation pre-treatment, recovery

ABSTRAK

PENGARUH VARIASI WAKTU *PRE-TREATMENT* OKSIDASI, WAKTU FUSI, DAN KONSENTRASI NaOH TERHADAP *RECOVERY* TIMAH (Sn) DARI TIMAH BESI PT TIMAH TBK PADA PROSES FUSI ALKALI

Oleh

Made Anditha Dwipayana Ugracena

NIM: 116210069

(Program Studi Sarjana Teknik Metalurgi)

Industri peleburan dan pemurnian timah di Indonesia, khususnya PT Timah Tbk, menghasilkan produk samping berupa timah besi yang berasal dari proses pemurnian di *flame oven* dengan metode *liquation* yang masih mengandung timah bernilai tinggi. Akumulasi timah besi yang belum dimanfaatkan tidak hanya menimbulkan potensi kerugian ekonomi akibat hilangnya logam timah, tetapi juga berimplikasi pada meningkatnya biaya pengelolaan limbah dan risiko lingkungan. Upaya pemanfaatan kembali timah besi melalui pendekatan *pre-treatment* oksidasi dan fusi alkali diharapkan mampu meningkatkan *recovery* Sn, sekaligus mendukung strategi pemanfaatan sumber daya sekunder secara berkelanjutan. Penelitian ini dilakukan dengan menggunakan variasi waktu *pre-treatment* oksidasi (60, 90, dan 120 menit), waktu fusi alkali (60, 90, dan 120 menit), serta konsentrasi NaOH (3,5; 5,5; dan 7,5 M). Proses oksidasi dijalankan pada temperatur 800°C menggunakan *muffle furnace*, dilanjutkan fusi alkali pada kondisi serupa, kemudian hasilnya di *leaching* dengan aquades untuk melarutkan natrium stannat (Na_2SnO_3). Analisis kadar Sn dilakukan menggunakan metode titrasi iometri, sedangkan data dianalisis secara statistik dengan metode Taguchi dan ANOVA untuk menentukan pengaruh parameter proses serta kondisi optimum. Hasil penelitian menunjukkan bahwa waktu *pre-treatment* oksidasi merupakan parameter paling signifikan dengan kontribusi 64,31% terhadap persen *recovery* Sn, diikuti oleh konsentrasi NaOH sebesar 30,76%, sedangkan waktu fusi alkali memberikan pengaruh relatif kecil (2,50%). Kondisi optimum diperoleh pada kombinasi oksidasi 120 menit, fusi alkali 90-120 menit, dan konsentrasi NaOH 5,5 M, dengan *recovery* Sn tertinggi sebesar 69,51%. Temuan ini menegaskan potensi implementasi metode *pre-treatment* oksidasi–fusi alkali dalam meningkatkan efisiensi pemanfaatan *by-product* timah besi di PT Timah Tbk, sekaligus memberikan kontribusi terhadap pengembangan teknologi pengolahan sumber daya sekunder.

Kata Kunci: fusi alkali, konsentrasi NaOH, *pre-treatment* oksidasi, *recovery*, timah besi