Innovative Applications and Technological Breakthroughs of 60-tonne Double-Chamber Furnace in Aluminium Recycling Industry

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Abstract

This paper details the innovative technological breakthroughs in the 60-tonne double-chamber furnace aluminium recycling project implemented at Rio Tinto's aluminium electrolysis plant in Canada. Guided by CSA safety standards, the project introduces systematic innovations in safety design, material handling, aluminium tapping systems, molten aluminium circulation, and flue gas treatment, fundamentally rethinking and optimizing traditional double-chamber furnace design concepts. Key innovations include rigorous safety system design, intelligent material handling processes, innovative aluminium tapping systems, efficient molten aluminium circulation technology, and advanced flue gas treatment and heat recovery systems. Additionally, the project features comprehensive quality control measures and a safe method to charge a wide variety of aluminium scrap without direct contact with liquid aluminium. These innovative designs not only meet the stringent requirements of CSA standards but also provide new technical references and development directions for the aluminium recycling industry. Through these advancements, the project aims to enhance operational efficiency, reduce environmental impact, and set new benchmarks for safety and productivity in aluminium recycling.

Keywords: Aluminium recycling with double-chamber furnace, Safety design and CSA standard, Electromagnetic stirring, Flue gas treatment, Quality control.

1. Introduction

Aluminium recycling was identified as a key input for the Rio Tinto global strategy. As part of the aluminium circular economy options, a new recycling facility is being installed in the one of its smelter operations in Canada [1]. The source of aluminium scraps identified is from post consummation which implies a certain level of contamination.

The recycling / melting technology selected most meet:

- New scrap source with flexibility in shape / format / thickness / alloys / contamination
- Highest process safety standards more particularly to prevent molten metal explosion
- Aim at zero carbon emission while assuring best melting performance (melt rate + recovery)
- High environmental performance including particulates collection and gas treatment
- Flexibility for molten metal transfer via crucible to be re-introduce in Value Added Product (VAP) primary mix.

A double-chamber furnace technology has been selected. RT has been working with CNPT and Longray, a well-known furnace supplier. Design improvement has been integrated in other to meet the criteria listed above.

1.1 Recycling in Primary Operation

The new recycling facility will enable Rio Tinto to become the first primary aluminium producer in North America to incorporate post-consumer scrap into alloys. This will provide us with a new product offering to meet the growing customer demand for aluminium with a smaller environmental footprint.

It brings its own challenges in terms of incorporating recycling content to already proven value-added products mix in parallel of integrating to existing metal flow and casthouse equipment developed for Primary operation.

1.2 Scrap Type

The scrap used will be post-consumer scrap, mainly from metal recyclers located in Canada. Post-consumer aluminium scrap is aluminium that has been used in a product and is no longer needed, like used aluminium cans or car parts. It is collected after the product has gone through its full lifecycle and is then recycled to create new products.

The material is collected and sorted in different categories mostly based on alloy families. It comes in all formats; loose, shreds, bales and might contain organic contaminants such as plastic, oil, paint and others.

2. Double-Chamber Furnace Technology

Traditional recycled aluminium production involves multiple steps [2]: material handling, unpacking, crushing, sorting, paint removal in rotary kilns, and processing in double-chamber furnaces. For a 5 t/h production line, the pre-treatment equipment requires over 400 kW installed power, consuming 30–50 kWh electricity and 20–40 Nm^3 natural gas per tonne of aluminium. This conventional process is cumbersome, inefficient, and generates significant energy waste and environmental emissions.

To address these challenges and achieve efficient aluminium waste recycling, Rio Tinto's Recycling project collaborated with CNPT and Longray to develop an innovative double-chamber furnace using a new aluminium liquid circulation method.

The double-chamber furnace comprises a melting chamber, scrap chamber, transfer well, and electromagnetic stirring (EMS) [3]. The chambers are connected by channels to enable molten aluminium circulation, powered by EMS. The melting chamber features two regenerative burner sets for energy supply, while the scrap chamber has two burners set for auxiliary heating with automatic oxygen content adjustment based on raw material conditions.

A partition wall separates the chambers, with flue gas channels in the upper section allowing high-temperature gases to flow from the melting chamber to the scrap chamber. The scrap chamber includes a heat bridge for placing scraps where drying and pyrolysis occur.
The main structure is shown in Figure 1.

5. Conclusions

The new furnace design has very significant effects on improving product quality, increasing furnace productivity, enhancing production safety and reliability, and reducing energy consumption. These innovations not only meet the specific requirements of the Rio Tinto Recycling project but also provide new technical references and development directions for the recycled aluminium industry. In the future, we will further optimize the system design, explore the application of intelligent control technologies, and promote the development of the recycled aluminium industry towards greater efficiency, environmental protection, and safety.

Using this equipment, Rio Tinto will be the first primary aluminium producer in North America to incorporate recycled post-consumer aluminium into aluminium alloys.

Clean aluminium scrap sourced locally from used vehicles and construction materials will be remelted to produce recycled content that will be used in aluminium billets at the Arvida smelter as well as other products from Rio Tinto's Quebec facilities.

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