Development and Application of Automatic Flow Control and Emergency Devices in Aluminium Ingot Casting

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https://doi.org/10.71659/icsoba2025-ch014

Abstract

With the widespread application of aluminium materials in high-end fields such as aerospace and automotive manufacturing, the quality and production efficiency of aluminium ingot casting have become increasingly critical. Traditional casting processes face issues such as unstable flow control, fluctuations in molten aluminium temperature, and high risks associated with manual operations, resulting in low yield, production efficiency, and safety standards for workers of aluminium ingots. The adoption of an automatic flow control system and emergency device design enables rapid response in unexpected situations, effectively enhancing the automation level and safety assurance capabilities of the production process. The fully automated flow-controlled aluminium production line established by Guangxi Hualei effectively reduces manpower by 2–3 workers in the casting production line while increasing aluminium ingot production efficiency by over 44 %. Moreover, it achieves precise flow control to prevent molten aluminium leakage, resulting in zero incidents of leakage during casting or in the launder, which ensures both enhanced productivity and operational safety, offering valuable insights for aluminium ingot casting processes.

Keywords: Aluminium ingots for remelting, Automatic flow control, Emergency system, Laser ranging.

1. Background

In domestic production, the casting for classical aluminium ingots for remelting typically employs holding furnaces (non-tilting holding furnaces) equipped with molten aluminium tapping outlets. The flow rate regulation or sealing of the tap hole is manually adjusted using a stopper rod with a plug. Due to the poor precision and reliability of manual adjustment, the stability of molten aluminium flow is compromised, leading to potential aluminium ingot quality issues and production safety risks. Moreover, in cases of power outage or air supply interruption to the caster, delayed human response makes it difficult to promptly seal the tap hole, posing adverse effects on safe production. With the promotion of intelligent manufacturing in the aluminium industry, Computer Numerical Control (CNC) technology has been proposed to address issues such as flow control stability and automation in the casting process. The flexibility and intelligence of CNC technology enable rapid production plan adjustments based on market demand, driving aluminium casting and processing toward a more efficient and safer level.

2. Overview of Casting Process for Aluminium Ingots for Remelting

The production process of remelted aluminium ingots for ordinary aluminium includes key steps such as electrolytic molten aluminium, furnace charging, refining, skimming, sampling and inspection, tapping, residue removal, and cooling solidification, as shown in Figure 1. This series of procedures ensures both high quality and production efficiency of the aluminium ingots [1]. During this process, the alloying furnace technology achieves precise mixing and control of molten aluminium with different compositions to ensure the final product meets standard

requirements and satisfies the demands of casting and mould forming [2]. When the molten aluminium from the electrolytic cells has high consistency in purity, it can be directly poured into moulds using ladles without the need for furnace preparation. However, if the molten aluminium contains excessive impurities such as electrolyte bath, it is unsuitable for direct casting via ladles [3]. Refining is the process of effectively removing non-metallic impurities from molten aluminium after it is poured into the holding furnace by using refining agents, which helps improve the purity and quality of the molten aluminium. Residue skimming refers to the process of eliminating residue from the molten aluminium. Sampling and testing involve collecting samples in a specified order and method for chemical composition analysis, enabling accurate determination of the product's chemical composition to ensure compliance with quality standards. Tapping is the controlled discharge of molten aluminium from the holding furnace, whereas direct casting into lifting ladles does not require tapping [4]. Residue removal is the process of eliminating surface dross from molten aluminium in the mould, primarily to improve the surface quality of the ingot. Cooling and solidification involve first indirectly cooling the molten aluminium in the mould through contact with cooling water (primary cooling), allowing it to solidify and take shape. This is followed by direct water spray cooling (secondary cooling) to reduce the aluminium ingot temperature to ambient levels. This cooling method effectively controls the solidification rate while ensuring production safety, guaranteeing efficient and secure aluminium ingot formation.

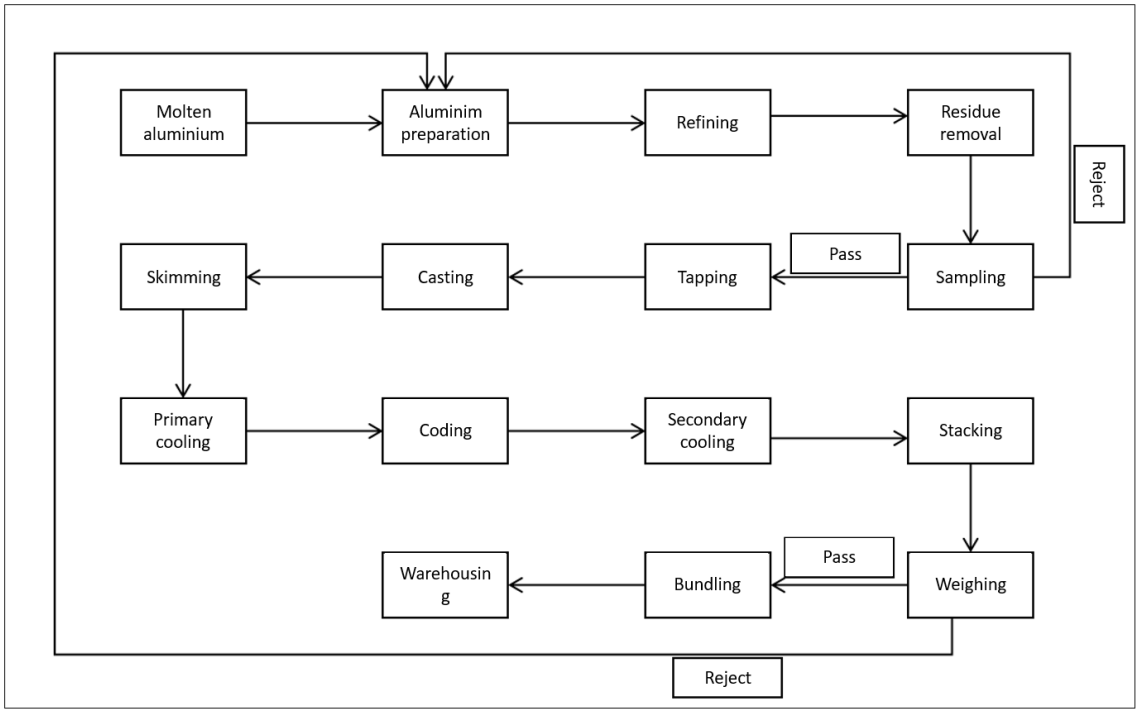

Figure 1. Schematic diagram of casting control and emergency equipment flow for aluminium ingots for remelting.

3. Automatic Flow Control Equipment and Process Flow

3.1 Composition of Control System and Control Process

The device is a new-generation automatic flow control system for aluminium ingot casting developed and applied by Guangxi Hualei. The system mainly includes a laser sensor, an auxiliary liquid level flow control mechanism, an automatic casting speed regulation device, a control system centre, and a ship-shaped casting ladle emergency tilt interlock device, as shown in

6. References

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