Batscan: The Coming of Age of a New Tool for Inclusion Detection in Liquid Aluminium

Jean-Louis Achard[1], Pierre Le Brun[2], Marc Bertherat[3], Pierre-Yves Menet[4], Nicolas Bauret[5] and Vincent Milani[6]
1. R&D Engineer
2. R&T Expert
3. BPC Leader
4. R&D Group Manager
Constellium – Technology Center – BPC Casting & Recycling, Voreppe, France
5. New Product Development Manager
6. Technical Expert
STAS, Saguenay, Canada
Corresponding author: pierre-yves.menet@constellium.com
https://doi.org/10.71659/icsoba2024-ch016

Abstract

After 10 years of development, the Batscan™, an inclusion detection tool in liquid aluminium developed by Constellium and marketed by STAS, has reached a level of maturity that makes it a unique and reliable enabler for liquid metal quality monitoring and process improvements. The measurement principle is based on controlled ultrasound transmitted to the liquid aluminium through inert ceramic waveguides immersed in the liquid aluminium. The measurement capabilities have been extended to cover the specific needs for a whole range of products, from the least to the most demanding such as packaging or aerospace applications. Whether positioned at the outlet of a casting furnace or after an in-line degasser, the Batscan™ can monitor a small percentage of the total volume of metal being cast from the beginning of the process to the last minute. It can detect events at a rate three orders of magnitude higher than the LiMCA while also detecting particles as small as 35 µm. The paper describes in more detail the elements above and provide a few examples of the operational benefits it can bring.

Keywords: Liquid aluminium, Batscan, Inclusion detection, Ultrasound, Ceramic waveguide.

1. Introduction

Inclusion detection in liquid aluminium is a crucial process in the metallurgical industry to ensure high-quality end products. The presence of non-metallic inclusions can significantly affect the mechanical properties and surface finish of aluminium products. Customers require that aluminium producers monitor the liquid metal cleanliness (inclusion content) so that the products they buy meet their requirements.

Here are some of the state-of-the-art methods for detecting inclusions in liquid aluminium. More details can be found in review papers such as that by Don Doutre et al. [1].

1.1 Off-line Inclusion Measurements

- **PoDFA** (Porous Disc Filtration Analysis): a predetermined quantity of liquid aluminum is filtered through a very fine porosity filter disc to concentrate inclusions at the filter interface (cake filtration). After solidification, the sample is cut, polished and the interface with the filter is observed under a microscope. It enables to see which inclusions are present in the metal and to some extent, the level of cleanliness.

- **Prefil** (Pressure Filtration Melt Cleanliness Analyser): it provides a snapshot of the inclusion content in molten aluminium but does so by measuring the pressure drop across a filter as the melt is processed. It is a relatively simple and established method that provides quantitative data on inclusion levels.

However, both techniques lack the real-time monitoring capability of in-line detection means. A major drawback is also the representativity of the measurements.

1.2 In-line Inclusion Measurements

The reference technique is the **LiMCA** (Liquid Metal Cleanliness Analyzer). The LiMCA measurement principle is as described on Figure 1: liquid metal is sucked up in a glass tube through an orifice. Two electrodes immersed in liquid metal are located on each side of the orifice. Whenever an inclusion passes through the orifice, it affects the electrical conductivity of the medium. One liquid metal (approximately 17.5 g) sampling is done every 80 s once the equipment is ready for measurements. Over an hour, this represents 45 measurements. For a 50-t cast, this means that about 1 kg of metal can be analyzed, i.e., 0.002 %.

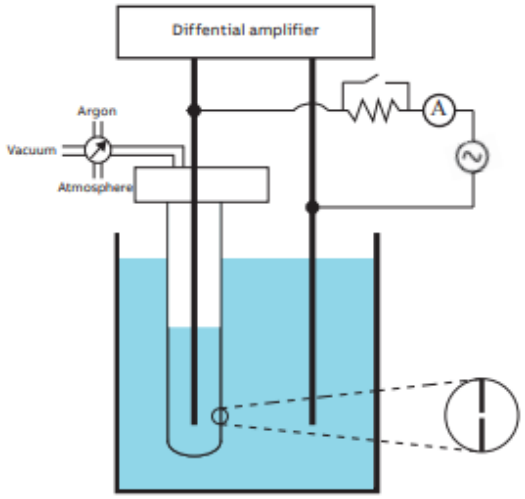

Figure 1. LiMCA measurement principle (source: ABB LiMCA III brochure [2]).

In terms of detection limit, the inclusion size range is between 15 and 300 µm, but the measurement range is between 20 and 155 µm.
The number of inclusions reported is extrapolated to 1 kg melt (× 57) and inclusions are sorted by size range.

The **Batscan** is a measurement technique based on control ultrasound [3] (see Figure 2). Two active waveguides are used to respectively emit and receive control ultrasound. The waveguides are made of a ceramic material which is inert with respect to liquid aluminium. The innovative feature of the Batscan is that the waveguide cross-section interface is wetted by liquid aluminium using power ultrasound. The analyzed cross section determined by the focal zone of the waveguides is ca. 10 cm². For a 50-t cast, the typical trough dimension leads to a metal cross section of 400 cm². The ratio between the liquid metal going through the focal zone and the metal being cast is 2.5 %. This corresponds to 1 250 kg being monitored.

5. References

1. Don Doutre et al., Aluminium cleanliness monitoring: Methods and applications in process development and quality control, *Light Metals*, 1985, 296–304.
2. ABB Measurement & Analytics, LiMCA III brochure, 2024.
3. Jean-Louis Achard et al., An innovative ultrasonic technology for the continuous quality monitoring of liquid aluminum on casting lines, *Light Metals*, 2018, 871–878.
4. Media news Constellium, https://www.constellium.com/about-us/stories/batscan-tm-revolutionizing-quality-monitoring-in-the-aluminum-industry (accessed on 13 July 2024).
5. Jean-Louis Achard et al., Batscan™, Constellium in-melt ultrasonic inclusion detector: industrial performance, *Light Metals*, 2020, 936–943.