AISTech 2022 — Proceedings of the Iron & Steel Technology Conference
16–18 May 2022, Pittsburgh, Pa., USA
DOI 10.33313/386/205

Advances in Cored Wire Injection and Calcium Treatment in Steelmaking

Edgar-Ivan Castro-Cedeño[1], Alexandre Carré[1], Jose Lujan[2]

[1] Affival SAS
70 rue de l'Abbaye, Hauts-de-France, France, 59730
Phone: +33 (0)32 773 6036
Email: alexandre.carre@affival.com

[2] Opta Group LLC
300 Corporate Parkway-118N, Amherst, NY 14226
Phone: 330 606 1249
Email: jlujan@optagroupllc.com

Keywords: cored-wire, calcium, clean steel, CFD modeling

INTRODUCTION

Affival [1], part of the Opta group, is one of the pioneers in the development of cored wire injection technology, with more than 40 years of experience in the manufacturing of cored wire and its associated injection equipment. Since its inception, cored wire injection technology has increasingly established itself as the preferred method of addition for trimming major components and microalloying in secondary metallurgy. In its simplest form, the cored wire consists of a metal casing wrapped around a core of alloying material (for instance: Ca, CaSi, CaFe, FeTi, FeB, FeV, FeNb, C, S, FeS, Al, etc.) [2].

When cored wire is injected into a liquid metal bath, the release of the wire filler material into the bath is delayed because of a complex transient process, leading up to the assimilation of the cored wire into the melt [3, 4]. This product feature enables higher alloy recoveries compared to lumpy/bulk additions and is especially useful for the addition of elements with high vapor pressure and low solubility such as calcium. In this case, ensuring that the release of calcium takes place deep within the melt enhances the performance of the calcium treatment, i.e., calcium has a larger timespan for achieving its intended role of inclusion modification before leftover unreacted calcium vapor is expelled from the ladle. Higher calcium recovery and tighter deviation of the calcium content are observed as a side effect.

One of the main axes for achieving a better performance of the cored wire additions in general, and calcium treatment in particular, is the optimization of both the cored wire design features and the wire injection conditions. At Affival, there is a team dedicated to conducting continuous R&D on cored wire design and the associated feeding equipment, as well as more theoretically oriented research on the calcium dissolution in the ladle and inclusion modification by this element.

In this work we present two examples of the most recent R&D development at Affival: 1) the DissolFil proprietary software, which simulates the thermal history of any given cored wire from the moment of introduction into a liquid metal bath up until the release of the feeder material, and 2) a multiphase CFD model that considers calcium release, transport, and dissolution into the steel ladle.

Modeling of Cored Wire Assimilation Into Liquid Metal Baths

A finite-volume model aimed at simulating the thermal phenomena occurring when the wire is injected into a liquid metal bath was developed recently [3, 4]. The main governing differential equations are written below. Equation (1) is the energy conservation equation with an enthalpy-based formulation that easily handles phase-change phenomena. Equation (2) presents the local heat balance at the wire/melt interface, which dictates whether melting, solidification, or simple heating is taking place at the wire/melt interface.

$$\rho \frac{\partial \mathrm{H}}{\partial \mathrm{t}} = \nabla \cdot (\lambda \nabla \mathrm{T}) \tag{1}$$

$$\rho \Delta H_m \frac{dV}{dt} = S\lambda \nabla T_{int} - hS(T_{melt} - T_{int}) \tag{2}$$

