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Furnace Tapping

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INTRODUCTION

Tapping a pyrometallurgical smelter is not an easy task, and a well-managed tapping process is essential for safe furnace operations. Draining of metal and slag is as important as maintaining a tap-hole so that it can be easily opened and closed. From a furnace containment perspective, the tap-hole is a high-wear and therefore high-risk area, and tap-hole failures can have devastating impacts on smelter operations. Tap-hole life cycle design and management require development of high-quality materials, equipment, and methods that not only take criteria for normal operating conditions into account, but also those of maintenance, repairs, and relines. The JOM Special Topic on Furnace Tapping presents a state-of-the-art picture of the tapping of furnaces from a multi-disciplinary engineering perspective, with special emphasis on industrial research.

PAPERS IN THIS TOPIC

The operational perspective frames the challenges involved in managing the tap-hole life cycle very well, and to this end three overview papers are included.

Goodall reviewed the practices employed at the Koniambo Nickel SAS ferronickel smelter from both tapping and refractory maintenance perspectives in his paper "Furnace tapping practices and tap-hole refractory maintenance at Koniambo Nickel SAS". The direct current (DC)-furnace design, equipment layout, and operational routines were described for the tapping practices. For the refractory maintenance practices, the details of the tap-hole design, repair criteria, and methodologies applied are discussed.

In their paper "PGM, Nickel, and Copper Tapping: An Updated Survey and Industry Trends", Nolet et al. presented results from an industry survey of the tapping practices applied in base metals and PGM industries. The objective of their paper was to encourage cross-pollination across different processes and industries and to provide a useful reference documenting best practices in matte and metal tapping operations.

Tangstad et al. discussed the optimal tapping process for manganese ferroalloy production in submerged arc furnaces (SAFs) in their paper "Conceptual tapping model of Mn-ferroalloy furnaces". From their perspective the optimal tapping process would be when slag and metal are drained from the furnace at the same rate as being produced and separated in the post tap-hole process. As this would not always be the case industrially, they discussed the tapping process in consecutive steps from flow from the back electrodes to the tap electrodes and then from the tap electrode through tap-hole, along the runner and into the ladle, with the intention to provide an overall summary of which elements may affect tapping.

The production of high-silicon alloys in SAFs involves the generation, in significant amounts, of intermediate process gas consisting of silicon monoxide (SiO) and carbon monoxide (CO). Gassing, defined as outbursts of high-rate gas flows through the tap-hole during tapping, is a regular phenomenon and such incidents pose risks to both health and equipment. SiO gas burns to fine SiO_2 particles, which can cause adverse health effects and fugitive particulate matter (PM) emissions. The combustion energy of SiO and CO is a source of high heat load for tapping operators and is also a source of thermal NOx generation. Three papers addressing this specific problem are included.

J. D. Steenkamp and Q. G. Reynolds are the Guest Editors for the Furnace Tapping topic in the November 2022 issue of JOM.

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In their paper "Gas flow and pressure drop in charge material in silicon production", Ringdalen et al. reported on laboratory-scale experiments in which the pressure drop and permeability were measured for different gas velocities through particle beds of different charge mixtures, based on raw materials and particle sizes utilised in industrial silicon production. The experimental results were up-scaled to conditions in industrial furnaces using a fluid flow modelling approach and the findings compared with results from measurements of pressure drop in industrial furnaces.

Andersen et al. reported on the results from a measurement campaign conducted at the Elkem Thamshavn plant in Norway in their paper "Tapping gas from the silicon submerged arc furnace—an industrial measurement campaign". Measurements were done over a 3-day period during which the composition of gas samples extracted during tapping were analysed by Agilent micro-GC, Protea atmosFIR, and Testo 350 and the particulate matter content measured with a LaserDust instrument from NEO Monitors. Existing flow and temperature measurements at the plant were applied in mass and energy flow calculations. Linear regressions were calculated for three predictors of NOx formation in the tap-hole gas and illustrated that total energy added to the tapping gas correlated well with NOx produced.

Gassing was also studied through mathematical modelling of reactive turbulent flows by Vachaparambil et al. in their paper "Gassing during tapping of silicon". The results illustrated that the flame resulting from combustion of SiO and CO in the gas leaving the tap-hole can extend for several meters and that the strength of the flame jet increased with the amount of gassing. The simulations also demonstrated that the NOx production increased with the amount of gas exiting the tap-hole and that thermal Nox formation did not substantially impact the length of the gas jet.

Technology and technology development plays an important role in managing the tap-hole life cycle effectively. The topic concludes with three such papers.

Gregurek et al. in their paper "Improving tapping experience—and why to choose a comprehensive approach" addressed the various factors considered for optimization of the tap-hole and tapping design. From their experience tap-hole and tapping optimization is generally not a one-time task but an ongoing improvement cycle comprising evaluation and adaptation of geometries, materials, data and technologies, considering changing process parameters and use of new technologies. Their paper described the methods and technologies applied to optimize tap-hole performance, tapping safety, and efficiency.

In their paper "Advances in robotic tapping and plugging of non-ferrous smelting furnaces: the MIRS robotic tapping machine", Madriaga et al. described a new robotic tapping and plugging machine for the slag tapping operation on a large copper flash smelting furnace. A summary of the operating features and performance aspects was reported on, together with the results of industrial trials conducted on a flash furnace.

Myklebust et al. in their paper "Use of a distributed micro-sensor system for monitoring the indoor particulate matter concentration in the atmosphere of ferroalloy production plants", evaluated the performance of small, low-cost sensors for measuring particulate matter content under conditions relevant for the indoor environment of the metallurgical industry. The commercial, low-cost Nova PM SDS011 particle sensor was benchmarked in two different ferroalloy plants against the Fidas 200S, which has been suitability-tested and certified according to the latest EU requirements (EN 15267, EN 16450). Twelve Nova sensors were tested over three months at a silicomanganese alloy plant, and 35 sensors were tested during one month at a silicon plant. The results demonstrated that the low-cost Nova sensors exhibited all the same trends and peaks in terms of PM concentration, but measured lower dust concentrations than the Fidas 200S.

CONCLUDING REMARKS

All papers included here were submitted by invited authors who demonstrated through their previous research outputs—many of which are included in the Proceedings of Furnace Tapping 2014, Furnace Tapping 2018, and Furnace Tapping 2022—the importance of their contributions to understanding and improving the management of the tap-hole life cycle. We would like to thank JOM for the opportunity to include a Special Topic on Furnace Tapping in its Editorial Calendar. We also would like to thank all peer reviewers for their valuable perspectives and inputs to these publications and, most importantly, the authors for submitting their work to JOM. We trust that you, the reader, will enjoy working through these papers as much as we guest editors did.

All titles and authors of the articles published under the topic "Furnace Tapping" in the November 2022 issue (vol. 74, no. 11) of JOM can be accessed via the journal's page at: http://link.springer.com/journal/11837/74/11/page/1.